Profiling the technical tactical components of performance in professional soccer.

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Profiling the Technical and Tactical Components of Performance in Professional Soccer

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Abstract

Soccer has received considerable interest within the existing notational analysis literature with particular focus upon the technical and tactical components of performance. Much of this research has however been limited by conceptual and methodological issues such as the failure to adopt rigorous performance profiling techniques and the use of inadequate data analysis procedures. The purpose of this thesis therefore was to profile the technical and tactical components of soccer performance via a case study of a professional British team using robust methodologies and advanced statistical techniques. All data were collected from match recordings provided by the participating soccer club using the computerised Noldus Observer Video Pro 4.1 behavioural measurement package (Noldus Information Technology, 2002). In Study 1 and Study 2 respectively, technical and tactical measures of 'on-the-ball' performance were developed and validated by professional soccer coaches and experienced notational analysts. The technical aspect of performance was subsequently assessed by constructing behavioural and outcome profiles corresponding to behaviour incidence and success rates. Tactical performance was investigated via the development of spatial profiles relating to the occurrence of the technical behaviours across the pitch surface. Collectively, the findings highlight the need to examine soccer performance at the team, playing position and individual player level to account for the inter- and intra-positional technical and tactical differences within the sport. Based upon the profiles produced within Study 1 and Study 2, Study 3 utilised advanced statistical modelling procedures to examine the potential influence of a number of situation variables upon the technical and tactical components of soccer performance. Log-linear and logit modelling revealed significant main effects and interactions of match location, opposition quality and match status upon behaviour incidence (technical), behaviour occurrence across the soccer pitch surface (tactical) and to lesser extent behaviour outcomes (technical). These findings suggest that potential 'confounding' variables need to be considered when making evaluations and predictions associated with the technical and tactical elements of soccer performance. Overall, the findings of this thesis have facilitated a greater understanding of the profiling of the technical and tactical components of soccer performance through using rigorous methodologies and advanced statistical procedures. Practical implications for soccer coaches and notational analysts are discussed in relation to the scouting of opposition teams and players, and

evaluation and prediction of performance. Future soccer-based notational analysis research should consider profiling the technical and tactical components of 'off-the-ball' behaviours and examine the influence of additional 'confounding variables' upon performance.

Declaration

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed..... ..... (Candidate)

Date.....22nd June 2007.....

STATEMENT 1

This thesis is the result of my own investigations, except where otherwise stated. Other sources are acknowledged by footnotes giving explicit references.

Signed..... ..... (Candidate)

Date.....22nd June 2007.....

STATEMENT 2

I hereby give consent for my thesis, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

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Aspects of the findings contained within this thesis have been published as follows:

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Taylor, J.B., Mellalieu, S.D., James, N. and Tucker, W. (2004). The effect of game location on individual performance in soccer. *Proceedings of the 6th World Congress of Performance Analysis in Sport*, p. 9. Belfast: Northern Ireland.

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Dedicated to the memory of Joseph Frederick Taylor (1950-2006)

Chapter 1 – Introduction

Soccer is the world's most popular sport and has great economic, social and cultural importance within many societies (Dobson and Goddard, 2001; Wesson, 2002; Reilly and Williams, 2003). These factors inevitably increase the pressure on soccer teams to be successful, as is evident at the professional level through the high turnover of coaches and players (Borrie and Knowles, 2003; Eubank and Gilbourne, 2003). It is therefore unsurprising that professional soccer clubs are becoming more willing to consult and employ specialist support staff, such as sports scientists, who can provide guidance relating to performance preparation and assessment (Richardson and Reily, 2002, Williams *et al.*, 2003a). In particular, the need to objectively observe, analyse and feedback performance-related information has led to an increased prevalence of notational analysis within modern professional soccer coaching structures (Olsen and Larsen, 1997; Kormelink and Seeverns, 1999; Carling *et al.*, 2001; Larsen *et al.*, 2001; Blaze *et al.*, 2004; Carling *et al.*, 2005). Within this context, notational analysis entails both the 'coding' of match events for quantitative analysis via statistical procedures and the use of match recordings for qualitative appraisal (Reilly and Gilbourne, 2003; Blaze *et al.*, 2004; Groom and Cushion, 2005).

In addition to its practical application, notational analysis also represents a branch of sports science that has received growing empirical interest (Reilly and Gilbourne, 2003). The mental and physical components of performance have received initial research attention (e.g. Peiser and Madsen, 1997; Sasaki *et al.*, 1999; O'Donoghue and Parker, 2001; O'Donoghue and Tenga, 2001; Shaw and O'Donoghue, 2004) but investigations have principally focused upon the predominant technical-tactical nature of the soccer (Castagna *et al.*, 2003). Many of these studies have however, been limited by conceptual and methodological issues. For example, commonly employed nomothetic study designs appear flawed as they fail to acknowledge the unique characteristics of individual teams (Pietersen, 2001; James *et al.*, 2002). Furthermore, research has tended to focus upon the team as a whole, yet evidence from applied settings demonstrates that performance evaluations are also conducted in relation to specific playing positions and individual players (e.g. Kormenlink and Seeverens, 1999; Carling *et al.*, 2005). Additional methodological problems include the use of inappropriate techniques for reliability testing and data

analysis together with a failure to ensure that the data presented are representative of performance (Hughes *et al.*, 2001a, 2004b). While various approaches to profiling performance in sport have been developed to address this final concern (e.g. Hughes *et al.*, 2001a, 2004b; Bracewell, 2003; James *et al.*, 2003; O'Donoghue, 2005; O'Donoghue and Ponting, 2005), to date they have been utilised within soccer research.

The construction of 'performance profiles' are beneficial as they are suggested to provide the basis for performance prediction and thereby move beyond the traditionally descriptive approach adopted in the notational analysis literature (Potter and Hughes, 2001; McGarry and Franks, 2003; McGarry and Perl, 2004). Nonetheless, the effectiveness of a 'general' performance profile for this purpose has been questioned as many variables may have a 'confounding' effect upon performance (James *et al.*, 2003). Indeed, the soccer coaching literature has proffered a number of factors that are suggested to influence performance but a paucity of related research exists, particularly at a behavioural level (Kormelink and Seeverens, 1999; Maynard, 2002; Carling *et al.*, 2005). Moreover, where the factors affecting behavioural performance have been investigated (e.g. Sasaki *et al.*, 1999; O'Donoghue and Tenga, 2001; Shaw and O'Donoghue, 2004; Bloomfield *et al.*, 2005a,b; Tucker *et al.*, 2005) this has occurred in isolation with a failure to address the potential interactive effects that appear to more accurately reflect the dynamic nature of soccer (Grehaigne *et al.*, 1997a; Kormelink and Seveerens, 1999; Grehaigne, 2001a; McGarry and Franks, 2003; Carling *et al.*, 2005; Reed and O'Donoghue, 2005).

Based on the highlighted limitations of previous notational analysis research in soccer, the purpose of this thesis is to profile the technical and tactical components of performance within a professional soccer team. To achieve this aim this thesis comprises three main objectives. The first objective is to utilise robust methodologies to construct and examine performance profiles relating to the technical facet of soccer performance at the team, playing position and individual player levels (Dunn *et al.*, 2003; Williams *et al.*, 2003b; Probert and Hughes, 2006). The second objective is to develop and investigate profiles corresponding to the tactical aspect of soccer performance at the team, playing position and individual player levels (Grehaigne *et al.*, 1997b; James *et al.*, 2002). The final objective is to determine the potential independent and interactive effects of the factors that have been purported to influence the technical and tactical components of soccer performance, thereby providing insight into the variables that coaches and notational analysts should consider when making

performance assessments and predictions (Kormenlink and Seeverens, 1999; Carling *et al.*, 2005).

The remainder of this thesis consists of five chapters: Chapter 2 provides a review of the conceptual and methodological issues in the existing soccer notational analysis literature, with particular focus on the technical and tactical components of performance at the team, playing position and individual player level. The next three Chapters then present studies corresponding to the thesis objectives. Specifically, Chapters 3 and 4 use rigorous methodologies to construct and examine profiles of the respective technical and tactical aspects of soccer performance at the team, playing position and individual player level. Chapter 5 then adopts advanced statistical modelling procedures to consider the independent and interactive effects of a number of situation variables upon the technical and tactical components of soccer performance. The final thesis chapter, Chapter 6, discusses the findings of these three studies in relation to the thesis aims and objectives and the existing soccer notation literature. This Chapter will also include practical recommendations for soccer coaches and notational analysts before concluding by considering the thesis limitations and possible directions for future soccer-based research in notational analysis.

Chapter 2 - Review of Literature

2.1 Overview

Notational analysis refers to the collection and statistical evaluation of data relating to events observed during sports performance and is often utilised in conjunction with video footage (Reilly, 2001; Reilly and Gilbourne, 2003; Blaze *et al.*, 2004; Groom and Cushion, 2005). The need for this procedure arises from the fact that the observations made by coaches are subjective, resulting in inaccurate and unreliable appraisals of performance (Franks and Miller, 1986; Franks, 2004). Notational analysis was first employed within professional soccer during the 1950s and has since become an integral part of many team's coaching structures (Olsen and Larsen, 1997; Kormelink and Seeverns, 1999; Carling, 2001; Larsen *et al.*, 2001; Lyons, 2001; Blaze *et al.*, 2004; Carling *et al.*, 2005). In addition to its practical applications notational analysis has also developed into a sub-discipline of sports science which converges with biomechanics and motor learning under the term 'performance analysis' (Bartlett, 2001; Hughes and Bartlett, 2002b). Early soccer-based notational analysis studies were sporadic (e.g. Reep and Benjamin, 1968; Reilly and Thomas, 1976; Gould and Gatrell, 1980) but evidence from the *Science and Football* conferences (see Reilly *et al.*, 1988, 1993, 1997, 2005a; Spinks *et al.*, 2002) demonstrate its development into a particularly popular area of research (Reilly and Gilbourne, 2003).

Performance has been defined as any observable behaviour and consists of mental, physical, technical and tactical components (Robertson, 1999; Williams *et al.*, 2003a). Although the mental and physical elements of performance have received attention within soccer notational analysis literature (e.g. Peiser and Madsen, 1997; Sasaki *et al.*, 1999; O'Donoghue and Parker, 2001; O'Donoghue and Tenga, 2001; Shaw and O'Donoghue, 2004) research has principally focused upon the sports predominant technical and tactical components (Castagna *et al.*, 2003). Consequently, in accordance with the thesis aims and objectives, it is the intention of this review to discuss current notational analysis literature related to the profiling of the technical and tactical aspects of soccer performance. This will initially be achieved by defining the 'technical' and 'tactical' within the context of soccer performance and identifying the sources of literature to be appraised. Relevant research into these performance elements at team level will then be considered before extending focus to similar investigations

conducted at playing position and individual player levels. Next an examination of performance indicators, defined as variables selected in an attempt to define some aspect or core trait of performance (Hughes and Bartlett, 2002a, 2004; Bracewell, 2003), will be conducted. In addition, the use of performance indicators, either in isolation or collectively, to produce a depiction of typical performance, termed a performance profile, will be evaluated due to their predictive potential (Hughes *et al.*, 2001a, 2004b; James *et al.*, 2003). The subsequent section will deliberate the factors that are suggested within soccer coaching literature to influence performance and appraise these in relation to empirical evidence. Finally, although conceptual and methodological issues within the existing soccer notational analysis literature will be highlighted throughout the review, the concluding section focuses in particular on the suitability of the various statistical techniques used for reliability testing and data analysis.

2.2 Definitions Related to the Technical and Tactical Components of Soccer Performance

In the context of this thesis, it is important to define what constitutes the technical and tactical aspects of performance. The term technical relates to technique and within notational analysis is primarily addressed through examining behaviour incidence and associated outcomes (Kormelink and Seeverens, 1999; Robertson, 1999; Carling *et al.*, 2005). In comparison, the tactical element of performance reflects the way in which behaviours are employed during a match in order to achieve a specific strategy, where strategy refers to the general plan devised to accomplish a particular aim (Robertson, 1999; Carling *et al.*, 2005). This distinction between strategy and tactics is important as they represent differing constructs, yet have often been utilised interchangeably within the previous literature (Grehaigne *et al.*, 1999). Indeed, caution is advised as terms such as 'patterns of play' or 'styles of play' have also been employed during studies to refer to strategy and tactics and highlights the lack of standardised terms within the field of notational analysis (Tenga and Larson, 2001; 2003).

A key point that arises from the definitions of 'technical' and 'tactical' is that these two components of performance are not entirely independent. For example, a high percentage of successful passes by a team may not necessarily indicate efficient technical performance but may represent a low risk passing strategy that relies predominantly on tactically 'safe' backwards and sideways passes (Carling *et al.*, 2005).

To date notational analysis research has failed to recognise this issue and findings are discussed in relation to the aspect of performance that is of interest to the author(s). As a result of this concern this review will proceed by considering the technical and tactical research in unison. Overall, the literature appraised will be sourced from conference proceedings, academic journals and relevant textbooks. Notational analysis studies have also been published within coaching journals such as the Football Association's *Insight* (e.g. Ensum *et al.*, 2000, 2002; Strudwick and Reilly, 2001; Low *et al.*, 2002; Taylor and Williams, 2002; Dunn *et al.*, 2003; Williams *et al.*, 2003b) but as it is unclear whether these articles have been subjected to a peer review process and employed the rigorous methodologies required for scientific dissemination they will only be referred to where a dearth of scientific literature exists or to support pertinent points.

2.3 Technical and Tactical Components of Team Performance in Soccer

Analysis of soccer performance in applied settings is generally focused towards attacking and defensive phases of play, as determined by whether or not the team of interest is in possession of the ball (Kormelink and Seeverens, 1999; Carling *et al.*, 2005). The objective of attacking play is to create goal scoring chances whereas defensive play aims to deny the opposition team time and space whilst attempting to regain possession of the ball (Hughes, 1999). However, existing notational analysis research into the technical and tactical components of soccer performance has been directed disproportionately upon the former phase, with a particular interest in attacking strategies and goal-scoring (Table 2.1). Indeed, Carling *et al.* (2005) state that soccer coaches and notational analysts, henceforth referred to as analysts, are essentially forced to make inferences about defence based upon the findings of the literature relating to attacking play. Unsurprisingly this has led to much technical and tactical information for behaviours associated with attack such as crosses, dribbles, passes and shots (e.g. Partridge and Franks, 1989a,b; Partridge *et al.*, 1993; Rico and Bangsbo, 1996; Scoulding *et al.*, 2004; Ensum *et al.*, 2005) but a dearth of investigations of defensive behaviours such as clearances, interceptions, tackles (e.g. Luhtanen *et al.*, 2001a; Grehaigne *et al.*, 2002; Ford *et al.*, 2004).

Much of the soccer-based notational analysis research conducted to date has been characterised by attempts to distinguish those technical and tactical elements that define successful performance (e.g. Grant *et al.*, 1999a; Low *et al.*, 2002; Hughes and Churchill, 2005). The implicit premise of these studies being that teams who regularly

Table 2.1 Summary of notational analysis literature relating to the technical and tactical components of soccer team performance.

Author(s)	No. of Matches	Sample	Reliability and Statistical Procedures	Main Findings
Abt *et al.* (2002)	703	Australian National League (1994-1998)	• Reliability: Not reported • Statistics: Chi-square, non-parametric trend analysis	• Incidence of goals ↑ throughout a match • Trend consistent across halves, 15 minute periods and 5 minute periods
Ali (1988)	18	Case study of a Scottish Premier League Team	• Reliability: Not reported • Statistics: Chi-square	• Identified seven major attacking patterns • Wing attacks most likely to result in shooting opportunities
Bate (1988)	Unclear	Various International and English League matches	• Reliability: Not reported • Statistics: Descriptive	• 48% of goals from ≤1 pass possessions, 78% ≤4 pass possessions • Advocates direct playing style
Bishovets *et al.* (1993)	Unclear	1990 World Cup	• Reliability: Not reported • Statistics: Correlation, factor analysis	• Players in winning teams had consistent and reliable tactical understanding
Bloomfield *et al.* (2005a)	22	3 English Premier League Teams (2003-2004)	• Reliability: Yes • Statistics: Descriptive	• Team tactics and strategies are influence by match • Majority of ball possessions occur in the midfield pitch 1/3
Brown and Hughes (2004)	33	2002 World Cup	• Reliability: Yes • Statistics: Kruskal-Wallis, Mann-Whitney, chi-square	• Each continent has a distinct style of play • Teams vary their styles of play (possession vs. direct) depending upon the specific pitch third within which they have possession
Burchill *et al.* (2006)	5	English Under 19 Premier Youth League	• Reliability: Not reported • Statistics: Descriptive	• All goals (n = 16) came from possessions involving ≤4 passes • Supports a direct style of play in youth soccer
Carey *et al.* (2001)	9	1998 World Cup	• Reliability: Yes • Statistics: Descriptive	• 79% of players were right footed (general population ~75-80%) • Similar skill levels for dominant and non-dominant feet
Dooan *et al.* (2001)	4	Turkish Division 1 and amateur matches	• Reliability: Not reported • Statistics: Chi-square	• More 'one and two touch' passing in professional soccer compared to amateur soccer • Suggest that 'one touch' is important to scoring goals
Dufour (1993)	Unclear	Not Reported	• Reliability: Not reported • Statistics: Descriptive	• Ball in play for ~60% of match duration • Team with most possession wins 65% of the time • Advocates direct style of play

Table 2.1 (Continued)

Author(s)	No. of Matches	Sample	Reliability and Statistical Procedures	Main Findings
Egesoy and Eniseler (2001)	Not reported	Turkish professional leagues (1993-1995)	• Reliability: Not reported • Statistics: Descriptive	• Team scoring first wins 65.7% -77.8% of the time • Most goals (~87.0%) are scored from inside the penalty area
Eniseler *et al.* (2001a)	6	Galatasary in the 1993-94 Champions League	• Reliability: Not reported • Statistics: Chi-square	• Crossing is an effective method to produce goals • Galatasary less technically and tactically astute than opponents
Eniseler *et al.* (2001b)	4	Turkey in the 1996 European Cup Qualifying Stages	• Reliability: Not reported • Statistics: ANOVA	• Analysis suggested that Turkey was better than opponent teams in the performance of duels, interceptions and pressurising opponents
Ensum *et al.* (2005)	64	2002 World Cup	• Reliability: Yes • Statistics: Logistical regression	• Important factors determining whether shots result in goals are distance, angle, if the shot was preceded by a cross, space and number of players between the shot taker and the goal
Ferit (2001)	3	Turkish Premier League teams in derby matches	• Reliability: Yes • Statistics: Descriptive	• The victorious teams generally displayed better technical and tactical performances
Fleig and Hughes (2004)	52	2002 World Cup	• Reliability: Yes • Statistics: Chi-square	• Counter attacks employed mostly by teams with ↓ FIFA rankings • Successful counter attacks rely on accurate passing, dribbling and use of wide pitch areas
Ford *et al.* (2004)	8	English Premier League Teams (2003-2004)	• Reliability: Yes • Statistics: Descriptive	• Possession regains in defensive 1/3 mostly from interceptions and tackles • Counter attacks from defensive 1/3 effective attacking method • Home teams counter attack more than away teams
Garganta and Goncalves (1997)	8	Portuguese male and female national teams	• Reliability: Not reported • Statistics: Independent t-test	• Position attacks utilised more than fast attacks • Females produced shots more quickly, performed less passes and used less players during attacks than the males
Garganta *et al.* (1997)	44	5 European Teams (Porto, Barcelona, Bayern Munich, Milan, Paris Saint Germain.	• Reliability: Not reported • Statistics: Chi-square	• Teams displayed similar attacking patterns leading to goals • Ball primarily won in the attacking 1/3, attacks lasted <10 seconds, involved <3 players and <3 passes

Table 2.1 (Continued)

Author(s)	No. of Matches	Sample	Reliability and Statistical Procedures	Main Findings
Gerisch and Reichelt (1993)	1	European Cup Semi-Final (1991) - First Leg	• Reliability: Not reported • Statistics: Descriptive	• Analysis of 1-on-1 situations show match periods of team strength and weakness termed 'dominance'
Grant and Williams (1998)	Unclear	English Premier League (1997-1998)	• Reliability: Not reported • Statistics: Descriptive	• Most players sent off: 1) in the last 15 minutes 2) played for the home team 3) when the match was being drawn
Grant *et al.* (1999a)	30	1998 World Cup	• Reliability: Not reported • Statistics: Descriptive	• Successful teams had more attempts at goal per game (18.1 vs. 9.5), more passes (362.7 vs. 308.9), more crosses (19.1 vs. 12.7)
Grant *et al.* (1999b)	64	1998 World Cup	• Reliability: Not reported • Statistics: Descriptive	• Incidence of goals scored ↑ throughout matches • >50% of goals scored involved a one-touch finish • Most goals from possession gained in the defending 1/3
Grant *et al.* (1999c)	10	1999 Women's World Cup	• Reliability: Not reported • Statistics: Descriptive	• Successful teams make more passes and dribbles, score more goals and perform more shots on-target than unsuccessful teams
Grehaigne (2001b)	1270	English 1st Div (1978-1979), French 1st Div (1996-1997), 1998 World Cup	• Reliability: Not reported • Statistics: Chi-square	• Goal incidence ↑ throughout matches • 77% of goals in final 15 minutes went to the team currently winning or alternatively resulted in victory
Grehaigne *et al.* (2002)	4	1994 World Cup	• Reliability: Not reported • Statistics: Not clear	• 'Block defence' most effective • Number of defenders should equal or exceed attackers
Harris and Reilly (1988)	24	Unclear	• Reliability: Yes • Statistics: t-tests, MANOVA, MANCOVA	• Teamwork and use of space contribute to attacking success • In attacking 1/3 attackers should aim to outnumber defenders
Hewer and James (2004)	211	British Premier League team (1998-2003)	• Reliability: Yes • Statistics: Chi-square	• European teams defend deeper than British teams • European matches characterised by more passes per possession and goals from outside the penalty area
Hook and Hughes (2001)	Unclear	European Championship 2000	• Reliability: Yes • Statistics: Chi-Square	• Unsuccessful teams were predictable in attack, relied on aerial balls and forced to take shots from long distances

Table 2.1 (Continued)

Author(s)	No. of Matches	Sample	Reliability and Statistical Procedures	Main Findings
Hughes and Churchill (2005)	30	2001 Copa America	• Reliability: Yes • Statistics: Chi-square	• No significant differences between the patterns of play leading to shots for successful and unsuccessful teams
Hughes and Franks (2005)	Unclear	1990 and 1994 World Cups	• Reliability: Unclear • Statistics: Descriptive	• When data normalised longer passing sequences led to ↑ shots • Shots to goal ratio was better for direct play
Hughes and Petit (2001)	68	1998 World Cup	• Reliability: Yes • Statistics: Chi-square	• Conclusions of Partridge and Franks (1989a,b) still apply in modern soccer
Hughes and Snook (2006)	15	2004 European Championships	• Reliability: Yes • Statistics: Chi-square	• Teams classified into 3 groups based on tournament seeding • Shots to goal ratio reflected seedings but overall few differences
Hughes *et al.* (1988)	Unclear	1986 World Cup	• Reliability: Not reported • Statistics: Chi-square	• Unsuccessful teams use wide pitch areas, successful use centre • Successful teams used ↑ touches of the ball per possession
Hughes *et al.* (1998)	20	English Premier League, 1996 European Championships	• Reliability: Not reported • Statistics: ANOVA	• Perturbations caused by good passes, skill and lost control were most likely to result in goals
Hughes *et al.* (2001b)	20	English Premier League (1995-1996)	• Reliability: Yes • Statistics: Descriptive	• Successful teams have wider tactical awareness and use a variety of methods to create goal scoring chances
Hughes *et al.* (2001c)	15	1996 European Championships	• Reliability: Yes • Statistics: Descriptive	• Average of 118.2 perturbations per game • One in four perturbations leads to a shot on goal
James *et al.* (2002)	21	Premier League Team - domestic and European matches (2001-2002)	• Reliability: Yes • Statistics: Chi-square	• European games - more play in the pre-defensive area, less in pre-offensive area • Strategy and tactics may be necessitated by opposition strengths
Japheth and Hughes (2001)	13	1998 World Cup, 2000 European Championship (matches involving France)	• Reliability: Yes • Statistics: Chi-Square	• 50% of goals against France due to errors in defending 1/3 • France's goal scoring ability ↑ between the competitions • France played ↑ possession football during the World Cup
Jinshan *et al.* (1993)	52	1990 World Cup	• Reliability: Not reported • Statistics: Unclear	• 27.8% of goals the result of wing attacks • ↑ goals from headers than in the previous World Cup (1986)

Table 2.1 (Continued)

Author(s)	No. of Matches	Sample	Reliability and Statistical Procedures	Main Findings
Jones *et al.* (2004)	24	English Premier League (2001-2002)	• Reliability: Yes • Statistics: Mann-Whitney	• Successful teams had ↑ possession irrespective of match status • Teams had ↑ possession when winning than when losing
Konstadinidou and Tsigilis (2005)	20	Four teams from the 1999 World Cup for women	• Reliability: Yes • Statistics: Correspondence analysis	• Teams observed to have different offensive strategies • Suggested agreement between offensive styles of corresponding international women's and men's teams
Kuhn (2005)	4	International matches 1953, 1974, 1998, 2002	• Reliability: Not reported • Statistics: Descriptive	• Player time and space has ↓ since 1950s • Formations have become more defensive since the 1950s
Lanham (1993)	479	International competitions and European Leagues	• Reliability: Not reported • Statistics: Descriptive	• A near constant figure of 180 possessions ±10% is needed for a team to score a goal
Lanham (2005)	Unclear	International competitions and European Leagues	• Reliability: Not reported • Statistics: Descriptive	• Maintains a goal occurs on average for every 180 possessions • 1.317 goals per team per game on average
Lemoine *et al.* (2005)	Unclear	County and semi-professional players	• Reliability: Not reported • Statistics: t-test	• One touch football appears to be an efficient method of attacking but is technically demanding
Luhtanen (1993)	Unclear	1990 World Cup	• Reliability: Not reported • Statistics: Correlation, ANOVA	• Successful teams generally created more scoring chances than lower ranked teams • Argentina's success was based on defensive strength
Luhtanen *et al.* (1997)	7	1994 World Cup (matches involving Brazil)	• Reliability: Yes • Statistics: t-test, Wilcoxon signed ranks test	• Brazil had most successful attacking trials into the attacking 1/3 and the highest number of scoring chances • Brazil used a passing (possession) style of play
Luhtanen *et al.* (2001a)	31	1996 and 2000 European Championships	• Reliability: Yes • Statistics: Spearman's correlation	• Rank on measured variables not reflective of tournament progress • Performance was determined by defensive factors and offensive factors in the 1996 and 2000 competitions respectively
Miyamura *et al.* (1997)	9	Various women's soccer - World Cup through university	• Reliability: Not reported • Statistics: Not reported	• Ball in play time ↑ with playing standard • Women less able than men to produce long passing possessions

Table 2.1 (Continued)

Author(s)	No. of Matches	Sample	Reliability and Statistical Procedures	Main Findings
Olsen (1988)	52	1986 World Cup	• Reliability: Not reported • Statistics: Descriptive	• At international level dribbling to a scoring position is not critical • 90% of goals were scored from within 16m of the goal
Olsen and Larsen (1997)	44	Norwegian international team (1991-1994)	• Reliability: Not reported • Statistics: Descriptive	• An early goal, or first goal, influences the outcome of the match • Advocates and justifies the direct playing style employed by Norway
Partridge and Franks (1989a,b)	50	1986 World Cup	• Reliability: Not reported • Statistics: Descriptive	• Many technical and tactical suggestions for production of efficient crosses and subsequent goal scoring chances
Partridge and Franks (1996)	6	Canadian university soccer	• Reliability: Not reported • Statistics: Descriptive	• Demonstrated how a notational analysis intervention coincided with improved technical and tactical performance in a player
Partridge *et al.* (1993)	59	1990 World Cup and 1990 World Collegiate Soccer Championship	• Reliability: Yes • Statistics: Hotelling T^2 test	• World Cup players more skilful in passing and receiving ball • Collegiate games characterised by direct styles of play • Similar goal to shot ratios (~1:12) for both levels of play
Peiser and Madsen (1997)	20	Italian Serie A and English Premier League	• Reliability: Not reported • Statistics: Descriptive	• Higher levels of physical contact in the English Premier League but fewer fouls committed • Number of illegal contacts and serious and deliberate fouls lower in the English Premier League
Pollard and Reep (1997)	22	1986 World Cup	• Reliability: Not reported • Statistics: Descriptive	• 1 goal in every 10 shots on average • <25% of possessions contained >4 passes
Pollard *et al.* (1988)	74	1982 World Cup, English 1st Division (1984-1985)	• Reliability: Not reported • Statistics: Descriptive	• World Cup teams utilise possession-based styles of play • The majority of 1st division teams displayed direct styles of play
Reep and Benjamin (1968)	3213	English 1st Division 1957-1962, various 1953-1967 and 1966 World Cup	• Reliability: Not reported • Statistics: Descriptive	• ~50% of goals from passing moves originate in the attacking 1/4 • 1 in 10 shots leads to a goal • Soccer dominated by chance
Rico and Bangsbo (1996)	5	1992 European Championships	• Reliability: Not reported • Statistics: Not reported	• Dribbles ↓ between halves (corresponding means: 165 and 143) • Mean shots per game = 12.2, goals to shots ratio of 1:12

Table 2.1 (Continued)

Author(s)	No. of Matches	Sample	Reliability and Statistical Procedures	Main Findings
Sasaki *et al.* (1999)	26	Ipswich Town (1995-1996)	• Reliability: Not reported • Statistics: Wilcoxon non-parametric test	• More shots, shots on-target, shots blocked, shots wide, crosses and goal kicks during home matches
Scott *et al.* (2001)	32	1999 World Cup for women	• Reliability: Not reported • Statistics: Descriptive	• Incidence of goals ↑ throughout a match • Majority of possession regains leading to goals occur in the midfield 1/3 (44.3%)
Scoulding *et al.* (2004)	6	Successful and unsuccessful team from 2000 World Cup	• Reliability: Yes • Statistics: Mann-Whitney, chi-square	• Passing strategy does not distinguish between successful and unsuccessful teams
Seabra and Dantas (2006)	14	2002 World Cup (matches involving Brazil and Germany)	• Reliability: Yes • Statistics: Chi-square	• Proposes 'Space of Defensive Occupation' (SDO) to allow spatial analysis of performance rather than pitch divisions
Stanhope (2001)	Not reported	1994 World Cup	• Reliability: Not reported • Statistics: Chi-square	• No evidence to support possession style of play over a direct style.
Starosta (1988)	Unclear	Polish 1st Division, 1978 World Cup, 1986 World Cup	• Reliability: Not reported • Statistics: Descriptive	• Left footed players displayed greater shooting efficiency than right footed players but players that could use both feet were superior
Starosta and Bergier (1993)	Unclear	1978 World Cup and 1988 Junior European Championships	• Reliability: Not reported • Statistics: Descriptive	• Players predominantly utilised their right foot for skill performance (69.8%) • 45.6% of players used both feet for skill performance
Suzuki (2005)	1	2002 World Cup	• Reliability: Not reported • Statistics: Structural equation modelling (SEM)	• Development of soccer defending skill scale (SDSS) • SDSS consists of 9 items which are proposed to measure defensive performance
Suzuki and Nishijima (2004)	1	2002 World Cup	• Reliability: Not reported • Statistics: SEM	• Appears to be exactly the same study as Suzuki (2005) although more detailed
Suzuki and Nishijima (2005)	1	2002 World Cup	• Reliability: Not reported • Statistics: SEM	• Cross-validation of SDSS

Table 2.1 (Continued)

Author(s)	No. of Matches	Sample	Reliability and Statistical Procedures	Main Findings
Tenga and Larson (2003)	1	Norway vs. Brazil (Authors omit further detail)	• Reliability: Yes • Statistics: Chi-square	• Differences in the playing styles of the two teams only evident for attacking play and not defending performance
Tiryaki *et al.* (1997)	4	1994 World Cup (matches involving Switzerland)	• Reliability: Not reported • Statistics: Chi-square	• Majority of passes in midfield 1/3 (58%) • Similar incidence of crosses from left and right pitch sides
Tiryaki *et al.* (2001)	7	1996 European Championships (matches involving Turkey)	• Reliability: Not reported • Statistics: Chi-square	• Turkey played identically in elimination and final competition stages
Tucker *et al.* (2005)	30	English Premier League (2004-2005)	• Reliability: Yes • Statistics: Chi-square	• ↑ 'attacking behaviours' in advanced pitch areas at home • ↑'defensive behaviours' in less advanced pitch areas away
Verlinden *et al.* (2001a)	87	Not stated	• Reliability: Not reported • Statistics: Regression, discriminant analysis	• Soccer influenced by passing more than 1-on-1 situations • Losing matches easiest to predict (77.4% success) followed by drawing (41.7%) and winning (32.4%)
Verlinden *et al.* (2005)	26	1998 World Cup	• Reliability: Yes • Statistics: Chi-square	• Attacking sequences resulting in goals finish closer to goal than those that do not
Yamanaka *et al.* (1993)	Unclear	1990 World Cup	• Reliability: Yes • Statistics: Chi-square	• Playing strategies differ geographically: British Isles – long forward passes and aerial dominance; other European – short passes and dribbles; South America/Africa –good shot/cross ratio
Yamanaka *et al.* (1997)	8	1994 World Cup qualifying matches – Asia group	• Reliability: Not reported • Statistics: Chi-square	• Japan relied on dribbling and passing based tactics • Strategy of Japan different to that of Saudi Arabia
Yamanaka *et al.* (2002)	3	1998 World Cup (matches involving Japan)	• Reliability: Not reported • Statistics: Chi-square	• Japan had the tendency to pass more than their opponents but dribble less
Yiannakos and Armatas (2006)	32	2004 European Championship	• Reliability: Not reported • Statistics: Chi-square	• Incidence of goals ↑ throughout a match • Most goals come from organised offensive play • 34.1% of goals preceded by a long pass

win matches or are victorious in competitions or leagues display particular traits that can subsequently be identified and employed to provide a model for less successful teams to follow. While some rational conclusions have been made, for example that successful teams convert more of their shots to goals than unsuccessful teams (Japeth and Hughes, 2001; Taylor and Williams, 2002), it is unlikely that general laws for tactics and strategy can be established. Indeed, Pietersen (2001, p. 35) states:

> "....statistical material can be helpful and may have a direct implication for optimising match strategy. This is not a recipe for success, but an element in a coaches (inner) dialogue and reflections on contributing factors in getting good results as well as being part of the inspirational material that goes into the team's long term playing strategy."

It is therefore unsurprising that attempts to produce a framework of the 'winning formula' within notational analysis literature have resulted in contrasting results. For example, it has been suggested alternately that successful teams have a tendency to direct play through central areas of the pitch (e.g. Hughes *et al.*, 1988) and through wide areas (e.g. Ali, 1988; Jishan *et al.*, 1993; Fleig and Hughes, 2004). A possible explanation for such contradictions is that the data from numerous teams are amalgamated to produce the requisite successful and unsuccessful team data sets. This has the effect of masking the individual team characteristics and would thus appear to result in limited data sets. James *et al.* (2002) have therefore advocated a 'fine-grained' idiographic approach to notational analysis investigations rather than general nomothetic analyses. This appears to support soccer coaching philosophies that state the importance of coaches attending primarily to the strengths and weakness of their own team and those of the opposition as opposed to searching for some general 'wining formula' (Kormenlink and Severeens, 1999; Pietersen, 2001). It would seem that the use of longitudinal case study designs are most appropriate within notational analysis investigations as this approach retains the traits of each team, with comparisons of case studies offering specific insight into the qualities of teams according to area of interest (James *et al.*, 2002).

The effectiveness of case study methodologies was exemplified by Garganta *et al.*'s (1997) analysis of the attacks that resulted in goals for five European teams

(Barcelona, Porto, Bayern Munich, Milan and Paris Saint Germain) during 44 sampled matches. By examining each team in isolation a summary of their goal-scoring characteristics were obtained with subsequent assessments demonstrating similar features for each team, such as the tendency for goals to be scored following possessions of ≤3 passes. Similarly, Bloomfield *et al.* (2005a) investigated the strategies of three English Premier league soccer teams through measuring the percentage of possession within the defensive, midfield and attacking pitch thirds according to score-line. All the sampled teams retained more possession of the ball than their opponents regardless of score-line. However, differences were observed between the teams when the distribution of possessions within the defensive, midfield and attacking pitch thirds was examined. It was consequently concluded that the strategies of the three analysed teams were unique and evolved depending upon the particular score-line. The approach utilised within the studies of Garganta *et al.* (1997) and Bloomfield *et al.* (2005a) evidently provides more valid insight into soccer performance than if the data for all the teams of interest had been analysed as a whole. These studies appear to provide a logical methodological framework for future notational investigations in soccer to follow.

An additional area that existing soccer notational analysis literature has examined is the technical and tactical related components of set-pieces, alternatively termed restarts or set-plays (Table 2.2). These events incorporate corners, drop balls, goal kicks, free kicks (both direct and indirect), penalties and throw-ins that occur after stoppages in play due to rule breaches, injuries, substitutions or the ball passing over a pitch boundary line. Whilst drop balls and goal kicks have not been of concern to researchers the remaining set-pieces have particular strategic importance as they are reported to account for 25.0% - 48.5% of goals scored (Bate, 1988; Hughes, 1999; Egosy and Enslier, 2001; Sousa and Garganta, 2002; Ensum *et al.*, 2000; 2002; Yiannakos and Armatas, 2006). In particular the penalty has received substantial research attention, possibly as over 70% result in goals (McGarry and Franks, 2000; Franks and Hanvey, 2001; Hughes and Wells, 2002; Morya *et al.*, 2005). However, penalties occur infrequently (cf. Luhtanhen, 1993; Ensum *et al.*, 2000; 2002) and the more commonly occurring free kicks, corners and throw-ins are responsible for the majority of goals associated with set-pieces (Ensum *et al.*, 2000; 2002; Sousa and Garantua, 2002). As a result, these set-pieces have received varying amounts of research interest with a variety of technical and tactical recommendations provided (e.g. Pollard

Table 2.2 Summary of notational analysis research relating to the technical and tactical aspects of set-pieces in soccer.

Author(s)	No. of Matches	Sample	Reliability and Statistical Procedures	Main Findings
Ali (1988)	18	Case study of a Scottish Premier League Team	• Reliability: Not reported • Statistics: Chi-square	• Corners involving many short passes lead to more goals
Bate (1988)	Unclear	Various International and English League matches	• Reliability: Not reported • Statistics: Descriptive	• 87% of set-pieces gained in the attacking third are preceded by possessions of <3 passes • 50% of shots and goals result from set-pieces in the attacking 1/3
Egesoy and Eniseler (2001)	Not reported	Turkish professional leagues (1993-1995)	• Reliability: Not reported • Statistics: Descriptive	• Set-plays accounted for between 17.9%-28.0% of goals scored within the leagues analysed
Ensum *et al.* (2000)	26	2000 European Championships	• Reliability: Not reported • Statistics: Descriptive	• Guiding principles for set-pieces: o Delivery, Organisation, Variety, Efficiency and Surprise (DOVES) • Free Kicks: o Central areas → blocked, wide areas → goals o Should be played with inswing or outswing • Corners: o All corner kick types effective if played into the 'danger area' o Most goals from corners to 'near post' • Throw-Ins: o In attacking 1/3 short throw-ins followed by immediate cross leads to most goals o Long throw-ins also effective • Goals from set-pieces: 43% from free kicks, 27% corners, 22% throw-ins and 16% penalties • Mean frequency of set pieces per match: Free kicks = 30.0, corners = 10.2, throw-ins = 33.4 and penalties = 0.5

Table 2.2 (Continued)

Author(s)	No. of Matches	Sample	Reliability and Statistical Procedures	Main Findings
Ensum *et al.* (2002)	64	2002 World Cup	• Reliability: Not reported • Statistics: Descriptive	• 48.5% of goals originate from set-pieces • Goals from set-pieces: 35% from free kicks, 27% corners, 17% throw-ins and 20% throw-ins • Mean frequency of set pieces per match: Free kicks = 26.2, corners = 10.2, throw-ins = 34.2 and penalties = 0.3 • Findings concurred with Ensum *et al.* (2000)
Franks and Hanvey (2001)	Unclear	Penalties from World Cups (1982-1994)	• Reliability: Not reported • Statistics: Descriptive	• Demonstrates how notational analysis of penalties can aid training and improve performance
Hill and Hughes (2001)	31	2000 European Championships	• Reliability: Yes • Statistics: Chi-square	• Corners played with swing, above head height and with few subsequent actions most effective in creating goal attempts
Hughes and Wells (2002)	Unclear but 129 penalties	World Cup and Champions League penalty shoot-outs	• Reliability: Yes • Statistics: Descriptive	• 73% of penalties scored, 20% saved and 7% missed • No penalty shots above waist height saved • Left and right footed players have same success rates
Jinshan *et al.* (1993)	52	1990 World Cup	• Reliability: Not reported • Statistics: Unclear	• 32.2% of goals from set-pieces in 1990 World Cup • 27.3% of goals from set-pieces in 1986 World Cup
Low *et al.* (2002)	40	2002 World Cup	• Reliability: Not reported • Statistics: Descriptive	• Shots to goal ratios from set-pieces: 10:1 for successful teams and 14:1 for unsuccessful teams
Luhtanen (1993)	Unclear	1990 World Cup	• Reliability: Not reported • Statistics: Pearson's correlation, ANOVA	• Mean frequency of set pieces (± standard deviation) per match: Free kicks = 6.1±3.1, corners = 4.5±3.0, throw-ins = 6.0 ±4.7 and penalties = 0.2±0.4
Morya *et al.* (2005)	Unclear but 75 penalties	2002 World Cup and European and South American club matches.	• Reliability: Not reported • Statistics: t-test, chi-square	• 70% success rate in scoring penalties. • ↑ chance of save by diving at or after ball contact • Advocate accuracy over power for the penalty taker.
Pollard and Reep (1997)	22	1986 World Cup	• Reliability: Not reported • Statistics: Descriptive	• Long throw-ins within attacking 1/3 more effective in producing goals than short throw-ins

Table 2.2 (Continued)

Author(s)	No. of Matches	Sample	Reliability and Statistical Procedures	Main Findings
Sousa and Garganta (2001)	Unclear	1994 World Cup	• Reliability: Not reported • Statistics: Chi-square	• Direct free kicks accounted for most goals from set-piece (42%) followed by penalties (25%), corners (13%), throw-ins (12%) and indirect free kicks (4%)
Taylor *et al.* (2005)	20	English Premier League (2001-2002)	• Reliability: Not reported • Statistics: Chi-square	• Corners should be played with swing to edge of the six yard box or pulled back to the front of 18 yard box • Attacker making 1st ball contact maximises scoring chance
Yiannakos and Armatas (2006)	32	2004 European Championship	• Reliability: Not reported • Statistics: Chi-square	• Set-pieces account for 35.6% of goals • 40% corners, 30% free kicks, 25% penalties and 5% throw-ins reported, however it is unclear what this represents

and Reep, 1997; Hill and Hughes, 2001; Ensum *et al.*, 2000, 2002; Taylor *et al.*, 2005). A common implication of these investigations is that the success of set-pieces relies to a large extent on the technical ability of the players involved in their execution. Indeed, one of the main differences highlighted between teams deemed 'successful' or 'unsuccessful' is the respective set-piece to goal ratios of approximately 10:1 and 14:1 respectively (Low *et al.*, 2002).

2.4 Playing Positions and Individual Players in Soccer

Within applied settings the evaluation of soccer performance not only occurs with regard to the team as a whole but also in relation to specific playing positions and individual players (Kormenlink and Seeverens, 1999; Carling *et al.*, 2005; Beetz and Lames, 2006; Leser, 2006). In contrast, despite guidance for such analyses being available (e.g. Hughes and Franks, 2004; Carling *et al.*, 2005), a distinct lack of notational analysis studies have focused upon these team structures (Table 2.3). The following two sections will consider the existing notational analysis literature that has investigated playing positions and individual players with a particular focus on the technical and tactical aspects of performance.

2.4.1 Technical and Tactical Components of Soccer Performance at Playing Position Level

The rules of soccer do not stipulate how players should be arranged upon the pitch surface except for one individual being designated as a goalkeeper. However, the remaining ten 'outfield' players are not positioned randomly but normally conform to predefined formations (see Bray, 2006, for an interesting discussion on the evolution of playing formations). Within contemporary soccer these playing formations generally classify outfield players into the positions of 'defenders', often subdivided into 'centre backs' and 'full backs', 'midfielders' and 'forwards' and will be adhered to within this thesis (Reilly and Thomas, 1976; Bray, 2006).

Nicholls *et al.* (1993) and Norris and Jones (1998) utilised a combination of coach questionnaires and notational analysis to investigate the importance of distinct soccer playing positions. Overall, analysis of the technical aspects of performance, achieved via examination of the occurrences and outcome of behaviours executed, failed to support the notion that particular playing positions were key to the soccer team. This contrasted with the opinion of many of the surveyed coaches but it was evident that

Table 2.3 Summary of notational analysis literature relating to the technical and tactical components of playing position and individual player performance in soccer.

Author(s)	No. of Matches	Sample	Reliability and Statistical Procedures	Main Findings
Beetz and Lames (2006)	1	Qualification match for 2007World Championship for women	• Reliability: Not reported • Statistics: Not reported	• Area covered by player indicative of tactical role • Areas of coverage can be amalgamated to reveal the tactical line-up (formation) of a team
Dunn *et al.* (2003)	6	English Premier League	• Reliability: Not reported • Statistics: Descriptive	• Distinct technical profiles to each playing position • Passing most common behaviour in all positions • Every position performed all measured behaviours
Gould and Gatrell (1980)	1	1977 FA Cup Final – Liverpool vs. Manchester United	• Reliability: Not reported • Statistics: Descriptive, matrices and *q*-analysis	• A team is more than the sum of its parts • Liverpool were particularly dependent on Kevin Keegan • Manchester United had good team structure
Grehaigne *et al.* (1997b)	Unclear	Auxerre home matches in which they won (1993-1994)	• Reliability: Not reported • Statistics: Descriptive	• Individual players have distinct 'action area' • An average position or 'bary centre' can be calculated • Collective 'bary centres' indicate team organisation
Hughes and Probert (2006)	31	2004 European Championship	• Reliability: Yes • Statistics: Chi-square	• Unique technical demands to each playing position • No differences in the quality of skill performance for each playing position • No difference in incidence or quality of behaviours performed by successful or unsuccessful teams
James *et al.* (2002)	21	British Premier League club in domestic and European matches (2001-2002)	• Reliability: Yes • Statistics: Chi-square	• Right fullback and central midfielder reflected the teams strategic and tactical changes between the two competitions
Kuhn (2005)	4	International matches 1953, 1974, 1998, 2002	• Reliability: Not reported • Statistics: Descriptive	• Players operate within pitch areas relating to their specific position of defender, midfielder or forward
Muniroglu (2001)	6	Case study of Ankara Demspor in Turkish 3rd Division (year not reported)	• Reliability: Not reported • Statistics: Friedman ANOVA	• Compared playing positions according to many variables • Few differences between playing positions

Table 2.3 (Continued)

Author(s)	No. of Matches	Sample	Reliability and Statistical Procedures	Main Findings
Nicholls *et al.* (1993)	6	English1st division	• Reliability: Not reported • Statistics: Mann-Whitney, chi-square	• Not all managers consider central playing positions as most important • Match analysis highlighted that certain individuals within teams were particularly dominant and they were distributed independent of specific playing position
Norris and Jones (1998)	10	English Premiership (1994-1995)	• Reliability: Not reported • Statistics: Chi-Square	• Coaches generally ordered playing position importance as centre back, goalkeeper, forward, centre midfield, fullback and wide midfield • Analysis suggested all positions of equal importance
Pearce and Hughes (2001)	32	2000 European Championship	• Reliability: Yes • Statistics: Descriptive	• Substitutions generally have a positive effect on team performance • Individual substitutes performances are varied (good, bad, indifferent)
Olsen and Larsen (1997)	44	Norwegian international team (1991-1994)	• Reliability: Not reported • Statistics: Descriptive	• Midfield playing position perform most behaviours followed by defence, attacker and goalkeeper playing positions respectively
Verlinden *et al.* (2001b)	28	1998 World Cup matches	• Reliability: Not reported • Statistics: Pearson's correlation, t-test	• Considers the degree of association (contingency) between operational lines (playing positions) in latitudinal and longitudinal directions • Results unclear – difficult to comprehend
Weimeyer (2003)	Not Relevant	Fifteen coaches (10 qualified, 5 unqualified) from teams in the German 6th Division	• Reliability: Not applicable • Statistics: Not applicable	• Example of how 'fuzzy logic' can be used to assign soccer players a position based on their attributes • Coaches disagree on the traits that are important to each playing position
Williams *et al.* (2003b)	3	English Premier League	• Reliability: Not reported • Statistics: Descriptive	• Investigated amalgamated physical and technical performance components • Unique profiles for each playing position

their ranked lists of playing position importance also lacked agreement. The absence of coach concordance was also an issue reported by Wiemeyer (2003) during a study which intended to construct a fuzzy logic model that could assign soccer players to their most suited playing position. Specifically, coaches (n = 14) were asked to indicate the attributes (mental, physical, technical and tactical) that they felt were most pertinent to players occupying a variety of playing positions, but also more specific roles. Although a general consensus of the requirements for each position was not achieved some traits were commonly reported. For example, the majority of coaches (>10) agreed that players in the defensive positions needed to have good one-to-one play such as tackling and forwards need the ability to score goals and to head the ball. Despite the originality of Wiemeyer's (2003) idea it is unclear how this system would be utilised, particularly within applied settings. It is likely that professional soccer players already occupy their best suited positions and as the mental, physical, technical and tactical characteristic of younger players potentially change over time the use of the fuzzy logic model during talent identification and development processes is also questionable (Williams and Reilly, 2000; Luhtanen *et al.*, 2001b; Reilly *et al.*, 2003).

The research of Wiemeyer (2003) provides some insight into the technical and tactical characteristics expected by coaches for each playing position. However, this provides limited knowledge of the technical and tactical components of performance that are actually exhibited by each playing position. Initial research by Dunn *et al.* (2003) and to a lesser extent Williams *et al.* (2003b) established that the technical demands of soccer differ between each playing position. While all positions generally perform similar behaviours the incidences were discrepant. For example, fullbacks were identified as performing predominantly 'defensive technical actions' such as tackles, together with more crosses, free kicks and throw-ins than any other playing position. Likewise, the technical performance of centre backs was focused upon defensive behaviours such as clearances and headers with few dribbles performed and no shots attempted. In contrast, the midfield playing position was observed to execute most behaviours overall, took corner kicks, carried out more dribbles than any other position but were not involved with the taking of throw-ins. Finally, the forwards performed few defensive behaviours and throw-ins but in relation to other playing positions executed a high incidence of shots and headers. Overall, passing was found to be the most common technical aspect of performance and accounted for over 50% of the behaviours performed within all playing positions.

The findings of Dunn *et al.* (2003) and Williams *et al.* (2003b), while relatively detailed, appeared in a coaching journal and suffered from a number of limitations. Of particular concern was that the outcomes of the behaviours performed were not considered and the data were not subjected to statistical analysis. Recent research by Hughes and Probert (2006) addressed this latter concern and supported the conclusions of the previous investigations. While it was stated that the outcomes of behaviours were recorded corresponding data were not presented. Instead, a performance rating based on technique was provided yet this appeared limited. Specifically, the assignment of scores seemed subjective and was based on an amalgamation of pressure and technique ratings that did not allow for every possible eventuality. For example, it was unclear how a player was graded if they performed a skill poorly under high pressure or alternatively what was recorded if a player performed a skill with excellent technique under low pressure (Table 2.4).

Table 2.4 Technique ratings employed by Hughes and Probert (2006) to assess the quality of behaviours performed by soccer teams.

Technique Outcome Rating	Assessment Criteria
+3	Excellent technique performed under pressure
+2	Very good technique performed under slight pressure
+1	Good technique performed under no pressure
0	Average, standard technique
-1	Poor technique performed under pressure
-2	Very poor technique performed under slight pressure
-3	Unacceptable technique performed under no pressure

An investigation by Muniroglu (2001) did attempt to examine the outcomes of behaviours executed by the 'defence', 'midfield' and 'attack' positional 'blocks' but the results were not entirely clear and the variables measured were inconsistent across positions. For example, whilst the defence were assessed with regard to their ability to perform tackles successfully this was not examined for the attack positional block. Furthermore, the six matches were analysed by five different observers yet no reliability testing was reported. The ability of the individuals to accurately and consistently record the relevant information was therefore undetermined. Overall, aerial challenges,

dribbles, passes and shots were reported as being predominantly successful in all positions. No significant differences were found between the success rates of any of the behaviours performed between each positional block.

The technical aspect of playing positions performance has evidently received preliminary research interest but it is somewhat surprising that the tactical elements have apparently been overlooked. Kuhn (2005) presented some data associated with this aspect of playing position performance but was primarily interested in how team formations had changed over time (cf. Bray, 2006). Through analysing the number of ball possessions within four pitch areas by players classified as 'defensive', 'midfield' or 'attacker' it was found that formations had become more defensive over time. However, regardless of the era in which the match was played (1950s, 1970s, 1990s or 2000s) and the specific formation employed it was observed that the players within each positional category mainly operated within distinct areas of the pitch. The pitch was divided into four zones running from a team's own goal (Z1) through to the opposition's goal (Z4). Defensive players predominantly operated in Z2 followed by either Z3 or Z1 and finally Z4. Midfield Players mainly functioned in Z3 followed by Z2, with less ball possessions in Z1 and Z4. Finally the forward players were recorded as mostly functioning within Z3 then Z2 and Z4 with very few possessions (<6 in all cases) within Z1. However, the investigation was based upon just four matches between six teams who utilised varying formations and therefore presented limited data.

2.4.2 Technical and Tactical Components of Soccer Performance at Individual Player Level

Within rugby union, it has been demonstrated that technical related aspects of performance differ between individual players within identical playing positions, potentially because of differing decision-making profiles or allocated roles (James *et al.*, 2003). Similar research has not been conducted in soccer but it is evident that specific player roles are implied through the common use of terminology such as 'sweeper', 'winger', 'attacking midfield' and 'defensive midfield' (cf. Grehaigne *et al.*, 1997b; Wieymeyer, 2003; Bray, 2006; Thelwell *et al.*, 2006). In relation to this point it should be noted that the term 'role' relates to prescribed responsibilities (Eys *et al.*, 2006) and therefore it is often misapplied within notational analysis research which generally focuses upon observed behaviours. To date there have been no attempts to determine the extent to which roles implied by notational analysis research actually correspond to the

roles assigned by team coaches. This is a particular challenge for future research and may provide a novel solution to the lack of objective measures for assessing role performance that has been highlighted in sports psychology literature (e.g. Eys *et al.*, 2006).

In contrast to the research at playing position level the technical element of soccer performance has been less well researched in relation to individual players than tactical aspects. Furthermore, while research has presented detailed summaries of the technical demands at positional level (e.g. Dunn *et al.*, 2003; Williams *et al.*, 2003b; Hughes and Probert, 2006) the literature relating to individuals has been less comprehensive. For example, Chervenjakov *et al.* (1988) described a number of models that were employed by the Bulgarian Football Association to evaluate both technical and tactical aspects of individual player performance. The data collected via these models were reported to have led to the construction of normative tables against which individuals performance could be compared. However, the authors simply provided a description of their methods and therefore potentially interesting and informative data were not conveyed, possibly due to confidentiality agreements with the Bulgarian Football Association.

James *et al.* (2002) also presented a combination of technical and tactical data at individual player level when investigating variations in team strategy. Through a case study of a British soccer team it was established that the 'contributions' of individual players differed between European and domestic competitions and reflected changes in team strategy. For example, the tendency for more play to occur in offensive areas and through the right hand side of the pitch during domestic matches mirrored the dominant areas of operation for two midfield players and the right fullback respectively. However, it was unclear what constituted a player contribution and the technical analysis was limited to assessing the difficulty of the passes attempted by individuals within the midfield playing position. In addition, the tactical aspect of performance was assessed by identifying where behaviours were being performed upon pitch but the division of its surface into twelve areas appeared to restrict detail when considering individual players.

A particularly detailed analysis of the tactical element of soccer performance at individual player level was provided by Grehaigne *et al.* (1997b). By dividing the pitch into forty segments a meticulous representation of individual player 'action zones' was achieved. This approach appears particularly relevant to applied settings as soccer coaching literature commonly alludes to distinct zones of player operation (e.g.

Kormenlink and Seeverens, 1999; Carling *et al.*, 2005). Grehainge *et al.*'s (1997b) methodology recorded the positions of every player on the pitch at 30 second intervals and calculated the area that accounted for 80% of each player's frequency of appearance. Overall, the player action zones incorporated between 7 and 12 pitch areas which subsequently corresponds to an approximate pitch coverage of 17.5-30.0% (cf. Castagna *et al.*, 2003). Of the specific individuals analysed it was observed that the midfield players generally had the largest pitch coverage and the 'central striker' the lowest. However, due to recording positions at specific time intervals, the defined zones of operation did not reflect any particular phase of soccer match play upon which soccer coaches base analyses, such as on-the-ball behaviour, off-the-ball behaviour, attacking play or defensive play (Hughes and Franks, 2004; Carling *et al.*, 2005). Nonetheless, the production of such action zones has been suggested to be an effective means of assessing team work, strategy, tactics and individual roles (Grehaigne *et al.*, 1997b; Castagna *et al.*, 2003; Fujimura and Sugihara, 2005; Beetz and Lames, 2006).

2.5 Performance Indicators

As highlighted by the reviewed literature, notational analysis research has mainly focused upon a limited number of themes such as team strategy, goal scoring and set-pieces, yet within each of these areas numerous performance indictors have been utilised. Performance indicators are variables that are selected and examined, either in isolation or in jointly depending upon the aim of the analysis, to define some aspect of performance (Hughes and Bartlett, 2002a, 2004). Four groups of performance indicators have been acknowledged, with match classification, technical and tactical indicators particularly relevant to notational analysis research. Rather obviously biomechanical indicators fall within the domain of the biomechanist, interested readers are directed to Lees and Nolan (1998), Hughes, and Bartlett (2002a, 2004) and Lees (2002, 2003) for further review.

Match classification performance indicators primarily contain basic descriptive information and within soccer may include, for example, the number of goals scored and the incidence of tackles (Hughes and Bartlett, 2002a, 2004). This type of data is not only evident within notational analysis literature but also presented, to varying extents, within the media implying a general interest in such statistics amongst soccer fans. Technical and tactical performance indicators extend match classification data to provide more specific details of performance and correspond to the earlier definitions of

these performance components. To clarify, technical indicators relate to the occurrence of behaviours and their associated outcomes, such as the number of shots on-target and off-target (Hughes and Bartlett, 2002a; 2004). In contrast, tactical indicators are suggested to provide an indication of teamwork, movement, and the strengths and weaknesses of performers through examining the application of behaviours performed during a match (Hughes and Bartlett, 2002a; 2004). Examples of tactical performance indicators include the number of passes per ball possession, lengths of passes, duration of attacks, player positions and the distribution of behaviours across the pitch surface (e.g. Bate, 1988; Harris and Reilly, 1988; Garganta *et al.*, 1997; Grehaigne *et al.*, 1997b; Grehaigne *et al.*, 2002; James *et al.*, 2002; Brown and Hughes, 2004; Fleig and Hughes, 2004; Hughes and Snook, 2006; Seabra and Dantas, 2007).

Performance indicators provide a basis for the comprehensive evaluation of soccer performance but a number of issues need to be addressed. Firstly, Hughes and Bartlett (2002a, 2004) recommend that for performance indicators to be useful they should relate to successful performance or outcomes. This viewpoint is challenged here as it is felt that the identification and consideration of performance indicators that are associated with unsuccessful performances and outcomes are also essential if soccer performance is to be fully understood. Similarly, as previously highlighted, the search for a specific 'winning formula' and thus particular indicators of successful performance is debatable due to the potentially unique nature of each team or players performance (Pietersen, 2001). Moreover, the presentation of data relating to performance indicators can be problematic and potentially represents a threat to their validity as measures of performance. Hughes and Bartlett's seminal works (2002a, 2004) highlight that the presentation of raw data is often misleading and consequently normalised data such as ratios should be utilised where appropriate. This can be exemplified by a coach comparing the shooting performance of a player over two matches. As the player produces nine on-target shots in the first match compared to four in the second the coach concludes that the latter performance was least effective. However, the player performed twenty shots in the first match but only six in the second, therefore relative to the totals, the latter performance was actually more effectual (on-target shot to off-target ratios of 1:2.2 and 1:1.5 respectively).

Despite the apparent advantages of presenting normalised data caution is advised with interpretation. For example, Carling *et al.* (2005) highlight that a player with an 80% success rate for passing may be adjudged as having a superior performance to

another player who only accomplished 50%. Yet, further examination may show that the former player was primarily making 'safe' backwards and sideways passes whereas the latter players was taking risks with more difficult forward passes in an attempt to create goal scoring chances. Under such circumstance the coach may actually be more concerned by the first player's performance. Second, in some cases the raw data may actually be more appropriate than normalised data depending on the objective of analysis. If a researcher was investigating performance indicators relating to match outcome it is plausible that simple counts of goals scored and conceded would be of more importance than other measures such as the ratio of goals to shots. Lastly, many factors can affect soccer performance and thus should be accounted for to facilitate objective assessments (Kormelink and Seeverens, 1999; Carling *et al.*, 2005). For example, a player may achieve an 85% success rate in passing during a match against a weak opposition team but only achieve 70% in a subsequent match against the team who are currently top of the league (see section 2.7 for a discussion of factors influencing soccer performance). While such discrepancies are likely to be of concern to soccer coaches and analysts it appears naïve to not make allowances for the effects of the factors influencing performance.

2.6 Performance Profiles

The collection of data pertaining to performance indicators is suggested to provide a profile of a related aspect of performance (Hughes *et al.*, 2001a, 2004b). However a particular problem with the collection of such data is the question of how many matches need to be analysed to be representative of typical or average performance (Hughes *et al.*, 2001a, 2004b; Wells *et al.*, 2004). Within the extant soccer notational analysis literature extremes in sample size can be observed with Tenga and Larsen (2003) analysing just one match in comparison to 3,216 by Reep and Benjamin (1968). The findings of the former study are unlikely to be representative of performance due to the existence of match-to-match variation (O'Donoghue, 2004; James, 2006a), while the data set of the latter though admirable, is likely unnecessarily large and impractical. Where researchers may have time to assemble and analyse substantial samples of data, such luxuries are often unattainable in applied settings, hence coaches and analysts would benefit from guidance on the fewest number of matches required to enable valid conclusions to be drawn (Hughes *et al.*, 2001a, 2004b).

Initial research by Hughes *et al.* (2001a, 2004b) considered a range of sports and suggested that the establishment of a representative performance profile depends on both the nature of the data collected as well as the performers themselves. For example, it was suggested that in rugby union at least seven matches need be analysed for all presented variables to 'stabilise' within a satisfactory percentage error of the typical mean. The methods of Hughes *et al.* (2001a, 2004b) were employed by Brown and Hughes (2004) during a study of the attacking playing patterns of European, South American, African and Asian soccer teams in the 2002 World Cup. Behaviours of low incidence such as shots, crosses and headers were found to stabilise in as few as three matches, yet behaviours of higher occurrence, including dribbles, took approximately 10 matches. Variables with large match-to-match variance, such as passing, failed to stabilise at all and represented just one of a number of conceptual and methodological that has led to the development of alternative performance profiling procedures (e.g. Bracewell, 2003; James *et al.*, 2003; O'Donoghue, 2005; O'Donoghue and Ponting, 2005).

O'Donoghue and Ponting (2005) extended Hughes *et al.*'s (2001a, 2004b) original work by producing equations that accounted for the fact that the number of matches needed for a stable profile may be in excess of the actual sample size. Although this simplified the previous method considerably, the equations could only be utilised where performance indicators were normally distributed and therefore has limited applicability within notational analysis where data is generally non-normal (see section 2.8). O'Donoghue (2005) presented an insightful critique of Hughes *et al.*'s (2001a, 2004b) methods highlighting a number of strengths and weakness. A particular concern was that the reliance upon the mean enabled a level of typical performance to be described but there was no indication of how discrepant performance was about this measure. Consequently, a procedure was proposed that still employed the mean but also incorporated measures of the spread of the data, such as standard deviation and the inter-quartile range, to account for the variation inherent in sports performance (McGarry and Franks, 1996; O'Donoghue, 2004; Wells *et al.*, 2004). A further novel aspect of this method was that normative values for performance indicators were calculated based upon all data available from a particular population. This was exemplified using internet-archived records for women playing in the four tennis Grand Slam tournaments, with performance of a single player being compared against them.

Additional methods of performance profiling have also been developed in

studies of rugby union. For example, James *et al.* (2003) advocated the use of medians rather than the mean as a measure of central tendency due to the absence of normality within most notational analysis data (Nevill *et al.*, 2002; O'Donoghue and Ponting, 2005; James *et al.*, 2007). Furthermore, the presentation of confidence limits for the population median not only accounted for potential variations in performance but allowed an assessment of how representative the data were of typical performance with data from as little as two matches. Bracewell (2003) also outlined a technique for performance profiling in rugby but employed a single performance score rather than relying upon an assessment of each performance indicator in isolation. This approach borrowed heavily from methodologies developed for industrial quality control (see Montgomery, 1997) and monitored the fluctuations of the performance score over time, which was suggested to be indicative of player or team form. However, discrepancies between compound scores and ratings of performances provide by coaches suggest that this approach may be limited (Jones, 2006). Moreover, it is unclear how easily such compound scores can be deconstructed into their constituent parts. This may limit the methods in applied and research setting where the ability to easily examine the individual performance indicators could be important.

While the work of Hughes *et al.* (2001a, 2004b) has stimulated interest in robust methodologies for performance profiling the use of such procedures are rare within soccer. Consequently, it is uncertain if the data presented in past studies of soccer are representative of actual performance and therefore if the resulting conclusion are valid. Moreover, as the majority of current soccer-based notational analysis literature has been based on the description and explanation stages of scientific enquiry, the next logical step is to provide models that facilitate prediction of future performance (Potter and Hughes, 2001; McGarry and Perl, 2004). Although numerous potential methods for predicting performance have been suggested and utilised (see Potter and Hughes 2001; McGarry and Franks, 2003; McGarry and Perl; 2004) the use of representative data via performance profiles appears to be a particularly rational way of achieving this aim. From the performance profiling method used by James *et al.* (2003), for example, it was predicted with 95% certainty that the lock position in rugby union would perform between four and six successful tackles per match. However James *et al.* (2003) also cautioned that the production of a universal performance profile may be inadequate as factors such as match location, environmental conditions, opposition quality, time of day, injuries and match officials may have a 'confounding effect' on sport performance.

Indeed, the literature relating to soccer coaching has highlighted the importance of accounting for such factors when evaluating or predicting performance (e.g. Kormelink and Seeverens,1999; Carling *et al.*, 2005). James *et al.* (2003) subsequently suggested that numerous performance profiles maybe required to address this concern but it is evident that the identification of those variables that exert a significant influence on performance represents the preliminary step to achieve this aim.

2.7 Factors Influencing Soccer Performance

Performance profiling is undoubtedly useful for performance evaluation and prediction but there still exists a need to consider the specific variables that may account for performance variations (Kormenlink and Seeverens, 1999; James *et al.*, 2003; Carling *et al.*, 2005). Some performance discrepancies are likely due to inherent random variation but it is also probable that many other factors have an effect (Goldstein, 1979; Norman, 1998; James *et al.*, 2002; O'Donoghue, 2004; Wells *et al.*, 2004; Caring *et al.*, 2005; Choi *et al.*, 2006). Indeed, within the domain of the psychology, it is generally accepted that behaviour is codetermined by the person and the situation, known as the interactionist approach (Cox, 1998; Gill, 2000; Weinberg and Gould, 2003). To this effect, the soccer coaching literature has proffered a number of person and situation variables, such as match location, weather, motivation and anxiety, which may influence performance (e.g. Kormelink and Severens, 1999; Maynard, 2002; Carling *et al.*, 2005). In many cases empirical evidence is available to support these claims with the mental, physical, technical and tactical facets of performance receiving varying amounts of attention (e.g. Ridder *et al.*, 1994; Sasaki *et al.*, 1999; Eubank and Gilbourne, 2003; Jones *et al.*, 2004; Bloomfield *et al.*, 2005a,b; Reilly *et al.*, 2005b,c; Shaw and O'Donoghue, 2005; Tucker *et al.*, 2005; Bar-Eli *et al.*, 2006).

While both person and situation variables have been addressed within the research literature it is obviously difficult to assess every factor that affects performance. However, situation variables appear to be a particularly pertinent as Goldstein (1979) highlights that they alone can efficiently predict performance outcomes in team sports. The situation factors of match location and opposition quality have been acknowledged as the most important influences upon performance in many sports including soccer and have received much research attention (e.g. Schwartz and Barsky, 1977; Edwards, 1979; Barnett and Hilditch, 1993; Clarke and Norman, 1995; Nevill and Holder, 1999; Carron *et al.*, 2005). These investigations have principally

embraced the phenomenon that playing at home confers an advantage and that strong teams display higher home advantage against weaker teams than against comparable teams, with weaker teams having higher home advantage against comparable teams than against stronger teams (Schwartz and Barsky, 1977; Barnett and Hilditch, 1993; Norman, 1998; Madrigal and James, 1999; Nevill and Holder, 1999; Forrest *et al.*, 2005; Pollard and Pollard, 2005). Such studies have however, been considered in soccer with concern to global measures like goals scored, goals conceded and win/loss records (e.g. Clarke and Norman, 1995; Norman, 1998; Nevill and Holder, 1999). Consequently, there is little indication of whether these variables have an impact on performance at a more fundamental level, such as in relation to specific technical and tactical performance indicators.

Initial insight into the influence of match location at behavioural level was provided by Sasaki *et al.* (1999) with goal attempts, shots on-target, shots blocked, shots wide, successful crosses and goal kicks increasing when playing at home. Through questionnaire surveys, the players of the sampled team were also found to respond more favourably to crowd expectations, crowd judgement, hostile crowd reactions, facility familiarity, frustration and game domination when playing at home than during away matches. These findings were extended by Tucker *et al.* (2005) who conducted a case study of an English Premier League team. A greater incidence of corners, crosses, dribbles, passes and shots occurred during home matches while more clearances, goal kicks, interceptions and losses of control were evident when away. Examination of the behaviour outcomes highlighted more successful aerial challenges, crosses, passes and tackles made within home matches. Furthermore, Tucker *et al.* (2005) assessed tactical related performance with more aerial challenges, clearances and interceptions occurring within the defensive pitch third in away matches and more aerial challenges, crosses, dribbles, passes and attempts on goal being executed in the attacking pitch third during home matches. Collectively, the findings of Sasaki *et al.* (1999) and Tucker *et al.* (2005) therefore imply that a match location effect is present at a behavioural level.

The quality of opposition has been suggested as an important influence on performance, at least with regard to outcome measures, yet neither Sasaki *et al.* (1999) nor Tucker *et al.* (2005) opted to incorporate this variable into their studies. Indeed, a review of soccer-based notational analysis literature demonstrates a general neglect of this particular situation factor with teams instead assessed according to a successful versus unsuccessful classification, although there is some evidence of authors focusing

on measures such as team rankings or seedings (e.g. Luhtanen, 1993; Fleig and Hughes, 2004; Hughes and Snook, 2006). The principle issue with the concept of successful and unsuccessful teams is that a team may be classed as successful while not necessarily being of particularly high quality and vice versa (e.g. Scoulding *et al.*, 2004; Bente and Bolch, 2006). This is generally the result of studies using such classifications being carried out within finite events such as World Cups and European Championships where weaker teams may progress to the latter rounds at the expense of stronger teams due to the structure of the competition and the paucity of matches (see McGarry, 1998; Vukičević *et al.*, 2006 for discussions and analyses of sport competition structures). In contrast, where teams are deemed as successful or unsuccessful based on longer-term and balanced playing schedules, such as an entire league season, this categorisation would appear to be more indicative of team, and thus opposition quality (e.g. Jones *et al.*, 2004).

A further situation factor that has recently received interest in soccer-based research literature has been match status as determined via score-line. For example, O'Donoghue and Tenga (2001) examined the work rates of a selection of Premier League players finding that less high intensity work was performed when winning and losing compared to drawing. However, these results were limited as they were only based on the 10 minute period following a goal being scored. Indeed, further research by Bloomfield *et al.* (2005b) suggested that such changes were transitory and not sustained for the whole extent of a particular match status. While the previous two studies examined physical aspects of performance with reference to match status at professional level similar conclusions have also been drawn from amateur soccer (Shaw and O'Donoghue, 2004).

More relevantly to this thesis, the technical and tactical facets of performance have also been investigated in relation to match status. Specifically, Jones *et al.* (2004) reported that under losing match status team ball possessions were of longer duration than when winning with no difference when drawing. However, teams deemed as successful (finished in the top three of the 2001-2002 English Premier League) had longer ball possessions regardless of match status than unsuccessful teams (finished in the bottom three of the 2001-2002 English Premier League). With regard to the tactical element of soccer performance Bloomfield *et al.* (2005a) found that regardless of match status the majority of ball possessions occurred within the midfield pitch third. However, variations in the percentage of ball possession within the defensive and

attacking pitch thirds as a function of match status were suggested to infer evolving match strategies in response to the score-line. Indeed, the notion that strategic differences are evident at a behavioural level in soccer was also highlighted by Tucker *et al.* (2005) during their study of match location effects and implies 'strategic decision-making'. This term was utilised by Dennis and Carron (1999) to describe the varying strategies adopted by coaches as a function of match location and opposition quality in ice hockey. Specifically, a more assertive fore-checking style (constant pressure placed on the puck carrier by at least two of the three forwards in the offensive zone) was prescribed during home matches compared to away and was most commonly employed against weak opposition. Moreover, these instructions were reflected in the actual behaviours performed by the players as assessed through notational analysis methodologies. However, as is evident from the findings of Bloomfield *et al.* (2005a) in relation to match status, and also anecdotal evidence within research and coaching literature, it is plausible that many other factors other than match location and opposition quality impinge on strategic decision-making (Pollard, 1986; Kormelink and Seeverens, 1999; Carling *et al.*, 2005).

The deliberation of further situation factors in relation to technical and tactical aspects of performance in soccer is somewhat sparse and in some cases limited due to conceptual or methodological issues. For example, some work has considered the influence of time of day on technical elements of performance but they represented laboratory-based experiments where the times at which measurements were taken did not always reflect those at which soccer matches occur (e.g. Reilly *et al.*, 2005b,c). Furthermore, while the weather has been suggested within notational analysis research to have an impact on soccer performance (e.g. Ali, 1988) the use of objective meteorological measures, such as those obtained by Lee and Garraway (2000) during their study of injuries in rugby union, have not be incorporated into notational analysis studies. A final issue is that situation variables are generally analysed in isolation and therefore potential interactions between factors are unaccounted for (e.g. does the frequency and success of shots performed change when playing at home against weak opposition compared to playing away against strong opposition?). Consequently, the dynamic nature of soccer, as demonstrated through the previously identified interaction of match location and opposition quality, has not been effectively addressed (Barnett and Hilditch, 1993; Nevill and Holder, 1999). Whilst it is acknowledged that the examination of every possible influence on performance is implausible, both due to

conceptual and methodological constraints, steps should be taken to move away from the current trend to focus completely upon single variables. This will allow researchers to refine predictive models of performance while having numerous benefits in applied settings for both performance preparation and evaluation (Komenlink and Seeverens, 1999; Nevill *et al.*, 2002; McGarry and Franks, 2003; McGarry and Perl, 2004; Carling *et al.*, 2005).

2.8 Statistical Techniques Within Notational Analysis

A recurring issue within notational analysis is the failure of researchers to employ appropriate methods for assessing the accuracy of the data collected (Hughes *et al.*, 2002, 2004a). In addition, subsequent analyses of data have also been limited due to the application of unsuitable statistical techniques (Hughes *et al.*, 2002, 2004a). The pervasive problem within both of these areas is that parametric statistical procedures are often employed despite the fact that performance indicators are predominantly nominal and conform to discrete data distributions (Hughes *et al.*, 2002, 2004a; Nevill *et al.*, 2002; O'Donoghue and Ponting, 2005; James *et al.*, 2007). The following sections of this review will therefore consider previous approaches to reliability testing and statistical analysis and identify the methods that are currently recommended.

2.8.1 Reliability Testing

For research findings to be considered valid they must be based upon reliable information yet Hughes *et al.* (2002, 2004a) reported that 70% of notational analysis studies fail to present the accuracy of their data. Within notational analysis reliability indicates the extent to which the events recorded by the analyst(s) reflect what actually happened within a match (James *et al.*, 2007). To date, three main sources of inaccuracy, namely definitional, observational and operation errors, have been identified (James *et al.*, 2002). Definitional errors occur when the descriptions given to specific events to aid in their identification, known as operational definitions, are not fully understood or lack clarity. By contrast, observational errors originate from analysts missing and failing to record events due to inadequate observations. Lastly, operational errors occur when the analyst recognises an event correctly but proceeds, due to lack of care and/or attention, to record an alternative event. To ensure that these three sources of error are effectively addressed a number of procedures have been advised. Firstly, sufficient training should be given to any analyst so that they are fully aware of what is

being collected and how this is to be achieved, although it has been suggested that the familiarity of the analyst with sport of interest is a more important factor (Wilson and Barnes, 1998). Next, both intra-observer reliability (an observer collects data from the same performance on separate occasions and compares results) and inter-observer reliability (independent observers analyse the same performance and their results are compared) should be employed (Hughes *et al.*, 2002, 2004a; James *et al.*, 2002, 2007). Both approaches offer a good indication of analyst accuracy but inter-observer testing appears to have a particular benefit for revealing misinterpretations of the operational definition as intra-observer testing will not be influenced by an analyst who consistently misapplies an operational definition (James *et al.*, 2007).

Intra-observer and inter-observer testing provide suitable datasets with which to assess reliability but there is still a need to consider how agreement within and between analysts can be evaluated. Hughes *et al.* (2002, 2004a) state that correlations have regularly been utilised but, as stated by Bland and Altman (1986, 1999), this procedure measures the strength of a relationship rather than concordance. While Bland-Altman plots (Bland and Altman, 1986, 1999) were proposed as an alternative it is unclear if this approach, which was developed for parametric data, is viable within notational analysis research. More traditional non-parametric statistical tests such as the chi-square and Kruskal-Wallis have also been criticised in their application due to insensitivity, with differences greater than 20% suggested to be needed between data sets to achieve significance. This is problematic as conventionally less than 5% error is deemed an acceptable outcome for both intra-observer and inter-observer reliability testing, although differing levels of accuracy may be required according to the nature of the data collected (Hughes *et al.*, 2002, 2004a). Due to these issues Hughes *et al.* (2002, 2004a) recommend that the readily applied and interpretable calculation of percentage error should currently be adhered to.

2.8.2 Data Analysis

Numerous statistical techniques have been employed in the extant notational analysis literature with the predominant nominal nature of the data collected resulting in the chi-square test of significance being particularly prominent (Hughes *et al.*, 2002, 2004a; Nevill *et al.*, 2002; see also Tables 2.1-2.3). The chi-square test of significance is often used with a single classification variable, for example to examine differences in the occurrence of corner types (e.g. Taylor *et al.*, 2005), but it can also be used for

crosstabulations, or contingency tables, of two classification variables (e.g. whether the type of corner kick varies according to match location). If more than two classification variables are of interest log-linear and logit modelling procedures are most appropriate (Knoke and Burke, 1980; Gilbert, 1981; Marascuilo and Busk, 1987; Norusis, 1993; Tansey *et al.*, 1996; Tabachnick and Fidell, 2001; Nevill *et al.*, 2002; Hendrickx, 2004; Field, 2005). The principle difference between log-linear and logit models results from the conceptualisation of the dependent variable (Knoke and Burke, 1980). Specifically, log-linear models consider the frequency counts within the cells of a contingency table as the dependent variable and the classification variables as independent variables. Alternately, logit models investigate the influence of the classification variables on another classification variable which is subsequently regarded as the dependent variable (Knoke and Burke, 1980; Tabachnick and Fidell, 2001).

The major benefit to utilising the log-linear and logit approaches when analysing notational analysis data are manifest in that more complex study designs can be employed and thus provides greater insight into the mechanisms of sport performance (Nevill *et al.*, 2002). Nevertheless, apart from exemplar data presented by Nevill *et al.* (2002), Eom and Schutz (1992) have completed the only notational analysis study using such techniques. Using log-linear analysis they examined how a skill outcome in volleyball (serve, serve reception, set, spike, block or dig) was affected by the quality of the previous skill together with the influence of classification variables they termed transition process, team standing and game outcome. Overall, it was concluded that the execution of the skill performed was impinged upon by the quality of the preceding skill and this remained consistent across the selected classification variables.

The study of Eom and Shultz (1992) highlights how log-linear analysis can be utilised effectively within the analysis of sports performance. However, both log-linear and logit analysis can be employed in additional ways that offer greater insight into the patterns underlying the data collected (cf. Knoke and Burke, 1980; Norusis, 1993; Tabachnick and Fidell, 2001). For example, by examining in more detail which variables and their associations, also termed interactions, are not significant a simpler model of the data can be produced. The obvious benefit to identifying a reduced model is the increased interpretability of the trends within the data (Field, 2005). It is generally accepted that the best way to approach model building is from a theoretical perspective with the variables and associations retained within models being based upon empirical evidence (Knoke and Burke, 1980; Gilbert, 1981). Where this approach is not

appropriate, due to a paucity of related research literature, models can be selected according to statistical procedures such as forward or backward elimination (Knoke and Burke, 1980). Current thinking suggests that backward elimination methods are preferable as they guarantee an initial model that adequately fits the collected data (Norusis, 1993; Nevill *et al.*, 2002). It is important to note that logit modelling differs from the general log-linear model in that only terms involving the dependent variables are included in the models selected, nonetheless the approach to model selection is unchanged.

Following the development of 'best fit' models an equation, similar to that in multiple regression, can be developed and thus provides a means to predict performance. Specifically, the equations can be used to predict the cell frequency (of each cell in the crosstabulation of selected variables) in the case of log-linear models and the odds of being in various categories of the dependent variable in logit analysis. Moreover, additional information relating to the direction and significance of the terms contained within the equations can be acquired and examined through the use of model parameter estimates and associated z-scores (for further detail see Knoke and Burke, 1980; Norusis, 1993; Tabachnick and Fidell, 2001). Consequently it appears that the use of sophisticated contemporary statistical techniques such as log-linear and logit modelling provide a logical approach to extending current research methodologies within notational analysis and thus knowledge of soccer, and indeed sports, performance.

2.9 Summary

The preceding review has highlighted the use of notational analysis within research with particular reference to the technical and tactical components of performance. This current literature has unquestionably increased knowledge of these aspects of soccer performance, particularly at a professional playing level. However, it is also evident that many of the investigations have lacked clarity and utilised inadequate procedures. Therefore, to ensure a robust and objective approach to analysing soccer performance a number of conceptual and methodological issues need attention. Firstly, the conventional nomothetic evaluation of soccer performance has led to the individual characteristics of the teams analysed becoming amalgamated within limited data sets. As a result, a more 'fine-grained' method utilising case-studies offers a practical approach to examining soccer performance. Secondly, although soccer is a team game,

the current literature focuses disproportionately upon this whole. Consequently, the technical and tactical facets of performance have received little consideration at playing position and individual player levels. This contrasts with the applied use of notational analysis and thus represents an area of particular concern. Furthermore, where technical and tactical data have been presented, either at team, playing position or individual player levels, there has been a failure to ensure that the data is accurate or representative of typical performance. This has obvious implications for the validity of any conclusions drawn from the data collected and hence appropriate reliability testing and performance profiling methodologies need to be rigorously employed. Finally, the need to move away from purely descriptive research towards the modelling and prediction of performance has been suggested. While the production of valid performance profiles appears, to some extent, to address this concern there is also a requirement to examine the influence of variables, particularly those relating to specific situations, upon the technical and tactical elements of soccer performance. This will also provide an indication of the adequacy of a general performance profile and whether individual profiles specific to match situations are required. To date, notational analysis studies have demonstrated performance variations with regard to a limited number of situation factors (e.g. match location and match status) but have failed to effectively incorporate other pertinent influences, such as opposition quality. Moreover, research has investigated the independent effects of situation factors rather than potential interactive effects. This primarily appears to be due to a failure to adopt advanced statistical techniques such as log-linear and logit modelling procedures and therefore the dynamic nature of soccer has not been effectively addressed (Grehaigne *et al.*, 1997a; Kormelink and Seveerens, 1999; Grehaigne, 2001a; Nevill *et al.*, 2002; Carling *et al.*, 2005).

Overall, this review highlights the need for a comprehensive approach to the measurement and interpretation of the technical and tactical components of soccer performance at the team, playing position and individual player level. Clearer identification of related technical and tactical performance profiles, together with consideration of the influence of situation variables, will provide a basis upon which to develop predictive models of soccer performance. Subsequently, greater understanding of the technical and tactical components of soccer will be achieved.

Chapter 3 – Study 1

Profiling the Technical Component of Soccer Performance

Preparation for sports performance should be based upon scientific evidence rather than subjective or lay opinion (Williams *et al.*, 2003a). Despite this recommendation, the preceding review of literature in Chapter 2 has highlighted a dearth of investigations that have provided detailed and objective summaries of the technical component of soccer performance, particularly at team and individual player levels. Dunn *et al.* (2003), William *et al.* (2003b) and Hughes and Probert (2006) have endeavoured to resolve this issue by describing the behaviours exhibited by particular playing positions but their investigations have been limited by a number of inadequate procedures. These include a failure to sufficiently address the outcomes of the behaviours performed and a neglect of rigorous performance profiling methodologies, making it impossible to discern if the findings relating to technical aspects of soccer were in fact representative of typical performance.

In response to the limitations highlighted in the existing literature the aim of this study was to implement robust methodologies to construct and examine performance profiles relating to the technical facets of the soccer performance at the team, playing position and individual player level. The first objective was to establish behavioural and outcome profiles at team level within a professional soccer team. Based on previous research it was hypothesised that aerial challenges, clearances, dribbles, passes and tackles would be the predominant behaviours performed (e.g. Rico and Bangsbo, 1993; Yamanaka *et al.*, 1997, 2002; Eniseler *et al.*, 2001a; Ferit, 2001; Japeth and Hughes, 2001; Tucker *et al.*, 2005). Furthermore it was expected that clearances, dribbles, passes and tackles were most likely to result in successful outcomes whereas crosses and shots were most likely to be unsuccessful (e.g. Dufour, 1993; Tiryaki *et al.*, 1997, 2001; Egesoy and Eniseler, 2001; Eniseler *et al.*, 2001a; Tucker *et al.*, 2005). However, in accordance with Eniseler *et al.* (2001b) it was predicted that aerial challenges would be approximately 50% successful and thus not demonstrate a particular tendency towards either successful or unsuccessful outcomes.

The second objective was to develop and contrast behavioural and performance profiles between the fullback, centre back, midfield and forward playing positions. Given the findings of Dunn *et al.* (2003), Williams *et al.* (2003b) and Hughes and

Probert (2006) it was predicted that the fullback position would predominantly perform 'defensive technical actions' such as tackles and clearances, together with more crosses, free kicks and throw-ins than any other playing position. Similarly, the technical performance of centre backs was expected to be focused upon defensive behaviours such as clearances and aerial challenges with few dribbles performed and no shots attempted. In contrast, the midfield position was expected to be characterised by crosses and dribbles with few throw-ins, while the forward position was envisaged to be characterised by a high frequency of aerial challenges and shots but a small number of clearances, tackles and throw-ins. In general, passing was expected to be the dominant behaviour within the behavioural profiles of all playing positions with the midfield playing position executing the most behaviours overall. Existing research has failed to adequately consider the results of behaviours executed at a positional level but based on Muniroglu (2001) it was tentatively hypothesised that aerial challenges, dribbles, passes, shots would have success rates >50% across all positions although no significant differences were expected. The final objective was to ascertain if behavioural and outcome profiles differed between individual players within the fullback, centre back midfield and forward playing positions (intra-positional analysis). As intra-positional differences have been previously reported in rugby union (James *et al.*, 2003) it was hypothesised distinct variations would be observed between individual player behavioural and outcome profiles within each playing position.

3.2 Methodology

3.2.1 Study Design

A computerised notational analysis system was developed to assess on-the-ball behaviours and associated outcomes performed at the team, playing position and individual player level within a professional British soccer club during the 2002-2003 domestic league season. Data collection was based upon sport-specific performance indicators identified from the existing soccer notation literature and validated by a panel of professional coaches and experienced analysts. Behavioural and outcome profiles were then constructed and compared across the positions of fullback, centre back, midfield and forward (inter-positional) and also between selected individual players within each of these positions (intra-positional). Ethical approval for the study was sought and granted by the University of Wales Swansea Ethics Committee (Appendix A).

3.2.2 Participants

Video footage of matches played by a professional British soccer club during the 2002-2003 domestic season were sampled based upon availability (n = 21). The majority of the matches were played at the teams own ground (n = 12) with the overall results consisting of 5 wins, 3 draws and 13 losses, with 23 goals scored and 34 conceded. Within the selected matches 34 outfield players (mean age ± standard deviation = 25.0 ± 5.6 years) made at least one appearance and were included in the inter-positional analysis (mean appearances ± standard deviation = 7.5 ± 5.7). In contrast, players were only considered for intra-positional analysis if they had competed for the full duration (90 minutes) of five or more of the selected matches (n = 15, mean appearances ± standard deviation = 11.8 ± 4.0). This decision was taken to negate potential problems with the analysis of small data sets and the fact that more than one match is needed to be representative of a player's performance (Hughes *et al.*, 2001a, 2004b; Bracewell, 2003; O'Donoghue, 2004). Additionally, to maintain consistency within the intra-positional analyses, individuals were excluded if they had appeared in more than one playing position (e.g. if an individual had played at fullback in some of the matches and centre back in others).

3.2.3 Identification of Performance Indicators

To assess the technical component of soccer performance, sport-specific performance indicators relating to behaviour incidence and outcome were developed in a three-stage process. First soccer-based notational analysis publications spanning more than 40 years were reviewed with a list of previously utilised performance indicators compiled. Next, each performance indicator was considered with regard to it relevance as a behaviour or behaviour outcome within the context of the current study and subsequently omitted or amended where necessary. For example, performance indicators such as 'runs with the ball' and 'dribbles' were amalgamated into a single behaviour of 'dribble' whereas 'set-pieces' were separated into the behaviours of 'corners', 'free kicks' and 'throw-ins'. A unique classification for 'penalties' was omitted due to their low occurrence and this behaviour was instead classified as a 'shot' (Ensum *et al.*, 2000, 2002). Furthermore, as analysis was taking place post-event from match recording with a single camera source, behaviours were excluded when they corresponded to performance aspects that occurred 'off-the-ball' (i.e. players being deemed as offside). Following this review the categories of behaviour were established as: aerial challenges, clearances, crosses,

dribbles, interception, losses of control, passes, shots (including penalties), tackles, times tackled, corners, free kicks and throw-ins. Based on the performance indicators identified from the existing research behaviour outcomes were dichotomised into successful and unsuccessful categories depending upon whether they were adjudged as having a positive or negative impact on team performance. For example, if a player was tackled but retained possession of the ball this was seen as positive, yet if they lost possession it was considered negative. Finally, for the purposes of standardisation and objectivity, with the assistance of a professional soccer manager and his assistant (both ex-international players with over 30 years professional coaching experience) and two notational analysis researchers (with a total of over 15 years experience), operational definitions for each behaviour and their respective outcomes were developed (Appendix B).

3.2.4 Procedure

Match recordings were obtained directly from the sampled soccer club with the understanding their identity and that of the opposition would remain anonymous and be treated in the strictest confidence. All footage was converted directly to a digital format on the hard drive of a Dell Inspiron 5100 laptop computer via a Fast Multimedia Clipmaster MPEG converter (Fast Multimedia AG, 1999) with the original videos returned to the soccer club. Analysis of each match was subsequently implemented through the Noldus Observer Video Pro 4.1 behavioural measurement package (Noldus Information Technology, 2002) upon the aforementioned laptop computer. Data collection was based upon a pre-defined coding structure that employed specific keystrokes to represent information relating to the selected performance indicators (Figure 3.1). The order of data entry followed a cyclic sequence of player identification, playing position, behaviour performed and behaviour outcome, with this information only being collected for the sampled team. The raw data for each match were compiled in an SPSS v11.0 file (SPSS inc., 2001) for further analysis. Before the commencement of data collection for the actual study, all aspects of the methodological procedure were subject to a pilot study in which three soccer matches were observed and coded. This provided a final check on the suitability of the selected performance indicators, the operational definitions and the coding structure with no issues evident.

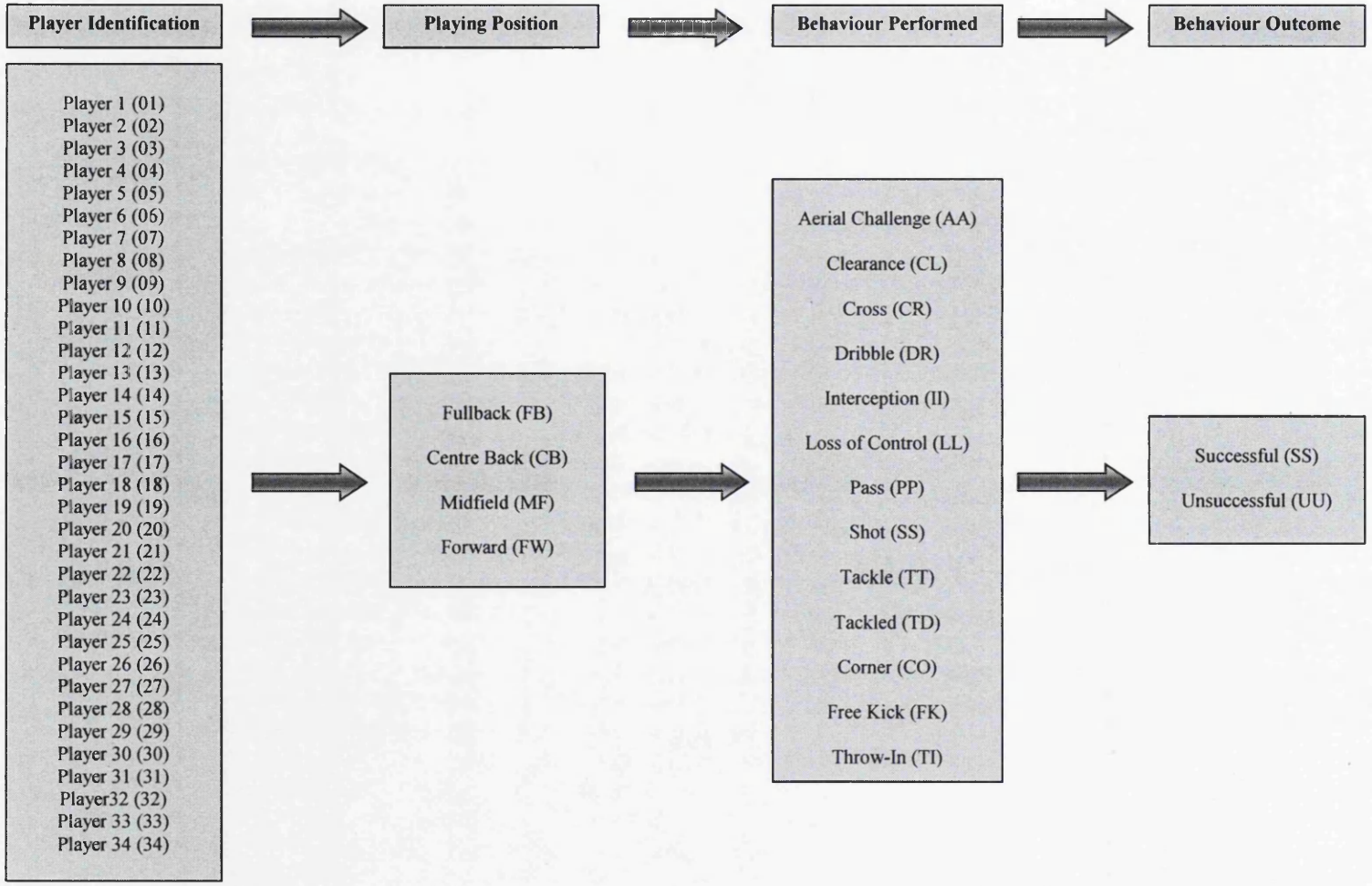


Figure 3.1 Coding structure and associated computer keystrokes (in brackets) for study 1 data collection.

3.2.5 System Reliability

Assessment of the notation system's reliability was completed using intra-observer and inter-observer testing procedures (Wilson and Barnes, 1998; James *et al.*, 2007). For intra-observer reliability, the researcher fully coded five soccer matches from the participating team. The selection of matches was based upon the inclusion of every player (n = 34) who featured in the final sample of matches. The same five matches were then recoded following an eight-week period to negate any possible learning effect. Data from both sessions were compared utilising the percentage error method recommended by Hughes *et al.* (2002; 2004a):

$$\%Error = \left(\sum\left(\text{mod}[O_1 - O_2]\right)/O_{mean}\right)\times 100$$

where Σ indicates 'sum of', mod denotes modulus, O_1 and O_2 represent the count of a particular variable during observation one and two and O_{mean} their associated mean. Inter-observer reliability testing followed a similar process but was undertaken independently by two experienced soccer analysts. Both observers were provided with five hour long training sessions prior to conducting the actual analysis in which full explanations and demonstrations of match observation and data coding procedures were given. Following these preliminary preparations the analysts coded each of the five sampled matches once, with their data being compared to that of the researcher's initial intra-reliability coding session. An acceptable level of error (<5.0%) was achieved on all variables in both intra- and inter-observer reliability tests (Hughes *et al.*, 2002, 2004a; Appendix C).

3.2.6 Data Analysis Overview

Data analysis comprised a four-stage process. Initially, data transformations were applied where the performance durations of players involved in intra-positional analyses were <90 minutes. Next, behavioural profiles were developed at the team, playing position and individual player level. Similarly, during the third stage of data analysis, outcome profiles were constructed at the team, playing position and individual player level. Lastly, the behavioural and outcome profiles were subject to statistical analysis.

3.2.6.1 Data Transformations for Appearance Durations <90 Minutes

Although a standard soccer match lasts for 90 minutes individual participants may not play for this amount of time due being sent-off or substitution. In such cases, data transformations were required to ascertain the likely performance of players involved in intra-positional analyses over a whole match. Data transformations were not needed for the overall team or playing positions as in these cases performance always lasts for a duration of 90 minutes. Simple time-rate conversions have been suggested to be inappropriate as a short segment of a match may not represent the whole (James *et al.*, 2003). For example, a team might be 'defending a lead' and a player substituted onto the pitch for the final five minutes of the match consequently makes four tackles. Using a simple time-rate conversion this equates to an excessive 72 tackles over 90 minutes. To overcome this limitation the methodology devised by James *et al.* (2003) for rugby union was modified for soccer. Specifically the formula applied was:

$$\text{Transformation} = F(\sqrt{90/n})((\log_{10}(90/n)) + 1)$$

where F equals the actual frequency of the performance indicator and n the number of minutes played. Applying the transformation to the tackling example, a less extreme figure of 38.3 tackles for the individual over the whole match would be achieved. As this example demonstrates the transformation can lead to a non-whole number for the frequency of a particular performance indicator, an irregularity when considering performance as behaviour is either an occurrence or a non-occurrence. This can lead to further anomalies of which caution is advised including medians display a decimal place other than the .0 or .5 that would normally be expected.

3.2.6.2 Construction of Team, Playing Position and Individual Player Behavioural Profiles

Behavioural profiles were determined through calculation of the median frequency of each behaviour performed by the team, playing positions and individual players together with 95% confidence limits for the population median (James *et al.*, 2003). Medians were selected as the measure of central tendency due to the non-normal nature of the data collected (cf. Nevill *et al.*, 2002; O'Donoghue and Ponting, 2005). The use of confidence limits has been suggested by James *et al.* (2003) as a particularly useful tool

for performance analysis because they provide an indication of the upper and lower limits between which the true (population) median is likely to lie based upon the collected data. Consequently, allowance is made for fluctuations in performance due to random error and the influence of potential confounding variables. Indeed, the use of a range of measures would appear to offer a better guide to expected performance than the use of a score, such as the median, in isolation (James *et al.*, 2003; O'Donoghue, 2004, 2005). Precise detail on the calculations of confidence limits for medians can be obtained from Zar (1999, pp. 542-543).

3.2.6.3 Construction of Team, Playing Position and Individual Player Outcome Profiles

Outcome profiles were established by calculating the percentage of successful outcomes relative to the total incidence of each behaviour performed at team, playing position and individual player levels (e.g. the % of successful passes out of all passes). 95% confidence limits for the population proportion were subsequently based upon the formula:

$$95\% \text{ confidence limits for proportions} = p \pm 1.96\sqrt{p(1-p)/n}$$

where p equals the proportion of successful behaviour outcomes and n the behaviour incidence (Spiegel and Stephens, 1999). Interpretation of the outcome profiles will focus upon the success rates for the executed behaviours but some caution is advised. Specifically, although the success rate may demonstrate a tendency towards successful or unsuccessful outcomes for a particular behaviours (i.e. the success rate is >50% or <50% respectively) is possible that the associated confidence limits may incorporate the 50% value, thus limiting our confidence to make such conclusions (Figure 3.2).

3.2.6.4 Evaluation of Team, Playing Position and Individual Player Behavioural and Outcome Profiles

The data for the overall team were analysed first via descriptive appraisal of behavioural and outcome profiles. Next, statistical comparisons were made between inter-positional behavioural and outcome profiles, followed by the intra-positional behavioural and outcome profiles. Due to the non-normal nature of the data contained within the

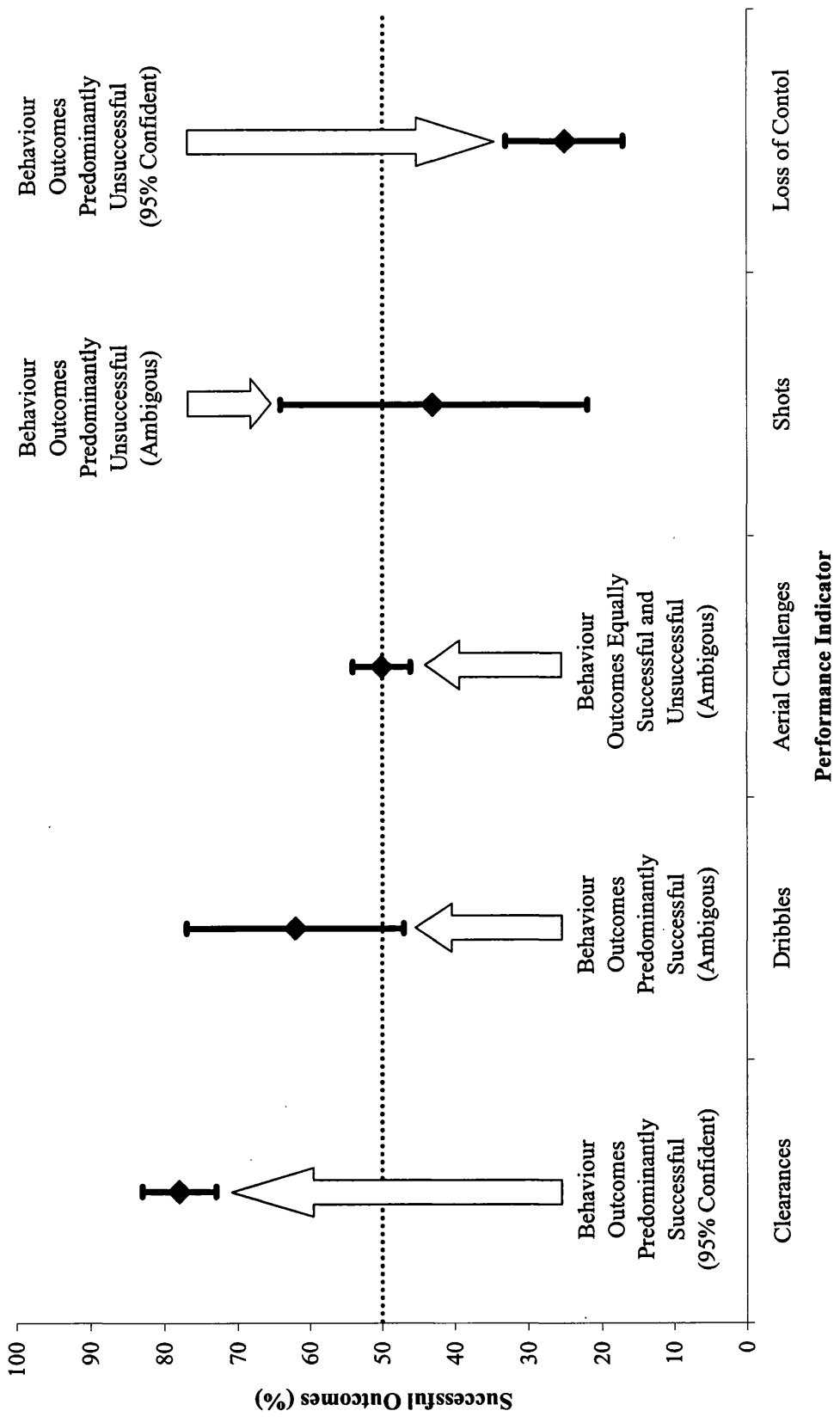


Figure 3.2 Exemplar data demonstrating the interpretation of behaviour outcomes based on success rates and associated 95% confidence limits.

behavioural and outcome profiles chi-square tests of significance were employed for all analyses (Vincent, 1999; Ntoumanis, 2001; Field, 2005). The formula for the calculation of chi-square was presented by Nevill *et al.* (2002) as:

$$\chi^2 = \sum((O-E)^2 / E)$$

where O is the observed frequency of each behaviour and E the expected frequency of each behaviour. In the case of the behavioural profiles, one-way chi-square tests of significance were utilised to test whether the frequency of behaviours performed differed between playing positions and individual players. By contrast, two-way chi-square tests of significance were used for the outcome profiles to examine if the overall proportion of successful and unsuccessful outcomes for each behaviour were discrepant between each playing position and also individual players. Where a playing position or individual did not perform a particular behaviour they were excluded from the corresponding inter- and intra-positional comparisons of behavioural and outcome profiles. Statistical significance was set at $p<0.05$ for all tests.

3.3 Results

3.3.1 Team Behavioural and Outcome Profiles

Within the sampled matches the most frequent behaviours performed by the team were passes, aerial challenges, dribbles and tackles with corners, losses of control, times tackled and shots least common (Table 3.1). For the team outcome profile, clearances, dribbles and interceptions were the most successful behaviours with losses of control and crosses resulting in the least successful outcomes (Table 3.1).

3.3.2 Inter-positional Behavioural Profile Comparisons

Distinct behavioural profiles were evident for the positions of fullback, centre back, midfield and forward (Table 3.2). The fullback playing position was observed to perform the most throw-ins ($\chi^2(3) = 1182.11$, $p<0.01$), while the same was true for centre backs with regard to clearances ($\chi^2(3) = 385.93$, $p<0.01$). The midfield playing position executed more crosses ($\chi^2(3) = 134.45$, $p<0.01$), dribbles ($\chi^2(3) = 316.59$, $p<0.01$), interceptions ($\chi^2(3) = 83.38$, $p<0.01$), passes ($\chi^2(3) = 379.06$, $p<0.01$), tackles ($\chi^2(3) = 336.45$, $p<0.01$) and free kicks ($\chi^2(3) = 77.37$, $p<0.01$) than the other three

Table 3.1 Behavioural and outcome profiles for a professional British soccer team during 21 matches of the 2002-2003 domestic league season.

	Behavioural Profile			Outcome Profile		
Behaviour	**Median Frequency**	**Upper 95% Confidence Limits**	**Lower 95% Confidence Limits**	**% Success**	**Upper 95% Confidence Limits**	**Lower 95% Confidence Limits**
Aerial Challenge	**79.0**	*92.0*	*74.0*	**48.5**	50.9	46.1
Clearance	**43.0**	*49.0*	*39.0*	**86.3**	88.5	84.0
Cross	**24.0**	*28.0*	*16.0*	**23.5**	27.3	19.6
Dribble	**64.0**	*78.0*	*49.0*	**77.8**	80.0	75.5
Interception	**25.0**	*29.0*	*22.0*	**83.3**	86.5	80.2
Loss of Control	**12.0**	*14.0*	*11.0*	**12.6**	16.6	8.7
Pass	**268.0**	*317.0*	*235.0*	**69.7**	70.9	68.5
Shot	**15.0**	*16.0*	*10.0*	**38.7**	44.3	33.1
Tackle	**64.0**	*75.0*	*54.0*	**66.6**	69.1	64.1
Tackled	**14.0**	*17.0*	*12.0*	**53.5**	59.1	48.0
Corner	**6.0**	*7.0*	*4.0*	**39.5**	48.3	30.7
Free Kick	**17.0**	*19.0*	*13.0*	**46.5**	53.0	40.0
Throw-In	**36.0**	*39.0*	*31.0*	**74.1**	77.2	70.9

Table 3.2 Behavioural profiles for the fullback, centre back, midfield and forward playing positions based upon medians (MDN) and 95% confidence limits (CL) for behaviour incidence during 21 matches of the 2002-2003 domestic league season of a professional British soccer team.

Playing Position	Measure	Performance Indicator												
		Aerial Challenge	Clearance	Cross	Dribble	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Corner	Free Kick	Throw -In
Fullback	**MDN**	**11.0**	**15.0**	**7.0**	**14.0**	**7.0**	**1.0**	**62.0**	**1.0**	**13.0**	**1.0**	**-**	**2.0**	**29.0**
	Upper CL	*14.0*	*18.0*	*11.0*	*18.0*	*11.0*	*2.0*	*87.0*	*1.0*	*18.0*	*4.0*	-	*4.0*	*32.0*
	Lower CL	*8.0*	*11.0*	*5.0*	*9.0*	*4.0*	*1.0*	*47.0*	*1.0*	*10.0*	*0.0*	-	*1.0*	*25.0*
Centre Back	**MDN**	**23.0**	**20.0**	**0.0**	**3.0**	**6.0**	**1.0**	**43.0**	**1.0**	**12.0**	**1.0**	**-**	**3.0**	**0.0**
	Upper CL	*30.0*	*23.0*	*1.0*	*6.0*	*8.0*	*2.0*	*69.0*	*1.0*	*17.0*	*1.0*	-	*5.0*	*1.0*
	Lower CL	*16.0*	*15.0*	*0.0*	*1.0*	*4.0*	*0.0*	*35.0*	*0.0*	*7.0*	*0.0*	-	*1.0*	*0.0*
Midfield	**MDN**	**17.0**	**6.0**	**9.0**	**27.0**	**8.0**	**4.0**	**99.0**	**4.0**	**27.0**	**5.0**	**6.0**	**5.0**	**1.0**
	Upper CL	*23.0*	*9.0*	*10.0*	*32.0*	*12.0*	*6.0*	*106.0*	*7.0*	*34.0*	*8.0*	*7.0*	*7.0*	*2.0*
	Lower CL	*13.0*	*5.0*	*5.0*	*18.0*	*6.0*	*3.0*	*84.0*	*3.0*	*26.0*	*3.0*	*4.0*	*3.0*	*1.0*
Forward	**MDN**	**25.0**	**1.0**	**5.0**	**16.0**	**2.0**	**6.0**	**57.0**	**5.0**	**7.0**	**7.0**	**-**	**0.0**	**2.0**
	Upper CL	*34.0*	*2.0*	*10.0*	*23.0*	*3.0*	*7.0*	*70.0*	*8.0*	*10.0*	*8.0*	-	*1.0*	*5.0*
	Lower CL	*21.0*	*0.0*	*3.0*	*13.0*	*1.0*	*5.0*	*43.0*	*5.0*	*5.0*	*5.0*	-	*0.0*	*1.0*

playing positions. In contrast, the forward playing position was characterised by the most aerial challenges ($\chi^2(3) = 154.19$, $p<0.01$), losses of control ($\chi^2(3) = 97.32$, $p<0.01$) and shots ($\chi^2(3) = 118.85$, $p<0.01$), as well as being tackled most often ($\chi^2(3) = 131.15$, $p<0.01$). In general, every playing position performed all behaviours except for corners, which were characteristic only to the midfield.

3.3.3 Inter-positional Outcome Profile Comparisons

Comparisons of the fullback, centre back, midfield and forward playing position outcome profiles revealed a number of trends in the proportions of successful outcomes of behaviours performed (Table 3.3). For example, across all positions clearances, dribbles, interceptions, passes and tackles were predominantly successful. In contrast, unsuccessful outcomes were mainly observed for crosses, losses of control and shots regardless of playing position. Similarly, the corner behaviour also tended to result in unsuccessful outcomes but, as reported with regard to the behavioural profiles, this particular action was only applicable to the midfield playing position. For the remaining behaviours, namely aerial challenges, times tackled, free kicks and throw-ins, a tendency towards successful or unsuccessful outcomes was not present between playing positions. Despite these trends differences were found in the proportion of successful and unsuccessful outcomes for aerial challenges ($\chi^2(3) = 45.94$, $p<0.01$), clearances ($\chi^2(3) = 10.12$, $p<0.05$), dribbles ($\chi^2(3) = 32.76$, $p<0.01$), interceptions ($\chi^2(3) = 10.99$, $p<0.05$), passes ($\chi^2(3) = 31.71$, $p<0.01$), tackles ($\chi^2(3) = 20.73$, $p<0.01$) and throw-ins ($\chi^2(3) = 58.28$, $p<0.01$) between all playing positions.

3.3.4 Intra-positional Behavioural Profile Comparisons

While inter-positional profiles provide an indication of the specific technical demands of soccer at a positional level they are based on an average profile for all players within that particular position. As this may lead to misrepresentation of more specific player characteristics behavioural profiles were subsequently constructed for individuals within each of the highlighted playing positions (Table 3.4 and 3.5). Differences were found between fullbacks for the frequency of clearances ($\chi^2(2) = 21.55$, $p<0.01$), dribbles ($\chi^2(2) = 18.50$, $p<0.01$), interceptions ($\chi^2(2) = 14.08$, $p<0.01$), passes ($\chi^2(2) = 38.77$, $p<0.01$) and throw-ins ($\chi^2(2) = 57.06$, $p<0.01$) performed. Centre backs were found to differ in the incidences of aerial challenges ($\chi^2(3) = 38.08$, $p<0.01$), clearances ($\chi^2(3) =$

Table 3.3 Outcome profiles for the fullback, centre back, midfield and forward playing positions based upon % success and 95% confidence limits (CL) for behaviours performed by a professional British soccer team during 21 matches of the 2002-2003 domestic season.

Playing Position	Measure	Performance Indicator												
		Aerial Challenge	Clearance	Cross	Dribble	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Corner	Free Kick	Throw -In
Fullback	**% Success**	**52.5**	**87.2**	**25.2**	**82.4**	**87.4**	**9.7**	**65.1**	**25.8**	**71.7**	**52.1**	**-**	**50.0**	**79.2**
	Upper CL	*58.7*	*90.9*	*31.9*	*86.9*	*92.3*	*20.1*	*67.6*	*41.2*	*76.8*	*66.2*	*-*	*63.9*	*82.5*
	Lower CL	*46.4*	*83.5*	*18.4*	*78.0*	*82.5*	*0.0*	*62.7*	*10.4*	*66.6*	*38.0*	*-*	*36.1*	*76.0*
Centre Back	**% Success**	**60.2**	**88.6**	**45.5**	**92.9**	**87.1**	**29.2**	**66.6**	**39.1**	**74.3**	**33.3**	**-**	**51.5**	**53.3**
	Upper CL	*64.6*	*91.7*	*74.9*	*97.6*	*93.0*	*47.4*	*69.5*	*59.1*	*79.7*	*60.0*	*-*	*63.3*	*66.0*
	Lower CL	*55.7*	*85.5*	*16.0*	*88.1*	*81.2*	*11.0*	*63.7*	*19.2*	*68.9*	*6.7*	*-*	*39.6*	*40.7*
Midfield	**% Success**	**44.6**	**78.4**	**23.4**	**77.9**	**76.1**	**11.3**	**72.9**	**39.4**	**64.1**	**60.3**	**39.5**	**42.6**	**83.3**
	Upper CL	*49.6*	*84.9*	*29.8*	*81.4*	*82.2*	*17.7*	*74.9*	*48.8*	*67.9*	*69.2*	*48.3*	*52.2*	*96.7*
	Lower CL	*39.5*	*71.9*	*16.9*	*74.5*	*70.0*	*5.0*	*71.0*	*30.0*	*60.3*	*51.4*	*30.7*	*32.9*	*70.0*
Forward	**% Success**	**40.3**	**84.6**	**19.7**	**69.6**	**86.8**	**11.1**	**72.0**	**41.0**	**56.3**	**50.0**	**-**	**33.3**	**41.3**
	Upper CL	44.2	98.5	26.6	74.3	95.9	16.8	74.5	49.4	*63.5*	*58.4*	*-*	*64.1*	*53.4*
	Lower CL	36.4	70.7	12.8	64.9	77.7	5.4	69.6	32.7	*49.1*	*41.6*	*-*	*2.5*	*29.1*

Table 3.4 Behavioural profiles for selected individuals within the fullback (FB) and centre back (CB) playing positions based upon medians (MDN) and 95% confidence limits (CL) for behaviour incidence during 21 matches of the 2002-2003 domestic league season of a professional British soccer team.

Player and Appearances	Measure	Performance Indicator												
		Aerial Challenge	Clearance	Cross	Dribble	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Corner	Free Kick	Throw-In
FB1 (n = 17)	**MDN**	**4.0**	**6.0**	**2.0**	**6.0**	**5.0**	**0.0**	**30.0**	**0.0**	**5.0**	**1.0**	**-**	**-**	**12.0**
	Upper CL	*7.0*	*7.0*	*4.0*	*8.1*	*5.0*	*1.0*	*40.4*	*1.0*	*7.0*	*2.0*	-	-	*15.0*
	Lower CL	*3.0*	*5.0*	*1.0*	*4.8*	*3.0*	*0.0*	*25.0*	*0.0*	*4.0*	*0.0*	-	-	*9.0*
FB2 (n = 17)	**MDN**	**4.0**	**7.0**	**4.0**	**4.0**	**3.0**	**0.0**	**24.0**	**1.0**	**7.0**	**0.0**	**-**	**-**	**16.0**
	Upper CL	*6.0*	*9.0*	*5.0*	*5.0*	*5.0*	*1.0*	*31.0*	*1.0*	*8.0*	*1.0*	-	-	*17.4*
	Lower CL	*2.0*	*6.0*	*3.0*	*1.0*	*2.0*	*0.0*	*22.0*	*0.0*	*3.0*	*0.0*	-	-	*12.0*
FB3 (n = 14)	**MDN**	**7.0**	**5.0**	**1.5**	**6.5**	**2.5**	**1.0**	**25.3**	**0.0**	**6.4**	**1.0**	**-**	**-**	**5.9**
	Upper CL	*11.0*	*8.0*	*3.0*	*9.1*	*4.0*	*2.6*	*36.0*	*1.1*	*10.0*	*2.8*	-	-	*17.0*
	Lower CL	*2.0*	*5.0*	*0.0*	*2.8*	*0.0*	*0.0*	*22.0*	*0.0*	*3.0*	*0.0*	-	-	*0.0*
CB1 (n = 12)	**MDN**	**7.8**	**13.4**	**-**	**1.0**	**2.1**	**-**	**19.5**	**0.0**	**6.9**	**-**	**-**	**-**	**0.5**
	Upper CL	*14.0*	*16.0*	-	*2.5*	*6.0*	-	*29.4*	*1.0*	*9.8*	-	-	-	*1.0*
	Lower CL	*6.5*	*6.8*	-	*0.0*	*1.0*	-	*11.0*	*0.0*	*5.0*	-	-	-	*0.0*
CB2 (n = 13)	**MDN**	**12.0**	**11.0**	**0.0**	**0.0**	**2.0**	**0.0**	**16.0**	**1.0**	**3.0**	**0.0**	**-**	**3.0**	**0.0**
	Upper CL	*16.0*	*15.0*	*1.0*	*2.0*	*4.0*	*1.0*	*21.0*	*1.0*	*6.0*	*1.0*	-	*6.0*	*1.0*
	Lower CL	*7.0*	*8.0*	*0.0*	*0.0*	*0.0*	*0.0*	*12.0*	*0.0*	*3.0*	*0.0*	-	*3.0*	*0.0*
CB3 (n = 13)	**MDN**	**12.0**	**8.0**	**-**	**4.0**	**3.8**	**1.0**	**31.0**	**0.0**	**6.0**	**0.0**	**-**	**3.0**	**0.0**
	Upper CL	*13.0*	*11.0*	-	*9.0*	*6.0*	*2.0*	*43.0*	*1.0*	*10.0*	*1.0*	-	*5.0*	*1.0*
	Lower CL	*9.0*	*5.0*	-	*1.0*	*3.0*	*0.0*	*22.0*	*0.0*	*4.0*	*0.0*	-	*1.0*	*0.0*
CB4 (n = 6)	**MDN**	**10.5**	**5.5**	**0.0**	**1.5**	**2.0**	**0.5**	**26.5**	**0.5**	**5.0**	**0.0**	**-**	**6.0**	**-**
	Upper CL	*19.0*	*7.0*	*1.0*	*11.0*	*5.0*	*2.0*	*35.0*	*1.0*	*11.0*	*1.0*	-	*11.0*	-
	Lower CL	*6.0*	*2.0*	*0.0*	*1.0*	*0.0*	*0.0*	*16.0*	*0.0*	*1.0*	*0.0*	-	*1.0*	-

Table 3.5 Behavioural profiles for selected individuals in the midfield (MF) and forward (FW) playing positions based upon medians and 95% confidence limits (CL) for behaviour incidence in 21 matches of the 2002-2003 domestic league season of a professional British soccer team.

Player and Appearances	Measure	Performance Indicator												
		Aerial Challenge	Clearance	Cross	Dribble	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Corner	Free Kick	Throw-In
MF1 (n = 12)	**MDN**	**3.0**	**0.0**	**2.0**	**14.0**	**1.5**	**2.0**	**27.0**	**2.0**	**8.0**	**2.5**	**-**	**-**	**-**
	Upper CL	*5.0*	*1.0*	*3.0*	*18.0*	*3.0*	*3.0*	*32.0*	*3.0*	*10.0*	*4.0*	-	-	-
	Lower CL	*1.0*	*0.0*	*1.0*	*11.0*	*1.0*	*0.0*	*18.0*	*1.0*	*3.0*	*2.0*	-	-	-
MF2 (n = 6)	**MDN**	**3.5**	**2.5**	**3.5**	**10.5**	**9.5**	**0.5**	**50.0**	**0.5**	**12.5**	**1.0**	**2.0**	**5.5**	**-**
	Upper CL	*5.0*	*4.0*	*7.0*	*13.0*	*13.0*	*3.0*	*57.0*	*1.0*	*14.0*	*4.0*	*7.0*	*8.0*	-
	Lower CL	*1.0*	*2.0*	*0.0*	*5.0*	*2.0*	*0.0*	*33.0*	*0.0*	*9.0*	*0.0*	*0.0*	*1.0*	-
MF3 (n = 13)	**MDN**	**5.5**	**2.2**	**3.0**	**7.5**	**1.2**	**1.8**	**24.4**	**1.5**	**8.7**	**0.5**	**5.2**	**2.0**	**0.0**
	Upper CL	*7.0*	*3.0*	*6.0*	*9.8*	*3.0*	*2.0*	*27.0*	*2.3*	*13.0*	*1.0*	*7.9*	*3.0*	*2.0*
	Lower CL	*4.3*	*1.0*	*1.6*	*5.0*	*0.0*	*0.0*	*20.5*	*0.0*	*7.0*	*0.0*	*0.0*	*0.0*	*0.0*
MF4 (n = 12)	**MDN**	**4.0**	**3.0**	**2.0**	**6.0**	**3.4**	**1.6**	**34.0**	**0.0**	**14.7**	**1.5**	**-**	**-**	**0.0**
	Upper CL	*7.0*	*6.2*	*3.0*	*7.0*	*7.0*	*3.0*	*37.0*	*1.8*	*21.0*	*3.0*	-	-	*2.0*
	Lower CL	*2.3*	*1.0*	*0.0*	*3.0*	*1.0*	*0.0*	*17.1*	*0.0*	*8.0*	*0.0*	-	-	*0.0*
MF5 (n = 11)	**MDN**	**3.0**	**2.4**	**2.0**	**5.0**	**1.2**	**0.0**	**31.0**	**0.0**	**8.0**	**0.0**	**5.0**	**3.0**	**0.0**
	Upper CL	4.1	4.1	4.0	6.5	2.8	1.4	50.9	2.0	12.1	3.0	6.0	5.0	1.1
	Lower CL	1.0	1.0	0.0	0.0	0.0	0.0	20.7	0.0	2.8	0.0	1.0	1.1	0.0
FW1 (n = 8)	**MDN**	**20.0**	**1.0**	**0.5**	**2.5**	**1.1**	**2.0**	**29.5**	**1.6**	**3.0**	**2.5**	**-**	**-**	**-**
	Upper CL	*32.0*	*2.0*	*1.3*	*5.5*	*3.7*	*5.1*	*41.0*	*4.0*	*5.2*	*4.0*	-	-	-
	Lower CL	*11.0*	*0.0*	*0.0*	*1.0*	*0.0*	*0.0*	*16.0*	*0.0*	*0.0*	*1.0*	-	-	-
FW2 (n = 8)	**MDN**	**8.0**	**-**	**0.0**	**3.7**	**0.0**	**1.5**	**17.0**	**3.0**	**4.2**	**3.0**	**-**	**-**	**-**
	Upper CL	*10.0*	-	*3.0*	*7.0*	*2.0*	*8.9*	*23.7*	*4.0*	*10.0*	*5.0*	-	-	-
	Lower CL	*3.0*	-	*0.0*	*0.0*	*0.0*	*0.0*	*5.9*	*0.0*	*1.0*	*0.0*	-	-	-
FW3 (n = 19)	**MDN**	**8.1**	**0.0**	**1.3**	**6.0**	**1.0**	**2.3**	**19.0**	**4.0**	**1.3**	**2.1**	**-**	**0.0**	**-**
	Upper CL	*15.0*	*1.2*	*4.0*	*9.3*	*1.0*	*3.0*	*27.0*	*5.3*	*4.0*	*4.0*	-	*1.0*	-
	Lower CL	*7.0*	*0.0*	*1.0*	*5.0*	*0.0*	*1.0*	*15.2*	*2.0*	*1.0*	*1.3*	-	*0.0*	-

84.79, $p<0.01$), dribbles ($\chi^2(3) = 55.89$, $p<0.01$) interceptions ($\chi^2(3) = 32.51$, $p<0.01$), passes ($\chi^2(3) = 140.16$, $p<0.01$), tackles ($\chi^2(3), = 36.60$, $p<0.01$), free kicks ($\chi^2(2) = 47.19$, $p<0.01$) and throw-ins ($\chi^2(2) = 95.32$, $p<0.01$). Variations in the number of aerial challenges ($\chi^2(4) = 37.36$, $p<0.01$), clearances ($\chi^2(4) = 30.46$, $p<0.01$), crosses ($\chi^2(4) = 15.78$, $p<0.01$), dribbles ($\chi^2(4) = 95.79$, $p<0.01$), interceptions ($\chi^2(4) = 33.99$, $p<0.01$), losses of control ($\chi^2(4) = 18.14$, $p<0.01$), passes ($\chi^2(4) = 32.91$, $p<0.01$), shots ($\chi^2(4) = 23.23$, $p<0.01$), tackles ($\chi^2(4) = 84.32$, $p<0.01$), times tackled ($\chi^2(4) = 29.10$, $p<0.01$), corners ($\chi^2(2) = 60.27$, $p<0.01$), free kicks ($\chi^2(2) = 59.31$, $p<0.01$) and throw-ins ($\chi^2(2) = 15.75$, $p<0.01$) were found amongst midfield players. Finally, disparities were apparent between the frequencies of aerial challenges ($\chi^2(2) = 95.54$, $p<0.01$), clearances ($\chi^2(1) = 7.05$, $p<0.01$), crosses ($\chi^2(2) = 45.50$, $p<0.01$), dribbles ($\chi^2(2) = 208.77$, $p<0.01$), losses of control ($\chi^2(2) = 11.73$, $p<0.01$), passes ($\chi^2(2) = 165.98$, $p<0.01$), shots ($\chi^2(2) = 43.82$, $p<0.01$), tackles ($\chi^2(2) = 6.86$, $p<0.05$) and times tackled ($\chi^2(2) = 18.66$, $p<0.01$) for players within the forward playing position.

3.3.5 Intra-positional Outcome Profile Comparisons

Analyses between individual players within the fullback, centre back, midfield and forward playing positions revealed distinct outcome profiles (Table 3.6 and 3.7). The players within the fullback playing position were observed to predominantly be successful when performing aerial challenges, clearances, dribbles, interceptions, passes, tackles and throw-ins. Cross, loss of control and shot outcomes were generally unsuccessful with mixed trends towards success apparent for times tackled. However the proportion of successful and unsuccessful outcomes were found to be different for the passing behaviour only ($\chi^2(2) = 10.28$, $p<0.01$).

Regarding the four centre backs successful outcomes were most likely for clearances, dribbles, interceptions, passes, tackles and throw-ins, with unsuccessful outcomes principally observed following losses of control. Inconsistent trends towards either successful and unsuccessful outcomes were observed within the centre back playing position for aerial challenges, crosses, shots, times tackled and free kicks. Differences between the centre backs for the proportions of successful and unsuccessful outcomes were found for the aerial challenge ($\chi^2(3) = 8.89$, $p<0.05$) and passing behaviours ($\chi^2(3) = 12.07$, $p<0.01$).

For the five analysed players within the midfield position successful outcomes

Table 3.6 Outcome profiles for selected individuals within the fullback (FB) and centre back (CB) playing positions based upon % success and 95% confidence limits (CL) for behaviours performed during 21 matches of the 2002-2003 domestic season of a professional British soccer team.

Player and Appearances	Measure	Performance Indicator												
		Aerial Challenge	Clearance	Cross	Dribble	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Corner	Free Kick	Throw-In
FB1 (n = 17)	**% Success**	**58.5**	**91.8**	**20.5**	**86.5**	**94.0**	**11.1**	**68.4**	**20.0**	**73.1**	**57.1**	-	-	**82.0**
	Upper CL	*69.2*	*97.3*	*32.4*	*92.8*	*99.7*	*31.6*	*72.3*	*55.1*	*82.1*	*83.1*	-	-	*87.5*
	Lower CL	*47.9*	*86.4*	*8.5*	*80.1*	*88.4*	*0.0*	*64.4*	*15.0*	*64.1*	*31.2*	-	-	*76.4*
FB2 (n = 17)	**% Success**	**52.8**	**90.2**	**30.4**	**78.1**	**86.0**	**12.5**	**59.5**	**27.3**	**72.5**	**33.3**	-	-	**81.2**
	Upper CL	*64.3*	*95.4*	*41.3*	*88.3*	*95.0*	*35.4*	*64.0*	*53.6*	*81.2*	*60.0*	-	-	*85.9*
	Lower CL	*41.2*	*84.9*	*19.6*	*68.0*	*76.9*	*0.0*	*54.9*	*1.0*	*63.9*	*6.7*	-	-	*76.4*
FB3 (n = 14)	**% Success**	**53.4**	**82.1**	**18.5**	**79.7**	**77.4**	**7.7**	**68.5**	**33.3**	**65.8**	**68.8**	-	-	**73.0**
	Upper CL	*64.9*	*92.2*	*33.2*	*89.2*	*92.1*	*22.2*	*73.7*	*64.1*	*76.6*	*91.5*	-	-	*81.7*
	Lower CL	*42.0*	*72.1*	*3.9*	*70.2*	*62.7*	*0.0*	*63.3*	*2.5*	*54.9*	*46.0*	-	-	*64.3*
CB1 (n = 12)	**% Success**	**64.4**	**86.8**	-	**82.4**	**92.3**	-	**68.6**	**33.3**	**72.7**	-	-	-	**71.6**
	Upper CL	*74.3*	*93.0*	-	*100.0*	*100.0*	-	*75.1*	*86.7*	*83.5*	-	-	-	*75.3*
	Lower CL	*54.6*	*80.6*	-	*64.2*	*82.1*	-	*62.0*	*20.0*	*62.0*	-	-	-	*67.8*
CB2 (n = 13)	**% Success**	**63.0**	**90.1**	**100.0**	**81.8**	**84.6**	**40.0**	**63.0**	**37.5**	**76.9**	**50.0**	-	**62.5**	**100.0**
	Upper CL	*70.6*	*94.8*	*100.0*	*100.0*	*98.5*	*82.9*	*69.4*	*71.0*	*88.4*	*100.0*	-	*96.0*	*100.0*
	Lower CL	*55.4*	*85.3*	*100.0*	*59.0*	*70.7*	*0.0*	*56.5*	*4.0*	*65.5*	*0.0*	-	*29.0*	*100.0*
CB3 (n = 13)	**% Success**	**62.4**	**88.7**	-	**96.8**	**87.7**	**27.3**	**71.5**	**25.0**	**74.7**	**33.3**	-	**54.5**	**66.7**
	Upper CL	*70.2*	*94.7*	-	*100.0*	*96.2*	*53.6*	*75.8*	*55.0*	*83.7*	*71.1*	-	*69.3*	*100.0*
	Lower CL	*58.4*	*82.6*	-	*92.5*	*79.2*	*1.0*	*67.1*	*0.0*	*65.8*	*0.0*	-	*39.8*	*28.9*
CB4 (n = 6)	**% Success**	**44.3**	**83.9**	**0.0**	**94.7**	**92.3**	**40.0**	**57.3**	**66.7**	**76.5**	**0.0**	-	**30.8**	-
	Upper CL	*55.9*	*96.8*	*0.0*	*100.0*	*100.0*	*82.9*	*65.1*	*100.0*	*90.7*	*0.0*	-	*55.9*	-
	Lower CL	*32.6*	*70.9*	*0.0*	*84.7*	*77.8*	*0.0*	*49.6*	*13.3*	*62.2*	*0.0*	-	*5.7*	-

Table 3.7 Outcome profiles for selected individuals within the midfield (MF) and forward (FW) playing positions based upon % success and 95% confidence limits (CL) for behaviours performed in 21 matches of the 2002-2003 domestic season of a professional British soccer team.

Player and Appearances	Measure	Performance Indicator												
		Aerial Challenge	Clearance	Cross	Dribble	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Corner	Free Kick	Throw-In
MF1 (n = 12)	**% Success**	**35.3**	**100.0**	**28.0**	**77.5**	**75.0**	**10.5**	**77.4**	**33.3**	**65.2**	**61.8**	**-**	**-**	**-**
	Upper CL	*51.4*	*100.0*	*45.6*	*84.0*	*92.3*	*24.3*	*82.1*	*53.5*	*74.9*	*78.1*	-	-	-
	Lower CL	*19.2*	*100.0*	*10.4*	*71.0*	*57.7*	*0.0*	*72.7*	*13.2*	*55.5*	*45.4*	-	-	-
MF2 (n = 6)	**% Success**	**57.9**	**81.3**	**23.8**	**91.4**	**82.0**	**16.7**	**77.5**	**33.3**	**64.9**	**75.0**	**18.8**	**43.3**	**-**
	Upper CL	*80.1*	*100.0*	*42.0*	*98.6*	*92.6*	*46.5*	*82.3*	*86.7*	*75.7*	*100.0*	*37.9*	*61.1*	-
	Lower CL	*35.7*	*62.1*	*5.6*	*84.2*	*71.4*	*0.0*	*72.7*	*0.0*	*54.0*	*45.0*	*0.0*	*25.6*	-
MF3 (n = 13)	**% Success**	**46.4**	**66.7**	**27.8**	**72.6**	**76.5**	**0.0**	**61.7**	**38.9**	**55.7**	**58.3**	**31.0**	**36.4**	**80.0**
	Upper CL	*59.5*	*84.4*	*42.4*	*82.2*	*96.6*	*0.0*	*67.7*	*61.4*	*65.6*	*86.2*	*44.9*	*56.5*	*100.0*
	Lower CL	*33.4*	*48.9*	*13.1*	*63.1*	*56.3*	*0.0*	*55.7*	*16.4*	*45.8*	*30.4*	*17.0*	*16.3*	*44.9*
MF4 (n = 12)	**% Success**	**32.6**	**78.8**	**30.0**	**82.7**	**75.0**	**26.3**	**77.5**	**0.0**	**67.8**	**58.8**	**-**	**-**	**77.8**
	Upper CL	*46.6*	*92.7*	*50.1*	*93.0*	*88.4*	*46.1*	*82.0*	*0.0*	*75.4*	*82.2*	-	-	*100.0*
	Lower CL	*18.6*	*64.8*	*9.9*	*72.4*	*61.6*	*6.5*	*72.9*	*0.0*	*60.2*	*35.4*	-	-	*50.6*
MF5 (n = 11)	**% Success**	**51.9**	**89.5**	**21.7**	**90.7**	**66.7**	**0.0**	**72.5**	**44.4**	**62.7**	**55.6**	**52.4**	**47.1**	**66.7**
	Upper CL	*70.7*	*100.0*	*38.6*	*99.4*	*90.5*	*0.0*	*77.3*	*76.9*	*73.6*	*88.0*	*67.5*	*63.8*	*100.0*
	Lower CL	*33.0*	*75.7*	*4.9*	*82.0*	*42.8*	*0.0*	*67.7*	*12.0*	*51.7*	*23.1*	*37.3*	*30.3*	*13.3*
FW1 (n = 8)	**% Success**	**35.2**	**75.0**	**0.0**	**68.4**	**80.0**	**10.0**	**77.0**	**61.5**	**52.2**	**42.1**	**-**	**-**	**-**
	Upper CL	*42.6*	*100.0*	*0.0*	*89.3*	*100.0*	*23.1*	*82.6*	*88.0*	*72.6*	*64.3*	-	-	-
	Lower CL	*27.8*	*45.0*	*0.0*	*47.5*	*55.2*	*0.0*	*71.3*	*35.1*	*31.8*	*19.9*	-	-	-
FW2 (n = 8)	**% Success**	**40.4**	**-**	**16.7**	**60.0**	**75.0**	**0.0**	**77.0**	**33.3**	**48.3**	**25.0**	**-**	**-**	**-**
	Upper CL	*53.7*	-	*46.5*	*79.2*	*117.4*	*0.0*	*85.2*	*53.5*	*66.5*	*44.0*	-	-	-
	Lower CL	*27.0*	-	*0.0*	*40.8*	*32.6*	*0.0*	*68.8*	*13.2*	*30.1*	*6.0*	-	-	-
FW3 (n = 19)	**% Success**	**38.1**	**90.0**	**23.5**	**63.0**	**93.3**	**5.4**	**67.5**	**37.9**	**63.8**	**57.8**	**-**	**37.5**	**-**
	Upper CL	*45.7*	*100.0*	*37.8*	*72.1*	*100.0*	*12.7*	*72.7*	*50.4*	*77.6*	*72.2*	-	*71.0*	-
	Lower CL	*30.6*	*71.4*	*9.3*	*53.9*	*80.7*	*0.0*	*62.4*	*25.4*	*50.1*	*43.3*	-	*4.0*	-

were found to occur most often for clearances, dribbles, interceptions, passes, tackles, times tackled and throw-ins. However, the midfielders were primarily unsuccessful during the performance of crosses, losses of control, shots and free kicks. For the outcomes of aerial challenges and corners, contradictory trends regarding successful and unsuccessful outcomes were observed. For example, corners were mainly successful when executed by Midfielder 5 but unsuccessful for Midfielders 2 and 3. The proportions of successful and unsuccessful outcomes varied between the midfield players for dribbles ($\chi^2(4) = 11.67$, $p<0.05$), passes ($\chi^2(4) = 25.83$, $p<0.01$) and corners ($\chi^2(2) = 10.17$, $p<0.01$).

Finally, it was identified that the individuals within the forward playing position were mainly successful when performing clearances, dribbles, interceptions and passes. However, unsuccessful outcomes were predominant during the execution of aerial challenges, crosses and losses of control. Free kick outcomes also tended to be unsuccessful but only applied Forward 3. For the outcomes of shots, tackles and times tackled no consistent bias towards either successful or unsuccessful outcomes were observed. Overall the proportion of successful and unsuccessful outcomes of passes ($\chi^2(2) = 7.07$, $p<0.05$) and times tackled ($\chi^2(2) = 6.17$, $p<0.05$) were found to differ between the selected individuals within the forward position.

3.4 Discussion

The aim of this chapter was to utilise robust performance profiling methodologies to construct and examine performance profiles relating to the technical aspect of soccer performance at the team, playing position and individual player level. This was accomplished by producing behavioural profiles relating to behaviour occurrence and outcome profiles associated with the success rates of behaviours performed in a professional soccer team. Support was found for the majority of hypotheses under investigation providing support for the suggestion that the technical component of performance not only varies as a function of playing position but also between individuals within playing positions (cf. James *et al.*, 2003).

The first objective of this study was to develop and investigate the overall behavioural and outcome profile of a professional soccer team. The behavioural profiles constructed were found to concur with previous research in that aerial challenges, clearances, dribbles, passes and tackles were the most commonly executed behaviours

(Rico and Bangsbo, 1993; Yamanaka *et al.*, 1997, 2002; Eniseler *et al.*, 2001a; Ferit, 2001; Japeth and Hughes, 2001; Tucker *et al.*, 2005). Regarding the team's outcome profile, the prediction that clearances, dribbles, passes and tackles were most likely to result in successful outcomes was also confirmed (Dufour, 1993; Tiryaki *et al.*, 1997, 2001; Egesoy and Eniseler, 2001; Eniseler *et al.*, 2001a; Tucker *et al.*, 2005). Additionally, as predicted, aerial challenges were approximately 50% successful (Eniseler *et al.*, 2001b). As these finding are supported across numerous studies using diverse samples it appears that these aspects of the technical component of performance are relatively constant. These general findings have important implications for the development of soccer-specific training programmes but also provide an initial basis for evaluations of team performance. For example, if clearances were mostly unsuccessful during a match or over a series of matches this would represent a discrepancy from the 'general' profile of technical performance and thus require further investigation.

The second objective was to develop and contrast behavioural and performance profiles between the fullback, centre back, midfield and forward playing positions. All hypotheses relating to the incidence of behaviours within each playing position were supported with the distinct behavioural profiles constructed comparable to the findings of Dunn *et al.* (2003), Williams *et al.* (2003b) and Hughes and Probert (2006). As previously highlighted within section 2.4.2 notational analysis data in isolation only reflects observed behaviour but the consistency of finding across this study and the existing literature suggests that each position has a well defined behavioural profile related to specific responsibilities. Indeed, applied and research literature substantiates this claim with the centre back position being recognised as predominantly defensive, the fullback position also being defensive but supporting attacking play, the midfield position linking defensive and attacking play with the forward playing position mainly concerned with attacking the oppositions goal (e.g. Thomas and Reilly, 1976; Kormelink and Seeverens, 1999; James *et al.*, 2002; Wiemeyer, 2003; Carling *et al.*, 2005; Bray, 2006; Thelwell *et al.*, 2006).

Although the behavioural profiles of each playing position were found to be unique, a number of similarities were observed when the respective outcome profiles were examined. The findings of Muniroglu (2001) suggested that aerial challenges, dribbles, pass, shots would have success rates >50% in all positions but were not fully supported by this study. Specifically the results highlighted that clearances, dribbles, interceptions, passes and tackles were mainly successful (>50% success rate) whilst

crosses, losses of control and shots were mostly unsuccessful (<50% success rate). Corners were also predominantly unsuccessful but, as is evident from the behavioural profiles, were only carried out by the midfield playing position. For the remaining behaviours of aerial challenges, times tackled, free kicks and throw-in the results were less consistent across playing positions. A plausible explanation for these findings is the inherent difficulty associated with performing each behaviour. For example, a shot (which has to result in a goal or be saved to be deemed successful) is naturally going to be more difficult for any playing position than a clearance (which effectively just requires the player to kick the ball as far as possible up pitch or out of play). Whilst it is acknowledged that the findings regarding behaviour outcomes are influenced to a large extent by the operational definitions utilised, those employed within this study were corroborated by professional coaches and consequently provide a valid description of behaviour outcomes. Lastly, it is also notable that given the aforementioned 'roles' of each position that associated behaviours were often executed more successfully than compared to other positions. To clarify, the 'defensive' centre backs and fullbacks performed more successful tackles than other positions, with the same apparent for the shooting performance of the forward playing position. However, some anomalies, such as the centre back position being most successful at crossing were also observed. This is suggested to be the result of the low incidence of this behaviour within the playing position and implies that there is a need to consider both behaviour incidence and outcome when evaluating the technical component of performance (cf. Dunn *et al.*, 2003; Williams *et al.*, 2003b; Hughes and Probert, 2003).

The final objective of the study was to ascertain if behavioural and outcome profiles differed between individuals within the fullback, centre back midfield and forward playing positions. Intra-positional variations have been reported for the technical component of individual player performance within rugby union (James *et al.*, 2003) and were also confirmed within this study of soccer. For example, differences existed amongst fullbacks for the incidences of clearances, dribbles, interception, passes and throw-ins and for all behaviours between midfielder players. Such discrepancies may represent differing decision-making profiles and the assessments of situational probabilities made by individuals in response to a particular circumstance (Williams, 2000; James *et al.*, 2003; Williams *et al.*, 2004; Williams *et al.*, 2005). Where one forward may decide to pass, for example, another may dribble or shoot. It is also reasonable to conclude that these variations may also demonstrate players

individualising roles within their more generic playing position (James *et al.*, 2002). Nonetheless, caution is again recommended with placing too much emphasis on this conclusion without supporting evidence from the team's coach regarding designated responsibilities.

In contrast to the numerous intra-positional differences in the fullback, centre back, midfield and forward behavioural profiles, the outcome profiles were observed to be less discrepant. Regardless of playing position all individuals within intra-positional analyses were most likely to perform successful outcomes for clearances, dribbles, interceptions, passes and throw-ins whereas unsuccessful outcomes were most likely for losses of control and shots. However, trends across individuals were less apparent for aerial challenges, crosses, tackles, times tackled and free kicks. Within each playing positions a number of variations in behaviour outcomes were observed which may again reflect individuals' decision-making or possibly, to a lesser extent possible roles (cf. James *et al.*, 2002). However, it is also likely that these profiles provide an indication of player strengths and weaknesses. This was highlighted particularly well by centre back 4 for whom the success rate for aerial challenges was 44.3% compared to 64.4%, 63.0% and 62.4% for centre back 1, centre back 2 and centre back 3 respectively. Due to the prominence of this behaviour within this players behavioural profile such difference would appear to be 'real' and not the result of low incidence for example. In this case, the observed difference was found to be significant but further performance discrepancies in all playing positions failed to reach the required levels for statistical significance. For example, the execution of shots contrasted in the forwards from 33.3% - 61.5% yet the chi-square statistic failed to report significance. Consequently, there is a need for coaches and analyst to consider what constitutes a 'meaningful difference' when evaluating performance as relying upon statistical significance in isolation appears inadequate for the analysis of sports performance (Hopkins *et al.*, 1999; Hughes *et al.*, 2002, 2004a; Jones, 2006).

The current study has extended knowledge of the technical component of soccer performance through the use of rigorous performance profiling techniques at team, playing position and individual player levels. However, the focus upon technical aspects of performance in isolation appears limited as soccer has been identified as being of a predominantly technical-tactical nature (Castagna *et al.*, 2003). Consequently, in addition to the established profiles relating to behaviour incidence and behaviour outcomes, there exists a need to provide complementary tactical information. In line

with existing literature the provision of spatial data, corresponding to where upon the pitch behaviours are being executed (Grehaigne *et al.*, 1997b; James *et al.*, 2002; Hughes and Franks, 2004; Carling *et al.*, 2005), appears to provide a particularly logical method of achieving this aim.

Chapter 4 – Study 2

Profiling the Tactical Component of Soccer Performance

4.1 Introduction

Study 1 evaluated the technical component of soccer performance at the team, playing position and individual player level using a combination of behavioural and outcome profiles. The description of objective technical information however, fails to fully address the technical-tactical nature of soccer that relies on the application of such skills in relation to team strategy and tactics (Hughes, 1999; Castagna *et al.*, 2003). Within the soccer coaching and notational analysis literature the examination of the spatial dimensions of performance, that is where behaviours are occurring upon the pitch surface, represents a pertinent approach to assessing soccer tactics and strategy (Kormelink and Seeverens, 1999; Hughes and Franks, 2004; Carling *et al.*, 2005). While this concept has been regularly applied in relation to the performance of the whole team (e.g. Ali, 1988; Hughes *et al.*, 1988; Yamanaka *et al.*, 1993, 1997, 2002; Tiryaki *et al.*, 1997; Japheth and Hughes, 2001; Hughes *et al.*, 2001c; Brown and Hughes, 2004; Fleig and Hughes, 2004; Hughes and Snook, 2006) a paucity research has focused upon specific playing positions and individual player (e.g. Grehaigne *et al.*, 1997b; James *et al.*, 2002; Kuhn, 2005). Grehaigne *et al.* (1997b) provided a meticulous player 'action zone' but their study was limited as the reliability of the notation system employed was not reported, 20% of their data were discarded rather arbitrarily and were also recorded at pre-determined time intervals (30 seconds) rather than in respect to a certain phase of soccer play (e.g. on-the-ball play, off-the-ball-play, attacking play, defensive play; Kormelink and Seeverens, 1999; Carling *et al.*, 2005).

To complement the findings of Study 1 and address the highlighted issues within existing soccer-based notational analysis research, the aim of the current study was to examine the tactical aspect of soccer performance at team, playing position and individual player levels through the construction of reliable and detailed spatial profiles. The first objective was to provide a descriptive appraisal of the spatial dimensions of the sampled team's performance. Based on the findings of James *et al.* (2002) and Bloomfield *et al.* (2005a) it was expected that the midfield third of the pitch would contain the highest frequency of behaviours performed. Furthermore, a tendency for the sampled team to predominantly direct play through either wide or central pitch areas

was also hypothesised (e.g. Ali, 1988; Hughes *et al.*, 1988; Tiryaki *et al.*, 1997; James *et al.*, 2002; Fleig and Hughes, 2004).

The second objective was to develop and compare spatial profiles between the fullback, centre back, midfield and forward playing positions. Despite the dearth of related research literature some insight into this aspect of performance can be gleaned from playing position classifications and discussions of team formations (Grehaigne *et al.*, 1997b; Verlinden *et al.*, 2001b; Bray, 2006). For example, the 'defence' (i.e. fullback and centre back playing positions) would be expected to perform the majority of their behaviours nearest their own goal, the forward playing position nearest the opposition goal and the midfield playing positions between these extremes (cf. Kuhn, 2005). An exploratory hypotheses was consequently generated that predicted the fullback and centre back positions would perform the majority of their behaviours within the defensive pitch third while the midfield and forward positions would carry out the majority of their behaviours within the midfield and attacking thirds of the pitch respectively. In accordance with the findings of James *et al.* (2002) it was also suggested that the longitudinal and latitudinal distribution of the behaviours executed by each playing position would reflect that of the overall team.

The final objective was to establish and compare spatial profiles and detailed zones of operation for individual players within each playing positions. Existing coaching literature and preliminary empirical investigations imply that soccer players perform within restricted sectors of the pitch (Grehaigne *et al.*, 1997b; Kormelink and Seeverens, 1999; Carling *et al.*, 2005; Beetz and Lames, 2006). It was therefore expected that the individuals within each position would execute their behaviours in distinctive areas. The spatial profiles and zones of operation for individual player performance were additionally hypothesised to correspond to the spatial dimensions of their respective playing positions (James *et al.*, 2002). For example, if the forward playing position demonstrated a bias to the pitch left then it would be anticipated that individuals within this position would also display this trend.

4.2 Methodology

4.2.1 Study Design

Matches played by a professional British soccer team during the 2003-2004 domestic league season were sampled according to availability (n = 22) and observed post-event using the Noldus Observer Video Pro 4.1 behavioural measurement package (Noldus

Information Technology, 2002). Data collection was primarily based upon a spatial measure that assessed the occurrence of behaviours performed by the team, playing position and individual players, across nine defined sectors of the soccer pitch. To provide additional detail at individual player level a further spatial measure was developed to identify specific zones of operation and overall pitch coverage. These measures were validated by soccer coaches and experienced notational analysts.

4.2.2 Participants

The sampled soccer club provided access to video footage of matches played during the 2003-2004 domestic league season. In total 11 home and 11 away matches comprising 8 wins, 8 losses and 6 draws, with 31 goals scored and 29 goals conceded were available for analysis. The selection of players followed the rationale of Study 1, resulting in 30 players being included within team and inter-position analyses (mean age ± standard deviation = 24.0 ± 4.5 years, mean appearances ± standard deviation = 8.8 ± 6.0) and 14 players for intra-positional analyses (mean appearances ± standard deviation = 13.6 ± 4.1).

4.2.3 Measures

To assess the tactical facet of performance two spatial measures were developed. First, soccer coaching and notational analysis literature were reviewed to identify previously utilised pitch division for describing the spatial dimensions of performance. In general, evidence from applied settings suggested that this tactical information was communicated through longitudinal pitch divisions of the defensive third, midfield third and attacking third and latitudinal sectors of wide (i.e. left and right) and central pitch areas (Hughes, 1999; Kormelink and Seeverens, 1999; Carling *et al.*, 2005). While these divisions have also been employed within research literature a number of variations are evident according to the specific purpose of the study and the required level of detail (e.g. Ali, 1988; Hughes *et al.*, 1988; Yamanaka *et al.*, 1993, 1997, 2002; Tiryaki *et al.*, 1997; Japheth and Hughes, 2001; Hughes *et al.*, 2001c; Brown and Hughes, 2004; Fleig and Hughes, 2004; Hughes and Snook, 2006, see also Grehainge *et al.*, 2001). In accordance with the appraised literature the initial spatial developed was based upon 9 equally sized pitch areas (Figure 4.1) However, to provide more detail for individual players, a second spatial measure utilising 36 identical zones was devised following consultation with two experienced notational analysis researchers (Figure 4.2). The use

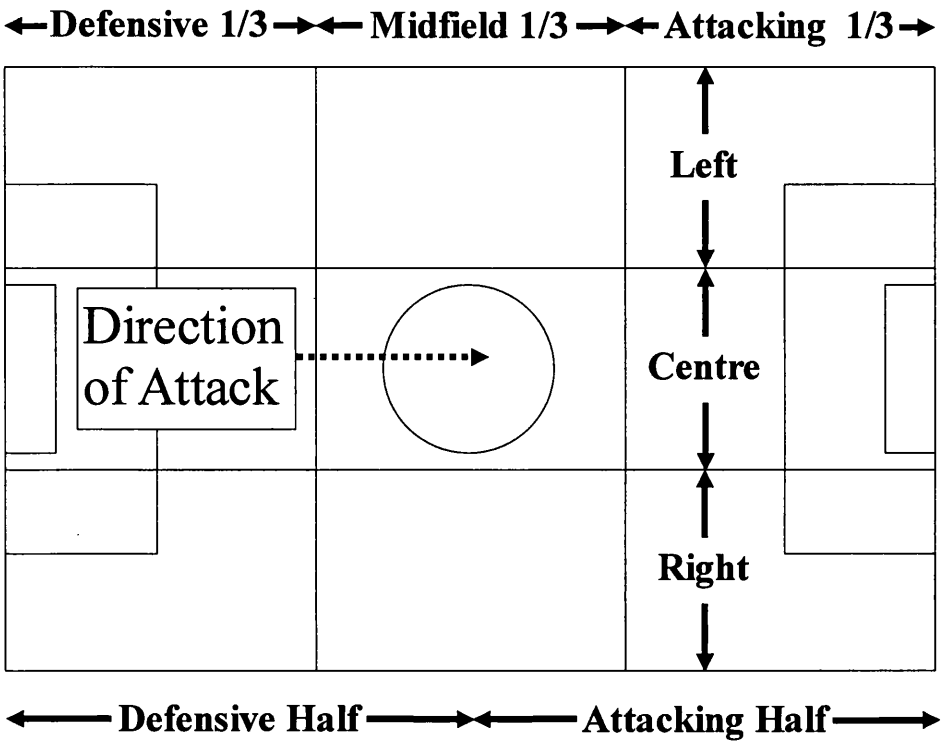


Figure 4.1 Pitch divisions employed for data collection and analysis relating to spatial profiles

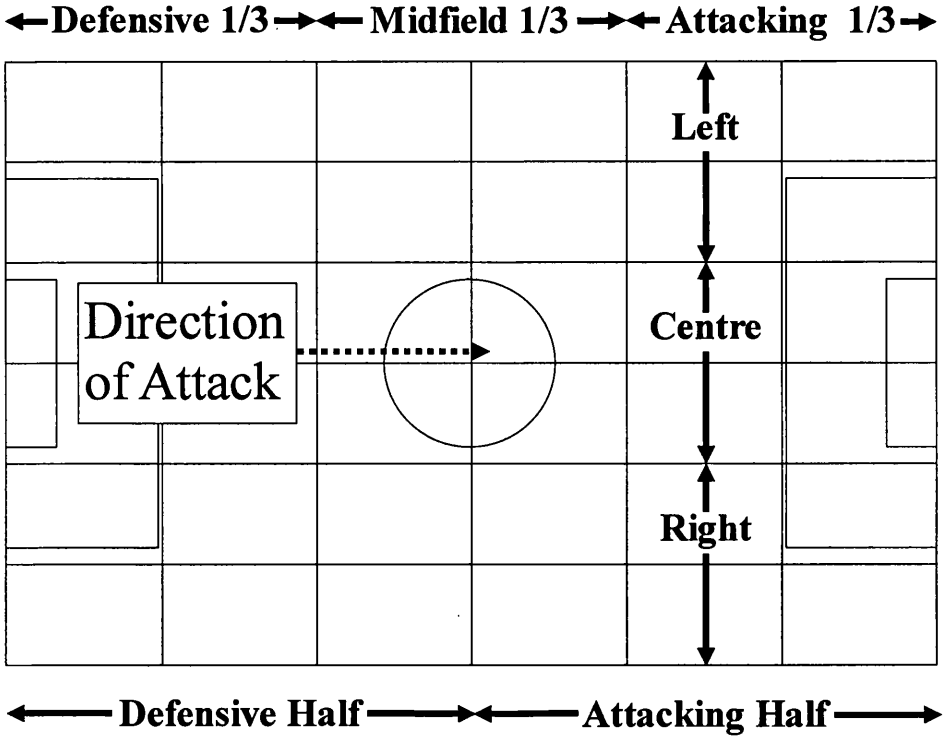


Figure 4.2 Pitch divisions employed for data collection and analysis relating to individual player zones of operation

of 36 areas was selected as a meticulous representation of the spatial functioning of individuals could be provided while maintaining the ability to identify pitch areas relatively easily during analysis of match footage. Furthermore, the second measure was effectively equivalent to the first measure but with each of the original nine defined areas subdivided into four further sectors, thus allowing direct comparisons between the two approaches. Indeed, this aided data collection as the spatial information were collated using the second measure with the frequencies in appropriate pitch areas being summed to allow construction and analysis of spatial profiles. Both spatial measures were subsequently validated by a professional soccer manager, his assistant (both ex-international players with over 30 years professional coaching experience), an independent coach (ex-professional player with 5 years coaching experience) and two notational analysis researchers (with a total of over 15 years experience).

4.2.4 Procedure

Ethical approval was obtained before commencement of the study from the University of Wales Swansea Ethics Committee (Appendix A). Consent to the use of match recordings was also acquired from the participating soccer club with the condition that that their identity and that of the opposition would remain anonymous and be treated in the strictest confidence. The procedures for obtaining and copying match recordings, together with the use of Observer Video Pro 4.1 behavioural measurement package for data collection, followed those outlined in Study 1. However, the coding structure and order of data entry were amended to include information pertaining to specific pitch areas and exclude the previously analysed behaviour outcomes (Figure 4.3). While the particular behaviours being performed were not of interest to the current study they were still coded to ensure the collection of relevant information (i.e. only the behaviours that were identified in Study 1 should be coded and not additional events such as goalkeeper actions or off-the-ball behaviour). As a result, changes were made to the manner in which dribbles were identified and recorded as there was a necessity to account for the fact that this behaviour could traverse more than one pitch area (Figure 4.4). After data collection the raw data were assembled in an SPSS v12.0 file (SPSS inc., 2003) for further analysis. Prior to initiating data collection for the current study three soccer matches were observed and coded was to provide a final check on the suitability of the spatial measures and the new coding structure with no areas for concern apparent.

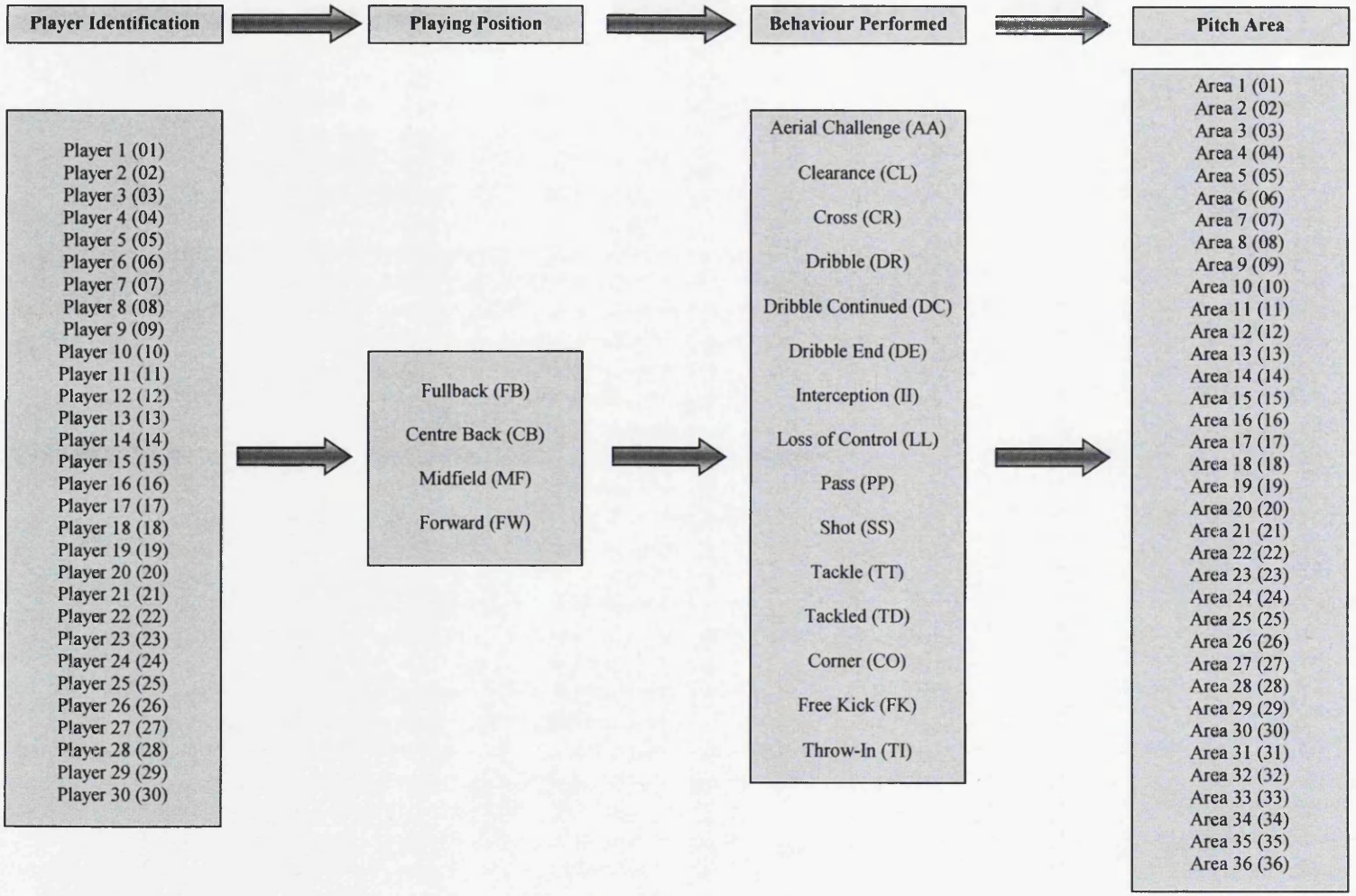


Figure 4.3 Coding structure and associated computer keystrokes (in brackets) for study 2 data collection.

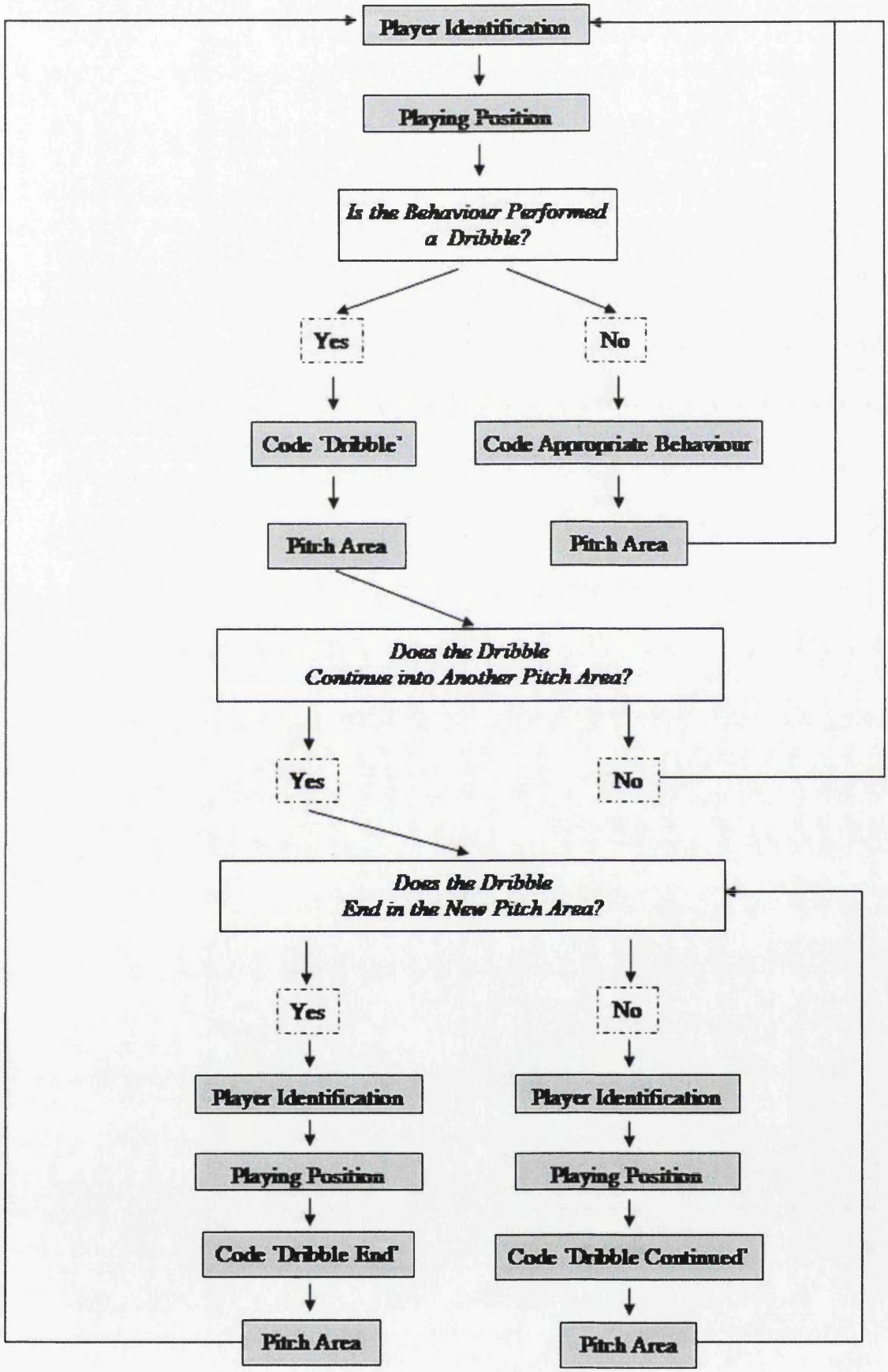


Figure 4.4 Data entry method to account for the amended coding of the dribble behaviour.

4.2.5 System Reliability

Due to the amended coding structure for the dribble behaviour, the inclusion of the spatial measures and the introduction of new players to the team since Study 1, the whole notation system was subjected to further reliability testing. In total, five matches were sampled from the participating team and analysed following the previously outlined methods (see section 3.2.5). To maintain consistency between the reliability results from Study 1, the same individuals were employed to provide the inter-observer reliability results within this study. They were again provided with five hour long training sessions on the system. For the identification of players, playing position and behaviour performed a level of <5.0% error was considered as acceptable (Hughes *et al.*, 2002, 2004a). With regard to pitch area identification (n = 9 and 36) the acceptance criteria was extended to <7.5% as this particular variable has been acknowledged to result in a large source of error (Hughes *et al.*, 2002, 2004a). Following reliability testing all variables fell within the set limits (Appendix D).

4.2.6 Data Analysis Overview

Data analysis involved four stages. First, data transformations were employed where players involved in intra-positional analyses had performance durations of less than 90 minutes. During the second and third stages respectively, spatial profiles and zones of operation were constructed. Finally, statistical analyses were conducted to compare the spatial profiles between (inter-positional) and within (intra-positional) playing positions. Intra-positional statistical analyses were complemented with visual assessments of individual player zones of operation where necessary.

4.2.6.1 Data Transformations for Appearance Durations <90 Minutes

For intra-positional analyses the data for player performances of <90 minutes in duration were subjected to the transformation described in Study 1 (see section 3.2.6.1).

4.2.6.2 Construction of Team, Playing Position and Individual Player Spatial Profiles

Spatial profiles were developed for the team, each playing position and individual players by calculating the median frequency of behaviours performed within each of the nine defined pitch areas together with 95% confidence limits for the population median (James *et al.*, 2003). This approach was selected due to the data being measured on a nominal scale (Nevill *et al.*, 2002; James *et al.*, 2003). In addition medians and

associated 95% confidence limits for the population median were calculated with reference to the longitudinal (defensive third, midfield third, attacking third) and also the latitudinal (left, centre, right) aspects of the pitch.

4.2.6.3 Construction of Individual Player Zones of Operation

Individual player zones of operation were constructed to supplement the information provided by the spatial profiles and thus offer a more in-depth analysis of the tactical component of performance. Each player's zone of operation was created by summing the number of behaviours performed within each pitch area (n = 36), sorting into rank order and then calculating quintiles. Each quintile represents one fifth of the percentile scale (Vincent, 1999) and facilitates direct comparisons between each area of the pitch and also between individual players. For example, if the frequency of behaviours performed by a player in a specific area was observed to be within the 5th Quintile, while another player was in the 3rd quintile it would be concluded that the former player executes a greater percentage of their behaviours within that area. To aid presentation of the zones of operation a particular colour shade and pattern was designated to each quintile and used to fill appropriate areas on a pitch diagram (cf. Grehaigne *et al.*, 1997b). For example, if a player failed to execute a behaviour within a particular area of the pitch the corresponding part of the zone of operation diagram would remain white whereas the most frequented locations were filled dark grey with spotted patterning (Figure 4.5).

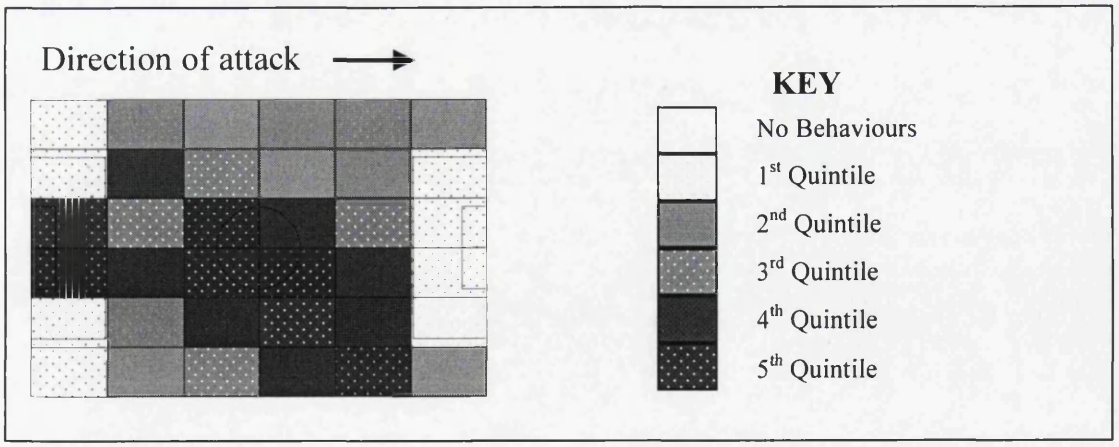


Figure 4.5 An example zone of operation as defined via the occurrence of behaviours performed within 36 pitch sectors.

4.2.6.4 Analyses of Spatial Profiles and Zones of Operation

Spatial profiles for the team, playing positions and individual players were evaluated via a combination of one-way and two-way chi-square tests of significance (see section 3.2.6.4) relating to the distributions of behaviours over the whole pitch and also along the longitudinal and latitudinal divisions. Chi-square tests of significance were selected as a result of the non-normal and nominal nature of the data with alpha levels set at $p<0.05$ (Vincent, 1999; Ntoumanis, 2001; Nevill *et al.*, 2002; Field, 2005). In addition, to supplement the information provided by the statistical analyses, individual player zones of operation were assessed visually. Finally the overall pitch coverage of each individual player in the matches which they appeared was determined by dividing the number of pitch areas within which a behaviour was performed by the total number of pitch areas (n = 36) and converting to a percentage.

4.3 Results

4.3.1 Team Spatial Profile

The spatial profile of the team demonstrated an unequal distribution of behaviours across the pitch surface ($\chi^2(8) = 1077.90$, $p<0.01$). Most behaviours occurred within the centre of the midfield third and least within the left of the attacking third (Table 4.1). With regard to the longitudinal aspect of the pitch most behaviours were observed

Table 4.1 Spatial profile for a professional British soccer team during 22 matches of the 2003-2004 domestic league season based upon medians and 95% confidence limits (CL) for behaviour occurrence within nine pitch areas.

Longitudinal Pitch Third	Latitudinal Pitch Third	Median Frequency	Upper 95%CL	Lower 95% CL
Defensive	Left	77.5	84.0	64.0
	Centre	116.5	138.0	109.0
	Right	57.0	72.0	51.0
Midfield	Left	79.0	92.0	72.0
	Centre	126.5	133.0	105.0
	Right	103.5	131.0	87.0
Attacking	Left	43.0	54.0	31.0
	Centre	72.5	77.0	59.0
	Right	86.5	95.0	74.0

within the midfield third (median = 298.0, upper 95% confidence limit = 354.0, lower 95% confidence limit = 273.0) followed by the defensive third (median = 266.5, upper 95% confidence limit = 292.0, lower 95% confidence limit = 231.0) and the attacking third (median = 200.0, upper 95% confidence limit = 225.0, lower 95% confidence limit = 180.0) respectively ($\chi^2(2) = 342.04$, $p<0.01$). In relation to the latitudinal dimension of the pitch behaviours were focused within central areas (median = 318.0, upper 95% confidence limit = 342.0, lower 95% confidence limit = 284.0) followed by the pitch right (median = 252.5, upper 95% confidence limit = 285.0, lower 95% confidence limit = 232.0) and the pitch left (median = 190.5, upper 95% confidence limit = 213.0, lower 95% confidence limit = 179.0; $\chi^2(2) = 765.83$, $p<0.01$).

4.3.2 Inter-position Spatial Profile Comparisons

Inter-positional comparisons revealed distinct spatial profiles each playing position ($\chi^2(24) = 4447.41$, $p<0.01$; Table 4.2). Specific analysis of the fullback playing position identified that in reference to the longitudinal aspect of the pitch the majority of behaviours occurred within the midfield third (median = 75.0, upper 95% confidence limit = 84.0, lower 95% confidence limit = 54.0) followed by the defensive third (median = 52.0, upper 95% confidence limit = 71.0, lower 95% confidence limit = 43.0) and the attacking third (median = 26.5, upper 95% confidence limit = 30.0, lower 95% confidence limit = 22.0; $\chi^2(2) = 468.43$, $p<0.01$). In the latitudinal dimension, the right of the pitch was the dominant area for fullback performance (median = 66.5, upper 95% confidence limit = 79.0, lower 95% confidence limit = 50.0) followed by the pitch left (median = 60.5, upper 95% confidence limit = 71.0, lower 95% confidence limit = 50.0) and lastly the central pitch areas (median = 25.5, upper 95% confidence limit = 39.0, lower 95% confidence limit = 19.0; $\chi^2(2) = 329.93$, $p<0.01$).

The centre back playing position mainly executed behaviours within the defensive third (median = 63.5, upper 95% confidence limit = 76.0, lower 95% confidence limit = 50.0) with less behaviours in the midfield third (median = 45.5, upper 95% confidence limit = 65.0, lower 95% confidence limit = 30.0) and the attacking third (median = 4.0, upper 95% confidence limit = 8.0, lower 95% confidence limit = 3.0; $\chi^2(2) = 923.44$, $p<0.01$). Differences were also identified in the latitudinal distribution of the behaviours performed by the centre back playing position ($\chi^2(2) = 341.00$, $p<0.01$) highlighting a tendency towards central pitch areas (median = 59.0,

Table 4.2 Spatial profiles for the fullback, centre back, midfield and forward playing positions based upon medians and 95% confidence limits (CL) for behaviour occurrence within nine pitch areas during 22 matches of the 2003-2004 domestic league season of a professional British soccer team.

Playing Position	Measure	Defensive Third			Midfield Third			Attacking Third		
		Left	Centre	Right	Left	Centre	Right	Left	Centre	Right
	Median	**20.0**	**11.0**	**19.5**	**24.0**	**9.0**	**34.0**	**9.0**	**2.0**	**13.0**
Fullback	*+CL*	*31.0*	*20.0*	*24.0*	*35.0*	*18.0*	*45.0*	*12.0*	*3.0*	*18.0*
	-CL	*19.0*	*8.0*	*12.0*	*18.0*	*7.0*	*23.0*	*4.0*	*1.0*	*9.0*
	Median	**19.5**	**29.5**	**12.5**	**9.5**	**26.5**	**13.5**	**1.0**	**3.0**	**0.5**
Centre Back	*+CL*	*22.0*	*36.0*	*17.0*	*12.0*	*36.0*	*17.0*	*2.0*	*5.0*	*2.0*
	-CL	*10.0*	*24.0*	*9.0*	*6.0*	*16.0*	*7.0*	*0.0*	*1.0*	*0.0*
	Median	**18.0**	**18.0**	**18.5**	**34.5**	**60.0**	**44.5**	**20.5**	**29.0**	**51.0**
Midfield	*+CL*	*29.0*	*27.0*	*26.0*	*44.0*	*73.0*	*56.0*	*29.0*	*32.0*	*68.0*
	-CL	*15.0*	*13.0*	*11.0*	*26.0*	*54.0*	*34.0*	*13.0*	*26.0*	*36.0*
	Median	**1.0**	**1.0**	**1.0**	**12.0**	**21.0**	**12.5**	**9.5**	**37.0**	**17.0**
Forward	*+CL*	*3.0*	*2.0*	*2.0*	*14.0*	*24.0*	*17.0*	*12.0*	*43.0*	*25.0*
	-CL	*0.0*	*1.0*	*0.0*	*8.0*	*18.0*	*9.0*	*7.0*	*27.0*	*12.0*

upper 95% confidence limit = 73.0, lower 95% confidence limit = 40.0), with similar behaviour occurrences in the left (median = 31.0, upper 95% confidence limit = 33.0, lower 95% confidence limit = 21.0) and right pitch sectors (median = 28.0, upper 95% confidence limit = 38.0, lower 95% confidence limit = 18.0).

The majority of behaviours carried out by the midfield playing position occurred within the midfield third of the pitch (median = 136.0, upper 95% confidence limit = 165.0, lower 95% confidence limit = 116.0) followed by the attacking (median = 117.5, upper 95% confidence limit = 133.0, lower 95% confidence limit = 98.0) and defensive pitch thirds (median = 53.5, upper 95% confidence limit = 70.0, lower 95% confidence limit = 47.0; $\chi^2(2) = 747.91$, $p<0.01$). The midfield playing position displayed a non-uniform distribution of behaviours across the latitudinal aspects of the pitch ($\chi^2(2) = 59.00$, $p<0.01$) although occurrences were comparable within the central area (median = 113.5, upper 95% confidence limit = 131.0, lower 95% confidence limit = 91.0) and the right side of the pitch (median = 117.0, upper 95% confidence limit = 134.0, lower 95% confidence limit = 102.0). Conversely fewer behaviours were observed on the left side of the pitch (median = 87.5, upper 95% confidence limit = 98.0, lower 95% confidence limit = 73.0).

The forward playing position was observed to mainly operate within the attacking pitch third (median = 75.5, upper 95% confidence limit = 88.0, lower 95% confidence limit = 60.0) and to a lesser extent in the midfield third (median = 43.0, upper 95% confidence limit = 38.0, lower 95% confidence limit = 52.0) and the defensive third (median = 4.0, upper 95% confidence limit = 6.0, lower 95% confidence limit = 2.0; $\chi^2(2) = 1278.00$, $p<0.01$). Finally, in relation to latitudinal pitch dimension the forward playing position primarily functioned within central pitch areas (median = 59.0, upper 95% confidence limit = 70.0, lower 95% confidence limit = 49.0), with fewer behaviours being executed on the pitch left (median = 27.0, upper 95% confidence limit = 45.0, lower 95% confidence limit = 21.0) and pitch right (median = 30.0, upper 95% confidence limit = 43.0, lower 95% confidence limit = 22.0; $\chi^2(2) = 228.84$, $p<0.01$).

4.3.3 Comparisons of Intra-positional Spatial Profile and Zones of Operation

Intra-positional comparisons revealed distinct spatial profiles (Tables 4.3 and 4.4) between the three selected fullbacks ($\chi^2(16) = 1617.93$, $p<0.01$), three centre backs

Table 4.3 Spatial profiles for selected individuals within the fullback and centre back playing positions based upon medians and 95% confidence limits (CL) for behaviour occurrence within nine pitch areas during 22 matches of the 2003-2004 domestic league season of a professional British soccer team.

Player and Appearances	Measures	Defensive Third			Midfield Third			Attacking Third		
		Left	Centre	Right	Left	Centre	Right	Left	Centre	Right
Fullback 1 ($n = 8$)	**Median**	**0.0**	**6.5**	**18.0**	**0.0**	**3.1**	**31.8**	**0.0**	**1.5**	**14.0**
	+CL	*1.0*	*10.0*	*44.0*	*2.0*	*12.4*	*48.0*	*1.0*	*8.9*	*24.0*
	-CL	*0.0*	*0.0*	*3.0*	*0.0*	*1.0*	*19.0*	*0.0*	*0.0*	*3.1*
Fullback 2 ($n = 12$)	**Median**	**0.0**	**13.8**	**18.5**	**0.0**	**4.8**	**18.2**	**-**	**1.0**	**6.7**
	+CL	*1.0*	*20.6*	*24.0*	*2.5*	*11.0*	*33.0*	*-*	*1.9*	*10.0*
	-CL	*0.0*	*8.0*	*5.0*	*0.0*	*1.9*	*2.0*	*-*	*0.0*	*0.0*
Fullback 3 ($n = 14$)	**Median**	**19.5**	**3.8**	**0.0**	**25.2**	**6.0**	**0.0**	**9.5**	**0.0**	**-**
	+CL	*30.0*	*6.0*	*0.0*	*41.4*	*9.0*	*1.0*	*12.0*	*2.0*	*-*
	-CL	*17.0*	*2.9*	*0.0*	*19.0*	*4.0*	*0.0*	*4.0*	*0.0*	*-*
Centre Back 1 ($n = 9$)	**Median**	**6.0**	**21.0**	**9.2**	**3.0**	**19.0**	**14.3**	**1.0**	**2.0**	**0.0**
	+CL	*17.0*	*27.0*	*16.0*	*9.0*	*23.0*	*17.0*	*1.0*	*4.0*	*3.0*
	-CL	*3.0*	*17.0*	*4.0*	*1.0*	*12.0*	*2.0*	*0.0*	*1.0*	*0.0*
Centre Back 2 ($n = 16$)	**Median**	**3.0**	**17.0**	**11.0**	**1.0**	**9.5**	**9.8**	**-**	**1.0**	**0.0**
	+CL	*5.0*	*24.8*	*18.0*	*2.0*	*22.0*	*20.0*	*-*	*2.0*	*2.0*
	-CL	*0.0*	*12.0*	*8.0*	*0.0*	*7.0*	*6.0*	*-*	*0.0*	*0.0*
Centre Back 3 ($n = 16$)	**Median**	**15.0**	**15.5**	**3.0**	**9.0**	**13.5**	**2.0**	**1.0**	**1.5**	**-**
	+CL	*19.0*	*19.0*	*4.0*	*11.0*	*21.0*	*3.0*	*2.0*	*4.0*	*-*
	-CL	*10.0*	*11.0*	*1.0*	*5.0*	*8.0*	*0.0*	*0.0*	*1.0*	*-*

Table 4.4 Spatial profiles for selected individuals within the midfield and forward playing positions based upon medians and 95% confidence limits (CL) for behaviour occurrence in nine pitch areas during 22 matches of the 2003-2004 domestic league season of a professional British soccer team.

Player and Appearances	Measure	Defensive Third			Midfield Third			Attacking Third		
		Left	Centre	Right	Left	Centre	Right	Left	Centre	Right
Midfielder 1 ($n = 21$)	**Median**	**1.0**	**4.0**	**5.0**	**2.0**	**16.0**	**12.0**	**3.0**	**8.0**	**16.0**
	+CL	*2.0*	*6.0*	*6.0*	*6.0*	*21.0*	*18.0*	*6.0*	*12.0*	*19.0*
	-CL	*1.0*	*2.0*	*3.0*	*1.0*	*11.0*	*11.0*	*1.0*	*7.0*	*9.0*
Midfielder 2 ($n = 15$)	**Median**	**6.0**	**7.0**	**1.0**	**11.0**	**12.0**	**2.0**	**2.0**	**2.0**	**2.0**
	+CL	*22.1*	*14.0*	*2.0*	*16.0*	*18.0*	*4.0*	*6.0*	*7.0*	*3.0*
	-CL	*4.0*	*4.0*	*0.0*	*9.0*	*6.0*	*0.0*	*1.0*	*0.0*	*0.0*
Midfielder 3 ($n = 10$)	**Median**	**8.3**	**5.5**	**9.5**	**11.5**	**28.5**	**13.0**	**6.5**	**5.0**	**9.0**
	+CL	*11.0*	*16.0*	*11.0*	*17.0*	*36.0*	*18.0*	*8.0*	*8.0*	*13.0*
	-CL	*3.0*	*0.0*	*3.0*	*6.0*	*15.4*	*6.0*	*2.0*	*0.0*	*3.0*
Midfielder 4 ($n = 11$)	**Median**	**-**	**1.0**	**10.2**	**0.0**	**5.0**	**17.2**	**0.0**	**3.0**	**30.0**
	+CL	-	*5.0*	*15.0*	*1.0*	*7.0*	*34.0*	*2.0*	*5.0*	*44.0*
	-CL	-	*0.0*	*0.0*	*0.0*	*0.0*	*10.0*	*0.0*	*1.0*	*28.0*
Midfielder 5 ($n = 17$)	**Median**	**1.0**	**1.0**	**0.0**	**5.0**	**13.0**	**9.0**	**5.0**	**21.0**	**5.0**
	+CL	*1.0*	*2.0*	*1.0*	*10.0*	*18.0*	*11.8*	*7.0*	*26.0*	*9.0*
	-CL	*0.0*	*1.0*	*0.0*	*3.0*	*11.2*	*3.0*	*2.0*	*15.0*	*3.1*
Midfielder 6 ($n = 8$)	**Median**	**2.5**	**7.0**	**2.0**	**7.0**	**27.0**	**13.0**	**3.5**	**8.0**	**9.5**
	+CL	*7.0*	*12.0*	*4.0*	*11.0*	*37.0*	*25.0*	*5.0*	*14.0*	*21.0*
	-CL	*0.0*	*3.0*	*3.0*	*6.0*	*14.0*	*13.0*	*1.0*	*4.0*	*11.0*
Forward 1 ($n = 19$)	**Median**	**1.0**	**1.0**	**0.0**	**5.0**	**14.0**	**9.0**	**3.6**	**23.0**	**6.0**
	+CL	1.0	2.0	1.0	10.0	18.0	10.0	6.0	26.3	8.0
	-CL	0.0	1.0	0.0	3.0	10.9	5.1	2.0	18.0	2.0
Forward 2 ($n = 15$)	**Median**	**1.0**	**-**	**-**	**5.0**	**7.0**	**4.0**	**6.0**	**16.0**	**9.0**
	+CL	2.0	-	-	8.0	9.0	8.0	11.0	21.9	22.0
	-CL	0.0	-	-	3.0	3.6	1.0	5.0	15.0	6.0

($\chi^2(16) = 469.58$, $p<0.01$), six midfielders ($\chi^2(40) = 2257.946$, $p<0.01$) and two forwards ($\chi^2(8) = 203.64$, $p<0.01$). Further statistical analysis relating to the longitudinal and latitudinal dimensions of each player's spatial profiles (Tables 4.5 and 4.6) supplemented with visual inspection of their zones of operation (Figure 4.6 through 4.9) provided more precise detail regarding individual tactical performance.

Within the fullback playing position, Fullback 1 was found to mainly operate within the midfield third ($\chi^2(2) = 52.04$, $p<0.01$) and towards the right of the pitch ($\chi^2(2) = 631.21$, $p<0.01$) whereas Fullback 2, while also biased to the pitch right ($\chi^2(2) = 272.08$, $p<0.01$), performed a similar number of behaviours in the midfield and defensive thirds ($\chi^2(2) = 100.20$, $p<0.01$). In contrast Fullback 3 executed the majority of their behaviours on the pitch left ($\chi^2(2) = 155.69$, $p<0.01$) and in the midfield third ($\chi^2(2) = 1141.59$, $p<0.01$). Inspection of the zones of operation supported the statistical findings but also demonstrated that the focus of all fullback performances were effectively along the length of the soccer pitch upon their respective sides (i.e. Fullback 1 and Fullback 2 on the pitch right and Fullback 3 on the pitch left).

With regard to the centre back playing position, all three individuals predominantly performed in central pitch areas but Centre Back 1 ($\chi^2(2) = 154.22$, $p<0.01$) and Centre Back 2 ($\chi^2(2) = 237.62$ $p<0.01$) also displayed a tendency to the right side of the pitch which contrasted to the left sided predisposition of Centre Back 3 ($\chi^2(2) = 267.59$, $p<0.01$). In the longitudinal direction, Centre Back 1 ($\chi^2(2) = 258.39$, $p<0.01$), Centre Back 2 ($\chi^2(2) = 307.02$, $p<0.01$) and Centre Back 3 ($\chi^2(2) = 333.56$, $p<0.01$) each executed the highest incidence of behaviours within the defensive third followed by the midfield third. Visual inspection of the zones of operation reinforced these findings and established that all three centre backs carried out the greatest percentage of their behaviours in a central area spanning the defensive and midfield thirds. It was also evident that the acknowledged right pitch side bias in Centre Back 1 and Centre Back 2 appeared to be more pronounced for the former individual.

Statistical examination of the spatial profiles and visual inspection of the zones of operation for players within the midfield playing position generally found the greatest number of behaviours to occur within the midfield pitch third (Midfielder 1 ($\chi^2(2) = 250.26$, $p<0.01$), Midfielder 2 ($\chi^2(2) = 137.24$, $p<0.01$), Midfielder 3 ($\chi^2(2) = 179.37$, $p<0.01$) and Midfielder 6 ($\chi^2(2) = 171.91$, $p<0.01$)). However, while Midfielder 1 and Midfielder 6 also displayed a inclination to the attacking third, Midfielder 2 displayed a

Table 4.5 Longitudinal and latitudinal breakdown of the spatial profiles for selected individuals within the fullback and centre back playing positions based upon medians and 95% confidence limits (CL) for behaviour occurrence within nine pitch areas during 22 matches of the 2003-2004 domestic league season of a professional British soccer team.

Player and Appearances	Measure	Longitudinal Pitch Divisions			Latitudinal Pitch Divisions		
		Defensive Third	Midfield Third	Attacking Third	Left	Centre	Right
Fullback 1 ($n = 8$)	**Median**	**26.0**	**35.8**	**15.5**	**0.0**	**11.9**	**66.0**
	+CL	*29.0*	*39.0*	*26.6*	*1.0*	*20.0*	*116.0*
	-CL	*23.0*	*25.0*	*3.1*	*0.0*	*12.0*	*40.0*
Fullback 2 ($n = 12$)	**Median**	**29.5**	**26.5**	**9.0**	**1.0**	**20.9**	**40.9**
	+CL	*39.0*	*39.0*	*10.2*	*5.0*	*30.3*	*61.0*
	-CL	*20.6*	*3.7*	*1.0*	*0.0*	*14.0*	*10.0*
Fullback 3 ($n = 14$)	**Median**	**26.6**	**31.1**	**11.5**	**58.5**	**11.5**	**0.5**
	+CL	*38.0*	*45.0*	*16.0*	*71.0*	*17.0*	*2.0*
	-CL	*21.0*	*23.0*	*7.0*	*49.0*	*5.8*	*0.0*
Centre Back 1 ($n = 9$)	**Median**	**38.0**	**33.0**	**3.0**	**8.0**	**42.0**	**26.0**
	+CL	*45.0*	*39.0*	*8.0*	*27.0*	*51.0*	*34.0*
	-CL	*34.0*	*33.0*	*1.0*	*3.0*	*41.0*	*6.0*
Centre Back 2 ($n = 16$)	**Median**	**32.5**	**25.5**	**1.7**	**4.7**	**32.0**	**25.2**
	+CL	*41.0*	*33.6*	*6.0*	*6.0*	*40.0*	*38.0*
	-CL	*28.0*	*15.0*	*0.0*	*2.0*	*24.0*	*15.0*
Centre Back 3 ($n = 16$)	**Median**	**35.0**	**27.0**	**3.0**	**26.0**	**31.5**	**4.5**
	+CL	*37.0*	*35.0*	*6.0*	*31.0*	*42.2*	*9.0*
	-CL	*28.0*	*16.0*	*1.5*	*19.9*	*25.0*	*3.0*

Table 4.6 Longitudinal and latitudinal breakdown of spatial profiles for selected individuals within the midfield and forward playing positions based upon medians and 95% confidence limits (CL) for behaviour occurrence within nine pitch areas during 22 matches of the 2003-2004 domestic league season of a professional British soccer team.

Player and Appearances	Measure	Longitudinal Pitch Divisions			Latitudinal Pitch Divisions		
		Defensive Third	Midfield Third	Attacking Third	Left	Centre	Right
Midfielder 1 ($n = 21$)	**Median**	**11.0**	**32.0**	**29.0**	**8.0**	**29.0**	**36.0**
	+CL	*15.0*	*43.0*	*39.0*	*15.0*	*36.0*	*40.0*
	-CL	*8.0*	*27.0*	*25.0*	*5.0*	*22.0*	*29.4*
Midfielder 2 ($n = 15$)	**Median**	**19.0**	**29.0**	**7.6**	**24.0**	**24.0**	**5.5**
	+CL	*42.0*	*39.0*	*15.0*	*37.0*	*31.0*	*8.0*
	-CL	*9.0*	*20.2*	*1.0*	*16.0*	*17.0*	*2.0*
Midfielder 3 ($n = 10$)	**Median**	**21.5**	**51.1**	**22.5**	**30.5**	**41.5**	**28.5**
	+CL	*35.8*	*67.0*	*30.7*	*35.8*	*64.0*	*36.0*
	-CL	*21.5*	*39.0*	*15.0*	*20.0*	*32.0*	*25.0*
Midfielder 4 ($n = 11$)	**Median**	**11.2**	**22.9**	**37.0**	**1.0**	**10.0**	**62.0**
	+CL	*19.0*	*42.0*	*49.7*	*6.0*	*16.0*	*97.0*
	-CL	*4.0*	*13.3*	*32.0*	*0.0*	*6.1*	*44.3*
Midfielder 5 ($n = 17$)	**Median**	**15.0**	**31.9**	**33.0**	**38.4**	**29.2**	**5.0**
	+CL	*16.0*	*40.0*	*38.6*	*49.0*	*36.0*	*11.0*
	-CL	*5.0*	*25.2*	*27.0*	*28.0*	*27.0*	*3.0*
Midfielder 6 ($n = 8$)	**Median**	**11.5**	**45.5**	**24.0**	**16.0**	**40.5**	**26.5**
	+CL	*19.0*	*60.0*	*36.0*	*25.0*	*52.0*	*50.0*
	-CL	*4.0*	*35.0*	*17.0*	*7.0*	*29.0*	*17.0*
Forward 1 ($n = 19$)	**Median**	**3.0**	**30.0**	**32.3**	**11.0**	**38.0**	**14.0**
	+CL	*4.0*	*32.7*	*39.0*	*19.0*	*42.0*	*19.4*
	-CL	*1.2*	*24.0*	*27.8*	*6.0*	*34.0*	*11.0*
Forward 2 ($n = 15$)	**Median**	**1.0**	**18.0**	**46.0**	**18.0**	**25.5**	**18.0**
	+CL	*3.0*	*20.0*	*53.0*	*30.0*	*27.0*	*29.0*
	-CL	*0.0*	*13.0*	*39.0*	*16.0*	*18.0*	*6.0*

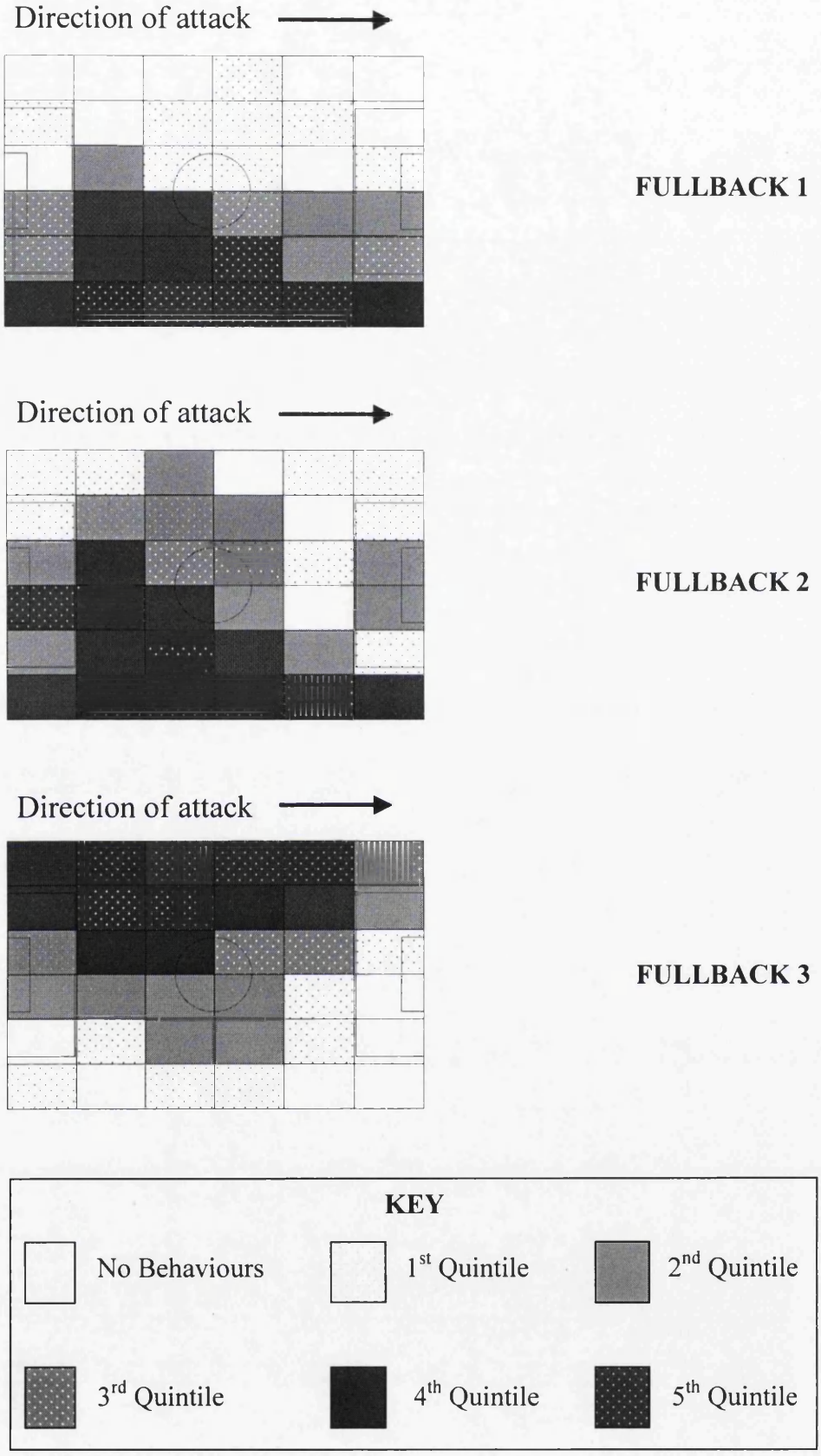


Figure 4.6 Zones of operation, based on behaviour occurrence within 36 pitch areas, for selected individuals within the fullback playing position of a professional British soccer team during 22 matches of the 2003-2004 domestic league season.

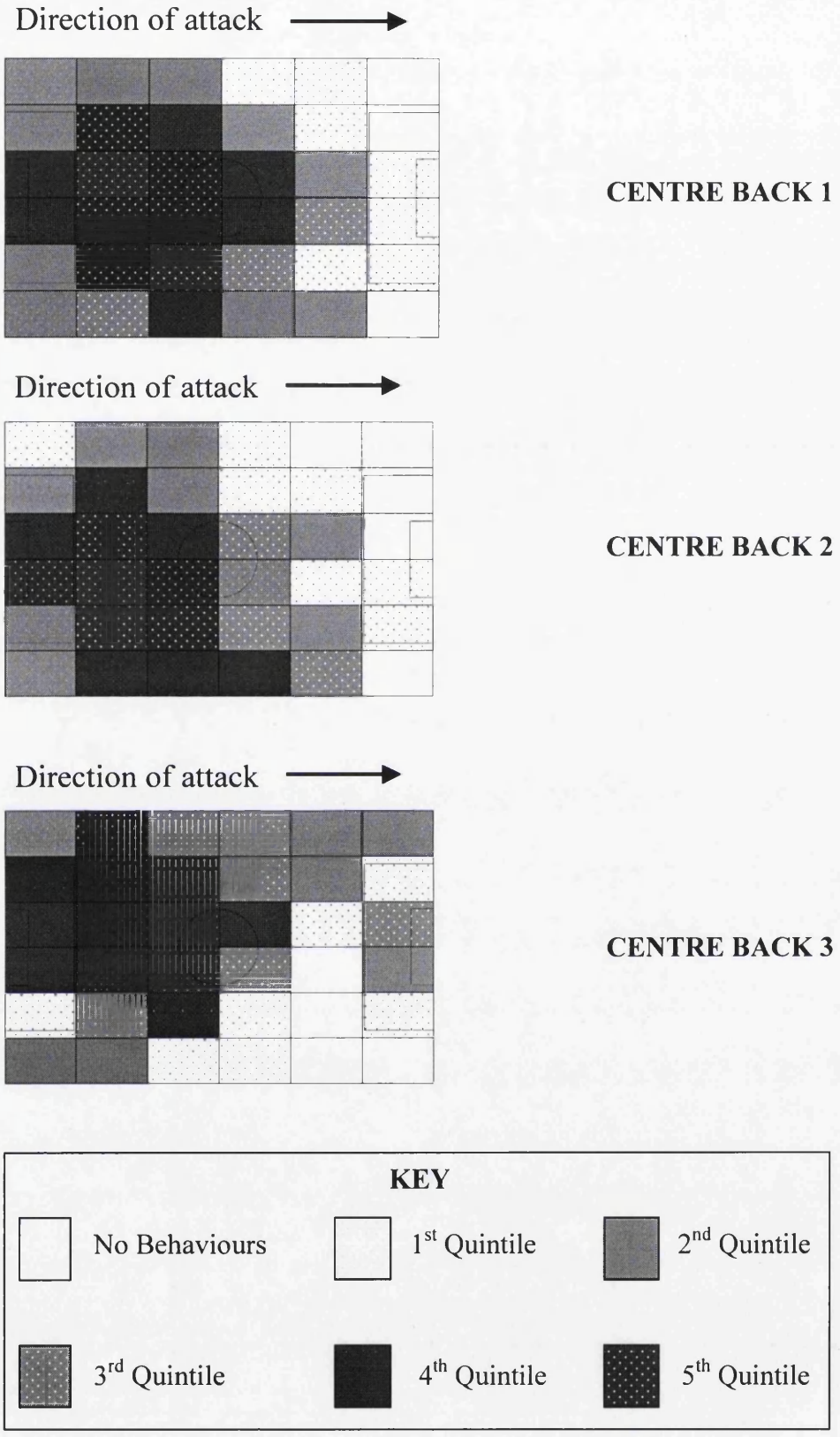


Figure 4.7 Zones of operation, based on behaviour occurrence within 36 pitch areas, for selected individuals within the centre back playing position of a professional British soccer team during 22 matches of the 2003-2004 domestic league season.

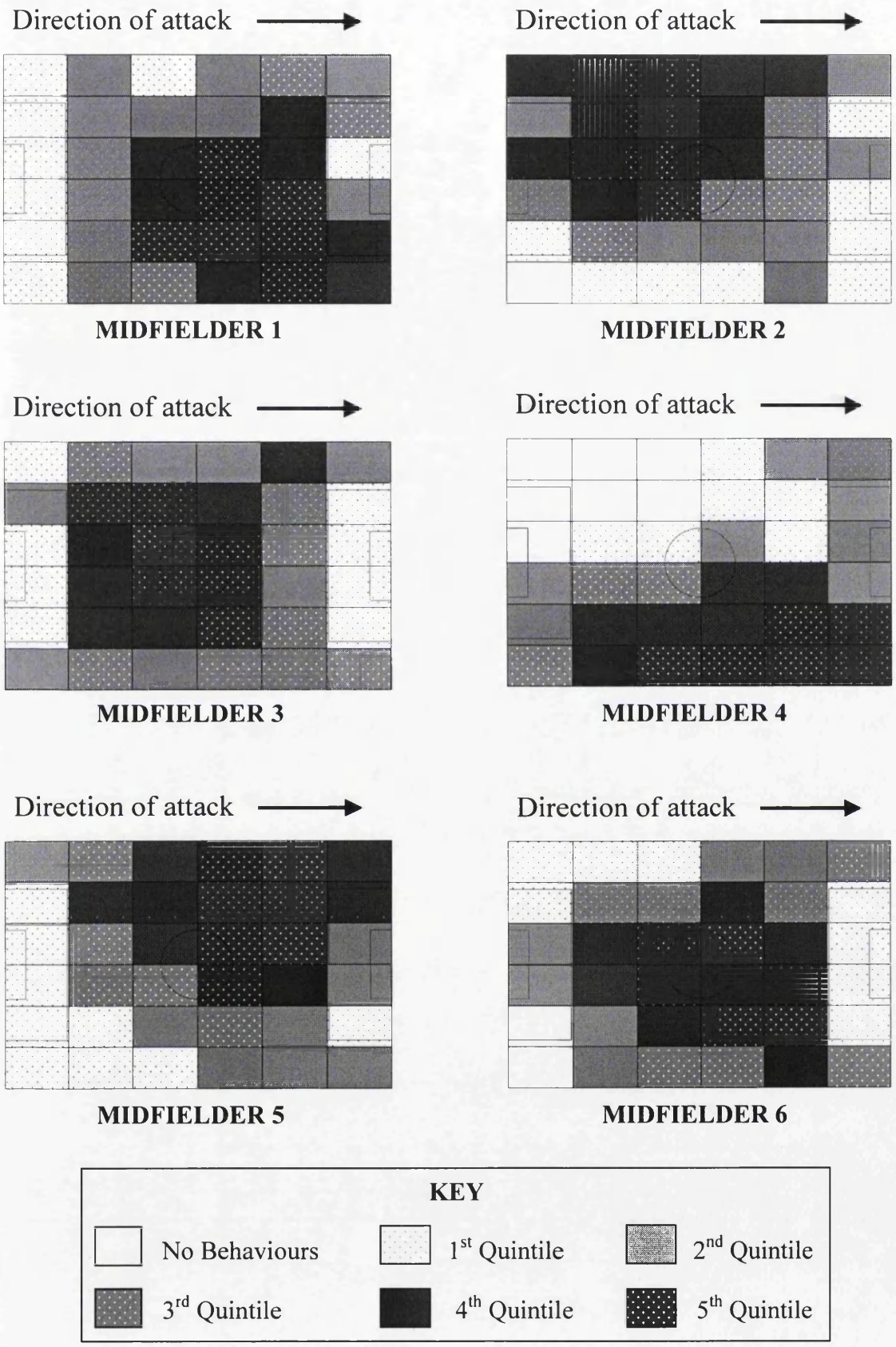


Figure 4.8 Zones of operation, based on behaviour occurrence within 36 pitch areas, for selected individuals within the midfield playing position of a professional British soccer team during 22 matches of the 2003-2004 domestic league season.

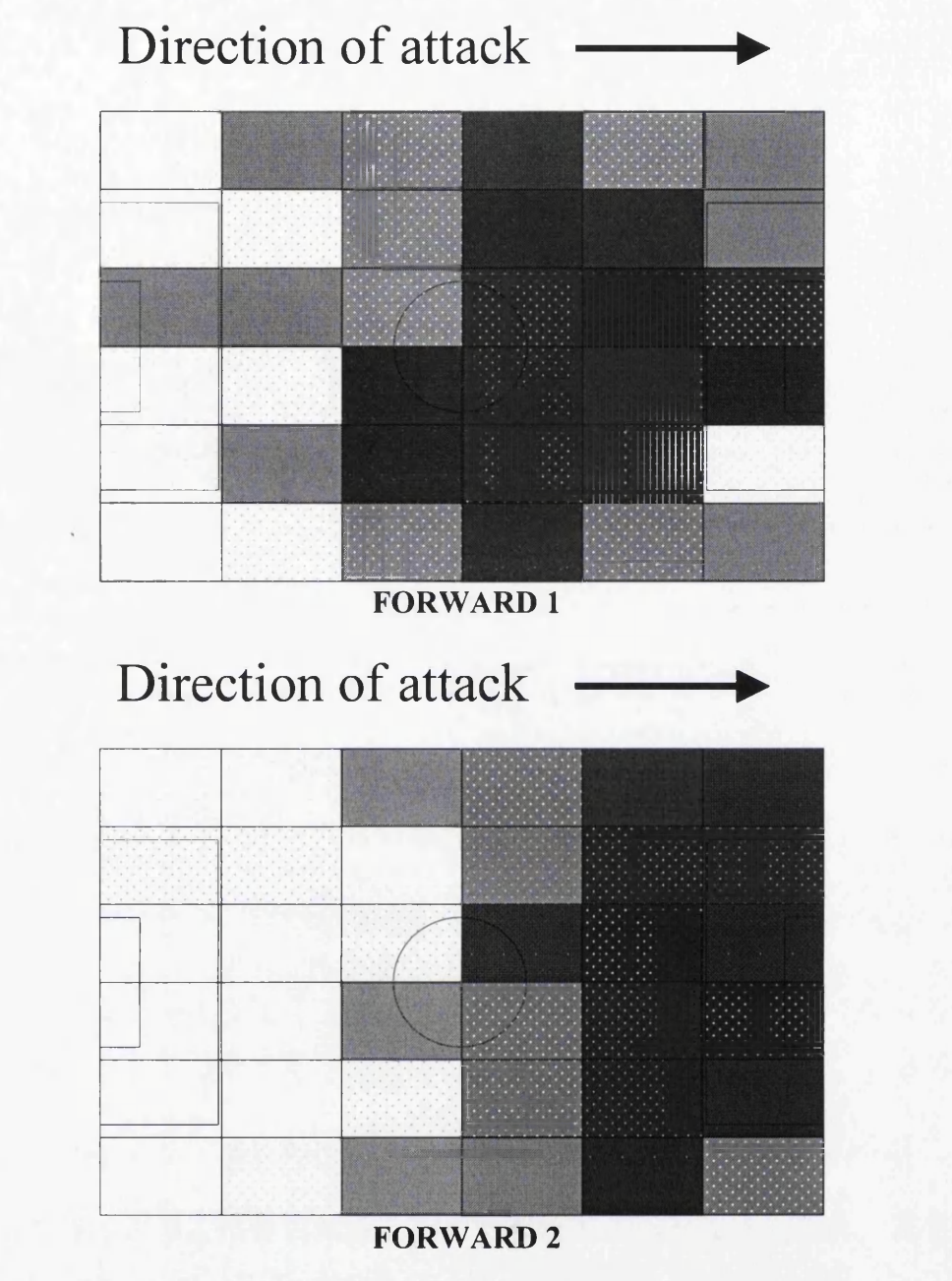


Figure 4.9 Zones of operation Zones of operation, based on behaviour occurrence within 36 pitch areas, for selected individuals within the forward playing position of a professional British soccer team during 22 matches of the 2003-2004 domestic league season.

trend towards the defensive pitch third. In contrast to all other players within the midfield playing position Midfielder 5 ($\chi^2(2) = 170.5306$, $p<0.01$) and, in particular, Midfielder 4 ($\chi^2(2) = 158.11$, $p<0.01$) principally performed behaviours within the attacking third followed by the midfield third. With reference to the lateral distribution of behaviours, Midfielder 3 ($\chi^2(2) = 40.66$, $p<0.01$) and Midfielder 6 ($\chi^2(2) = 93.14$, $p<0.01$) were both observed mainly within central pitch areas. Midfielder 1 ($\chi^2(2) = 231.54$, $p<0.01$) and Midfielder 4 ($\chi^2(2) = 849.41$, $p<0.01$) demonstrated a bias to the right hand side of the pitch whereas a left sided tendency was evident for Midfielder 2 ($\chi^2(2) = 249.05$, $p<0.01$) and Midfielder 5 ($\chi^2(2) = 277.39$, $p<0.01$).

Lastly, Forward 1 ($\chi^2(2) = 426.53$, $p<0.01$) and Forward 2 ($\chi^2(2) = 645.71$, $p<0.01$) primarily executed behaviours within the attacking third, although Forward 1 also demonstrated an inclination to the midfield pitch third. Evaluation of the zones of operation additionally revealed that, in contrast to Forward 1, Forward 2 rarely performed behaviour within the team's own half. In relation to the latitudinal distribution of behaviours across the pitch both Forward 1 ($\chi^2(2) = 296.82$, $p<0.01$) and Forward 2 ($\chi^2(2) = 12.42$, $p<0.01$) mainly functioned within central pitch areas.

4.3.4 Individual Player Pitch Coverage

Midfield players generally performed behaviours within the greatest number of pitch areas, with Midfielder 1, Midfielder 3 and Midfielder 6 displaying 100% pitch coverage over the course of the matches in which they appeared. Midfielder 2 and Midfielder 6 achieved 91.7% and 94.4% pitch coverage respectively whereas Midfielder 4 performed behaviours in 80.6% of the possible pitch areas. This coverage was identical to Forward 2 (80.6%) whilst Forward 1 performed behaviours within 97.2% of pitch areas. Fullback 1 (69.4%) displayed the lowest level of pitch coverage although this didn't appear characteristic of this particular playing position as Fullback 2 and Fullback 3 performed behaviours within 91.7% and 83.3% of pitch areas respectively. Finally the centre backs maintained a comparatively consistent level of pitch coverage (Centre Back 1 = 91.7%, Centre Back 2 and Centre Back 3 = 88.9%).

4.4 Discussion

The aim of this chapter was to examine the tactical aspect of performance exhibited by a professional British soccer team. This was accomplished through the development and

examination of spatial profiles at the team, playing position and individual player level. To provide additional detail regarding the tactical performance of each player individual zones of operation were also constructed. Support was found for the hypotheses under investigation that were derived from existing research literature. However, the exploratory hypothesis made in relation to the spatial profiles of each playing position was only partially supported. Overall, the results imply that the distribution of behaviours executed by the team, playing positions and individual players are not uniform across the pitch surface. In line with soccer coaching literature and existing research (e.g. Grehaigne *et al.*, 1997b; Kormelink and Seeverens, 1999; James *et al.*, 2002; Carling *et al.*, 2005) each playing position and individual player performed behaviours within distinct areas of the pitch that appear to relate to their tactical responsibilities (Fujimura and Sugihara, 2005; Beetz and Lames, 2007).

The first objective of this study was to examine the tactical element of the team's performance through the assessment of behaviour occurrence within nine areas of the soccer pitch. A bias of behaviours towards certain pitch areas was demonstrated reflecting the findings of existing studies of team strategy and tactics (e.g. Ali, 1988; Hughes *et al.*, 1988; Yamanaka *et al.*, 1993, 1997, 2002; Tiryaki *et al.*, 1997; Hook and Hughes, 2001; Hughes and Petit, 2001; Japheth and Hughes, 2001; James *et al.*, 2002; Brown and Hughes, 2004). With respect to the longitudinal pitch dimension, the majority of behaviours were executed within the midfield third supporting the findings of James *et al.* (2002) and Bloomfield *et al.* (2005a). This may reflect that passing, which is the most common behaviour (see section 3.3.1), occurs more in the midfield third than the defensive and attacking thirds combined (cf. Yamanaka *et al.*, 1993, 2002; Brown and Hughes, 2004). Furthermore, it appears that behaviours are concentrated within the midfield third as the competing teams are attempting to stop the ball approaching their own goal, as is highlighted by the fact changes of ball possession predominantly occur within this pitch segment (cf. Bate, 1988; Partridge *et al.*, 1993; Grehaigne *et al.*, 2002; Leser, 2006).

With regard to the lateral aspect of the pitch, the team mainly carried out behaviours within the central segment (cf. Ali, 1988; Hughes *et al.*, 1988; Tiryaki *et al.*, 1997; James *et al.*, 2002; Fleig and Hughes, 2004). Although this central tendency was prominent across the defensive and midfield thirds it was evident that, to a greater extent, the right side of the pitch was the dominant focus of behaviours within the attacking third. This may suggest that the team regain possession of the ball in central

areas when defending (cf. Grehaigne *et al.*, 2002; Leser, 2006) and direct ball into wide areas, specifically the right hand side, when attacking. Indeed, Tiryaki *et al.* (1997) have previously identified a similar pattern during an analysis of Switzerland in the 1994 World Cup. However, some caution is advised with this interpretation as the spatial profiles within this study were based upon all the on-the-ball behaviours executed and did not distinguish between those that were associated with attacking and defensive phases of play (Kormelink and Seeverens, 1999; Carling *et al.*, 2005).

The second objective was to develop and contrast spatial profiles between the fullback, centre back, midfield and forward playing positions. Due to a lack of relevant literature, exploratory hypotheses were generated which were only partially supported. As predicted the centre back, midfield and the forward playing positions were identified as predominantly operating within the defensive, midfield and attacking thirds of the pitch respectively (cf. Kuhn, 2005). However, while the midfield position frequently performed behaviours within all pitch thirds, the centre back and forward position rarely carried out behaviours within the attacking and defensive thirds respectively. This is indicative of the centre back playing position's principle role as goal defenders and the forward position as goal scorers, with the midfield having a dual responsibility in both defensive and attacking phases of play (cf. Wiemeyer, 2003; Bray, 2006; Probert and Hughes, 2006; Thelwell *et al.*, 2006). In contrast, the fullback position, which was hypothesised to mainly function within the defensive third, was actually observed to carry out most of their behaviours within the midfield third. This may relate to the fact that, despite the centre back and fullback playing positions making up the 'defensive unit' (Reilly and Thomas, 1976; Muniroglu, 2001; Kuhn, 2005; Bray, 2006), the fullback position also appears to have an attacking role. This is evident from the results of Study 1 and also existing literature which has shown the fullback playing position to perform behaviours such as crosses and shots (e.g. Dunn *et al.*, 2003; Hughes and Probert, 2006). Such research has also highlighted the responsibility of the fullback playing position for taking throw-ins following the ball passing over a pitch sideline. As this behaviour can occur anywhere along the longitudinal aspect of the pitch this may also account for the functioning of the fullback position outside of the defensive third. Indeed, Ensum *et al.* (2000, 2002) have reported that approximately seventeen throw-ins per match were awarded within the midfield and attacking pitch thirds during analyses of international competitions.

The second exploratory hypothesis that forecast a uniform distribution playing position behaviours across latitudinal pitch sectors was not supported. For example, the fullback position mainly operated in the left and right sides of the pitch whilst the centre back position had an inclination to central areas. To some extent, these findings are unsurprising given the configuration of these players in relation to each other as a 'defensive unit' (cf. Bray, 2006). Behaviour occurrence for the midfield and forward playing positions were also greatest within central areas but a tendency towards the pitch right was also observed for the midfield position. Indeed, the aforementioned team bias to execute behaviours in the central and right side of the midfield and attacking thirds was replicated in the spatial profile of the midfield playing position. A tendency toward the right hand side of the pitch over the left was also noted for the fullback position within the midfield and attacking pitch thirds. Similar findings were reported by James *et al.* (2002) and may suggest that the midfield and fullback playing positions have a particular influence on team strategy and tactics. While this differs from research which has advocated the equal importance all playing positions such conclusions were based upon technical performance indicators rather than specific measures of tactical performance (e.g. Nicholls *et al.*, 1993; Norris and Jones, 1998). Overall, the findings of this study reinforce the idea that direct links exist between team strategy and the tactical behaviour of individual playing positions (James *et al.*, 2002).

The final objective was to establish and compare spatial profiles and zones of operation for individual players within each playing positions. Examination of these measures supported previous research literature, signifying a distinct area of spatial operation for each player (Grehaigne *et al.*, 1997b; James *et al.*, 2002; Beetz and Lames, 2006). However, the suggestion in coaching literature that players operate within restricted zones (e.g. Kormelink and Seeverens, 1999) is questionable as all individuals within this study performed behaviour in over 69% of defined pitch areas during the analysed matches. A plausible explanation for this inconsistency is that while players are expected to focus their behaviours to confined pitch section they are occasionally required to perform outside of such restrictions. It was this concern that led Grehaigne *et al.* (1997b) to discard 20% of their data when observing the positioning of players upon the pitch and subsequently resulted in individual action areas that were equivalent to 17.5%-30.0% of the pitch surface. However, the inclusion of all data appears important as potential 'outliers' may represent discrepancies that require further investigation by a coach or analyst (Bracewell, 2003; Brillringer, 2007).

To some degree, the existence of intra-positional differences is logical due to the manner in which players are configured in relation to overall team formation (e.g. Verlinden *et al.*, 2001b; Bray, 2006). For example, fullbacks are commonly described as the left or right fullback in relation to the side of the centre backs, and hence the pitch, they are expected to perform. Similarly, midfielders can be considered as wide or central midfield players (cf. James *et al.*, 2002) and can both be subdivided further as left or right sided. Allowing for such intra-positional variations via visual inspections of the zones of operations suggests that the left (Fullback 3) and right fullbacks (Fullback 1 and Fullback 2) have similar spatial performance on their respective sides of the pitch, as do Midfielder 1 and Midfielder 5. Moreover, similar zones of operation were observed for individuals in different playing positions (e.g. Midfielder 2 and Centre Back 3). While this may be indicative of the specific tactical responsibility assigned to each player it may also imply role ambiguity or role conflict. Role ambiguity arises when an individual is unsure of their particular role whereas role conflict is the result of being assigned incongruent tasks (Eys *et al.*, 2006). The production of meticulous zones of operation therefore provides a useful diagnostic tool for soccer coaches and analysts. Overall, the existence of intra-positional variations in the spatial data suggest that categorisation of individual players according to generic positions is potentially misrepresentative when evaluating the tactical component of performance. Consequently, tactical instructions conveyed via spatial information at the playing position level should be supplemented with additional detailed data for appropriate individual players.

Collectively Study 1 and Study 2 have made a significant contribution to soccer-based notational analysis literature by providing detailed insight into the technical and tactical components of team, playing position and individual player performance using rigorous methodologies. This was achieved through the production of representative behavioural, outcome and spatial profiles, with zones of operation also developed for individual players. Despite these findings, James *et al.* (2003) have suggested that general profiles maybe insufficient in the analysis of sport due to factors such as match location and luck impinging on performance. While literature related to soccer coaching reinforces this opinion (e.g. Kormenlink and Severeens, 1999; Maynard, 2002; Carling *et al.*, 2005) it is evident that a paucity of research has examined the impact of such variables at a behavioural level (e.g. Sasaki *et al.*, 1999; O'Donoghue and Tenga, 2001; Jones *et al.*, 2004; Shaw and O'Donoghue, 2004; Bloomfield *et al.*, 2005a,b; Tucker *et*

al., 2005). Accordingly, there is a need to assess the influence of the factors purported to affect soccer in relation to the technical and tactical aspects of performance outlined in Study 1 and the current investigation. Through examining differing match circumstances a refined model upon which to base evaluations and predictions of the technical and tactical components of performance can be achieved (Mosteller, 1979; Potter and Hughes, 2001; McGarry and Franks, 2003; McGarry and Perl, 2004).

Chapter 5 – Study 3

Factors Influencing the Technical and Tactical Components of Soccer Performance

5.1 Introduction

The previous two studies have examined the technical and tactical components of soccer performance by assessing behavioural, outcome and spatial profiles at the team, playing position and individual player level. In addition, the tactical facet of individual player performance was investigated via specific zones of operation and percentage pitch coverage. These measures facilitated the objective assessment of the technical and tactical elements of soccer performance and, having been constructed through rigorous methodologies, provide representative models upon which future performance appraisals and predictions can be based (Mosteller, 1979; Potter and Hughes, 2001; McGarry and Franks, 2003; McGarry and Perl, 2004). However, James *et al.* (2003) have asserted that general profiles of performance maybe limited due to potential 'confounding' factors such as match location, environmental conditions, opposition quality, time of day, injuries and the match officials. This conclusion was made in relation to rugby union, but soccer coaching literature also suggests that effective evaluations of performance require that the conditions under which a match occur are accounted for (Kormenlink and Severeens, 1999; Carling *et al.*, 2005).

Many factors have been proffered as having an impact on soccer performance (e.g. Kormenlink and Severeens, 1999; Maynard, 2002; Carling *et al.*, 2005) and in line with the interactionist approach to psychology can be categorised as relating to the person or situation (Cox, 1998; Gill, 2000; Weinberg and Gould, 2003). Within soccer the situation factors of match location and opposition quality are acknowledged as particularly pertinent influences upon performance but these conclusions have been based upon global performance measures such as win/loss records and tournament rankings (Edwards, 1979; Barnett and Hilditch, 1993; Clarke and Norman, 1995; Norman, 1998; Nevill and Holder, 1999). Notational analysis research has provided preliminary evidence for the influence of match location on the technical and tactical components of performance at behavioural level yet the effect of opposition quality has been neglected (e.g. Sasaki *et al.*, 1999; Tucker *et al.*, 2005). An additional situation variable that has received attention within notational analysis literature is match status,

as determined by score-line. Match status has, to date, been suggested to influence the technical, tactical and physical aspects of performance and thus appears to be an important factor at behavioural level (e.g. O'Donoghue and Tenga, 2001; Jones *et al.*, 2004; Shaw and O'Donoghue, 2004; Bloomfield *et al.*, 2005a,b).

The highlighted notational analysis studies (Sasaki *et al.*, 1999; O'Donoghue and Tenga, 2001; Shaw and O'Donoghue, 2004; Bloomfield *et al.*, 2005a,b; Tucker *et al.*, 2005) support the notion that situation variables require consideration when evaluating the components of soccer performance (Kormenlink and Severeens, 1999; Carling *et al.*, 2005). Despite these findings, a particular limitation of existing research has been the examination of situation variables in isolation. This is inadequate as soccer, and sport in general, is a dynamic process under the influence of many interacting variables (Goldstein, 1979; Grehaigne, 2001a; McGarry and Franks, 2003; Carling *et al.*, 2005; Reed and O'Donoghue, 2005). Consequently, the aim of this study was to employ advanced modelling procedures to investigate the independent and interactive effect of the situation variables of match location, opposition quality and match status upon the technical and tactical facets of performance within a professional soccer team. In accordance with Study 1 and Study 2, technical performance was examined by considering behaviour incidence and outcome, whereas tactical performance was assessed via the distribution of behaviours across the pitch surface. Whilst the previous two studies considered technical and technical performance aspects at the team, playing position and individual player level the current study will only relate to the whole team due to the quantity of data required and complexity of analyses to be undertaken (Tabachnick and Fidell, 2001).

The first objective was to examine the independent effects and potential interactions of the selected situation variables in order to identify the best fitting model to account for the observed behaviour incidences, outcomes and occurrence across the pitch. Based upon previous soccer literature, it was expected that the models produced would include the match location, opposition quality and match status variables (e.g. Barnett and Hilditch, 1993; Clarke and Norman, 1995; Norman, 1998; Nevill and Holder, 1999; Sasaki *et al.*, 1999; Bloomfield *et al.*, 2005a; Jones *et al.*, 2004; Tucker *et al.*, 2005). In addition, due to findings of investigations utilising global performance measures, it was expected that match location and opposition quality would interact within the developed models (Barnett and Hilditch, 1993; Clarke and Norman, 1995; Nevill and Holder, 1999).

The second objective was to determine the direction and magnitude of the situation variable main effects and interactions within each model (e.g. was playing at home associated with a significant increase in the number of shots? Did playing away and losing correspond to a significant decrease in passing success?). This would provide an indication of the most pertinent effects within each model. Due to the potential complexity of the models established in objective one and the relative simplicity of current research no specific hypotheses were generated in relation to the interactive effects of the situation variables at this stage of the analysis. Nonetheless it was suggested that, with regard to the main effect of match location, more corners, crosses, dribbles, passes and shots would occur during home matches with less clearances, interceptions and losses of control (cf. Sasaki *et al.*, 1999; Tucker *et al.*, 2005). Additionally, more successful aerial challenges, crosses, passes and tackles were expected during home matches (cf. Tucker *et al.*, 2005). While a dearth of previous research prevents any hypothesis relating to the main effect of opposition quality it was predicted that behaviour occurrence within nine areas of the pitch would differ as a function of match status (e.g. Bloomfield *et al.*, 2005a).

The final objective was to employ the identified models to predict behaviour incidence, outcome and distribution across the pitch surface according to particular match circumstance. This would enable direct comparisons of the technical and tactical aspects of performance in respect to all possible combinations of the situation variables (i.e. how does the distribution of behaviours vary when playing at home against weak opposition and winning compared to playing away from home against strong opposition and drawing?). While the generation of explicit hypotheses was again precluded due to the restricted scope of previous research, it was expected that the technical and tactical components of team performance would be inconsistent across varying match situations (Pollard, 1988; Dennis and Carron, 1999; Kormelink and Seeverens, 1999; Carling *et al.*, 2005).

5.2 Methodology

5.2.1 Study Design

The Noldus Observer Video Pro 4.1 behavioural measurement package (Noldus Information Technology, 2002) was used to notate technical and tactical aspects of soccer performance during 47 matches played by a professional British soccer club during the 2004-2005 and 2005-2006 domestic league seasons. Data collection was

based upon behaviour incidence, outcomes and occurrence within nine pitch areas. A final sample of 40 matches was selected and the effects of match location, opposition quality and match status upon the technical and tactical elements of performance assessed. Approval for the study was granted by the University of Wales Swansea Ethics Committee prior to commencement of data collection (Appendix A). The participating soccer club also permitted to the use of their match recordings with the stipulation that their identity and that of the opposition would remain anonymous and be treated in the strictest confidence.

5.2.2 Participants

Following a request for footage, the participating soccer club provided 54 matches on video cassettes. During initial viewing five of the recordings were found to be incomplete with a further two deemed unusable due to issues associated with tape wear. Consequently, 47 matches from the 2004-2005 and 2005-2006 domestic league seasons were available for analysis. In total these matches consisted of 15 wins, 10 draws and 22 losses, with 59 goals scored by the team and 71 conceded.

5.2.3 Measures

Data collection was based upon the measures of the technical and tactical aspects of performance developed in Study 1 and Study 2. Specifically, technical information focused upon the frequencies of behaviours executed and their associated outcomes (see section 3.2.3 and 3.2.4) whilst the tactical component of performance was addressed by determining behaviour occurrence within nine equally sized pitch areas (see Figure 4.1).

5.2.4 Situation Factor Identification and Definitions

Many situation factors are suggested to influence soccer performance (Kormenlink and Seeverens, 1999; Maynard, 2002; Carling *et al.*, 2005) but match location, opposition quality and match status were selected for examination within this study. Match location and match status were included as initial empirical evidence has demonstrated these factors as having a significant effect on the technical and tactical components of performance (e.g. Sasaki *et al.*, 1999; Jones *et al.*, 2004; Bloomfield *et al.*, 2005a; Tucker *et al.*, 2005). Opposition quality was incorporated due to soccer-based research highlighting the importance of its interaction with match location, although to date this has only been established with regard to global performance measures (Barnett and

Hilditch, 1993; Clarke and Norman, 1995; Madrigal and James, 1999; Nevill and Holder, 1999). For the purpose of data collection each of the selected situation variables were subdivided into further categories or levels. Match location was dichotomised into traditional classifications of home or away depending upon whether the sampled team were playing at their own ground or that of their opponents (cf. Sasaki *et al.*, 1999; Tucker *et al.*, 2005). Opposition quality was split into strong and weak categories according to whether the opposing team finished in the top or bottom half of the league table (positions 1-12 or positions 13-24 respectively) within the relevant season. Final league standing was chosen as this was felt to be most reflective of the overall team quality. Finally, in accordance with past research match status was defined as winning, drawing or losing in relation to the number of goals scored and conceded by the sampled team at the time of data entry (e.g. Jones *et al.*, 2004; Bloomfield *et al.*, 2005a,b). For example if the sampled team had scored two goals and the opposition one goal then the match status would be winning whereas if both teams had failed to score a goal the match status would be drawing.

5.2.5 Procedure

Match recordings were obtained directly from the sampled soccer club and copied as outlined in Study 1 (see section 3.2.4). The Observer Video Pro 4.1 behavioural measurement package was employed to notate each match with the order of data entry following a repeated sequence of behaviour performed, behaviour outcome, location of behaviour execution on the pitch surface and current match status (Figure 5.1). The coding procedure outlined in Study 2 was generally followed although, as only whole team performance was of interest, individual players and playing positions were not entered and spatial data were coded with respect to nine pitch areas (see Figure 4.1 and section 4.2.4). In addition to the computer-based coding, supplementary information was collated by hand. First, prior to each observation, match location and the opposition quality were noted. Second, during each match, the exact times that goals were scored were recorded to enable verification of the match status coding. All data were assembled in an SPSS v13.0 file for further analysis (SPSS inc., 2004).

5.2.6 System Reliability

As the measures being employed for data collection had previously been examined for reliability no further testing was deemed necessary (see sections 3.2.5 and 4.2.5).

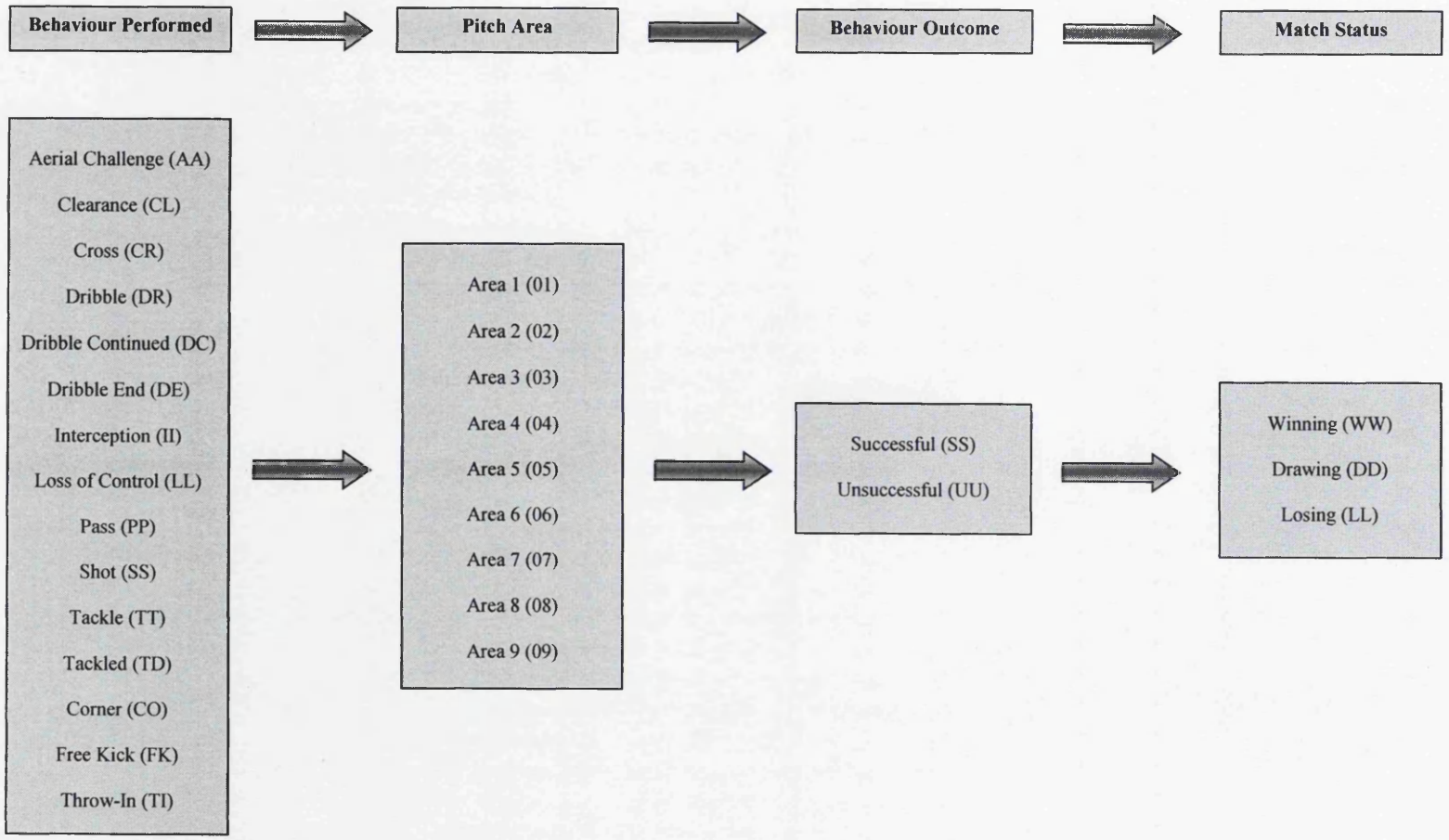


Figure 5.1 Coding structure and associated computer keystrokes (in brackets) for study 3 data collection.

5.2.7 Data Analysis Overview

Data analysis was completed in three stages. During the first stage the sample of 47 matches was reduced to account for imbalances in the number of matches played at home and away and the also against strong and weak opposition. Next, the behavioural, outcome and spatial data were subjected to data transformations due to discrepant match status durations. Finally the effects of match location, opposition quality and match status upon behaviour incidence, outcome and occurrence across the pitch surface were evaluated statistically through log-linear and logit modelling techniques.

5.2.7.1 Final Match Sample

Data were originally collected from 47 matches but inconsistencies were evident in the number of matches played home and away (23 vs. 24), against strong and weak opposition (22 vs. 25) and also in the durations of winning, drawing and losing match status (668 minutes, 2189 minutes and 1373 minutes respectively). To ensure that the models being constructed were not inadvertently influenced by these discrepancies, steps were taken to provide to obtain a balanced sample. Initially a crosstabulation of the variables of match location and opposition quality was constructed to establish the frequency of matches under each possible situation. The cell corresponding to matches played at home against strong opposition contained the fewest matches (n = 10) and thus to provide equality, the matches in the remaining three cells of the contingency table were also reduced to 10 through random selection. This new sample of forty matches consisted of 14 wins, 8 draws and 18 losses with 54 goals scored and 59 goals conceded.

5.2.7.2 Data Transformation for Raw Data

Despite the attempts to ensure a balanced sample of matches with regard to match location and opposition quality the total duration of each match status still varied under these conditions (Table 5.1). Consequently, the previously utilised amended version of James *et al.*'s (2003) transformation (see section 3.2.6.1) was applied to standardise all raw data to the duration of a single match (i.e. 90 minutes). For instance, if the number of behaviours performed in the left midfield pitch area was found to be 185 when playing at home against strong opposition and winning compared to 82 when playing away from home against strong opposition and winning, it would be incorrect to conclude that more behaviours are observed in the former case due to the inconsistency

in durations of these conditions (286 minutes vs. 78 minutes respectively). Indeed, by standardising the data using the specified equation the corresponding frequencies of behaviours within these pitch areas equal 51.7 and 93.6 respectively.

Table 5.1 Duration of each match status (minutes) as a function of match location and opposition quality during 40 matches of the 2004-2005 and 2005-2006 domestic league seasons of a professional British soccer team.

Match Location	Opposition Quality	Match Status		
		Winning	Drawing	Losing
Home	Strong	286	392	222
	Weak	244	470	186
Away	Strong	78	448	374
	Weak	60	498	342

5.2.7.3 Statistical Analysis

Due to the categorical and discrete nature of the variables of interest, log-linear and associated logit modelling techniques were selected for data analysis (Knoke and Burke, 1980; Gilbert, 1981; Marascuilo and Busk, 1987; Norusis, 1993; Tansey *et al.*, 1996; Tabachnick and Fidell, 2001; Nevill *et al.*, 2002; Field, 2005). Log-linear modelling was employed when the cell counts within crosstabulations of match location, opposition quality and match status represented the dependent variable (i.e. behaviour incidence and behaviour occurrence across the pitch surface). In contrast, logit modelling was utilised where analysis examined the influence of match location, opposition quality and match status upon a further variable (i.e. behaviour outcome). To this effect, the results were split into three distinct stages relating to the incidence of each behaviour performed (Results 3a), the behaviour outcomes (Results 3b) and finally the occurrence of behaviours across the pitch surface (Results 3c). Within each of these stages similar procedures were conducted, namely identification of the models of best fit, evaluation of model parameters and model predictions.

5.2.7.3.1 Identification of Models of Best Fit

Initial analysis examined interactions between the variables of match status, opposition quality and match status to establish the best fitting model that accounted for the

observed values of the dependent variable. For logit models only interactions involving the dependent variable were of interest (i.e. the main effect of behaviour outcome, and interactions involving this variable, such as Match Location X Behaviour Outcome). Due to the dearth of associated empirical research these models were identified using backwards elimination with the saturated model, which is the model that includes the all possible main effects and interactions between the selected variables, as the starting point (Norusis, 1993; Nevill *et al.*, 2002). At each step the highest-order terms were tested and the one resulting in the least significant change in likelihood-ratio chi-square removed, provided that the subsequent model was not significantly different from the saturated model ($p>0.05$, Norusis, 1993). For example, in the log-linear models the first step was to test if the three-way interaction Match Location X Opposition Quality X Match Status could be discarded while in the logit model the Behaviour Outcome X Match Location X Opposition Quality X Match Status interaction was evaluated. This process continued until no further terms could be excluded, and thus indicated that the best fitting model had been identified. As a further check on the suitability of the models established standardised residuals were examined, with absolute values of >1.96 signifying possible problems (Tabacknick and Fidell, 2001). Each best fitting model was described using shorthand notation based upon their highest-order terms (Gilbert, 1981). For example a three-way interaction between match location, opposition quality and match status is recorded as [LQS] where each capital letter relates to the situation factors of interest respectively. As these models are hierarchical in nature, higher-order terms implicitly signify the presence of all associated lower order terms. Hence, it is intuitively known that the model [LQS] also includes the effects [LQ], [LS], [QS], [L], [Q] and [S].

5.2.7.3.2 Evaluation of Model Parameters

During the second stage of each results phase parameter estimates were calculated for every term retained within the established models of best fit. These estimates provide an indication of the direction and magnitude of model effects (Norusis, 1993). A number of methods for estimating parameters exist and, although they require different interpretations, provide identical results (Tabacknick and Fidell, 2001; Hendrickx, 2004). In line with the recommendation of Hendrickx (2004) 'deviation contrast' parameter estimates were selected as they are intuitive and allow information for every cell in a crosstabulation to be obtained. Positive parameters occur in log-linear models

when the average number of cases in a row or column of a contingency table are larger than the overall average (the model constant or baseline) and subsequently correspond to an increase of cell frequency, with the opposite true for negative parameters. With regard to logit models, positive parameter estimates represent an increase in the odds of being in one category of the dependent variable compared to another (although more precisely the changes relate to ½ log odds when based on the parameter estimates produced in SPSS; see Norusis, 1993). In this study positive parameter estimates within logit models represent an increase in the odds of a successful behaviour outcome whereas negative parameter estimates area are associated with a decrease the in the odds of a successful behaviour outcome. It is important to note that model parameter estimates based on deviation contrasts sum to zero across the levels of a particular variable (Field, 2005). Therefore, with regard to match location and opposition quality, parameter estimates will only be presented for home matches and matches against strong opposition respectively as those for away matches and matches against weak opposition have identical magnitude but opposite directions (e.g. if the parameter for home matches was 1.235 then for away matches it would be -1.235). Lastly, each individual model parameter estimate was divided by its standard error to produce a z-score with values >1.96 being deemed significant (Knoke and Burke, 1980; Norusis, 1993; Tabachnick and Fidell, 2001; Field, 2005). In all cases collective significance was attributed to a situation variable if any of its individual z-scores were >1.96 (Tabachnick and Fidell, 2001).

5.2.7.3.3 Model Predictions

The models identified in the first stage of analysis provide the basis for additive regression-type equations into which appropriate parameter estimates can be substituted for predictive purposes. In the case of the log-linear model the full equation (i.e. the saturated model) is:

$$\ln\left(F_{ijk}\right) = \theta + \lambda_i^L + \lambda_j^Q + \lambda_k^S + \lambda_{ij}^{LQ} + \lambda_{ik}^{LS} + \lambda_{jk}^{QS} + \lambda_{ijk}^{LQS}$$

where for each contingency table cell the natural logarithm of the expected frequency, $\ln(F)$, is the summation of a model constant, θ, and parameter estimates, λ, for the main effects and interactions of match location [L], opposition quality [Q] and match status

[S]. This equation was amended in line with the models of best fit to enable forecasts of behaviour incidence (results 3a) and the occurrences of behaviours within each pitch area (results 3c). The predicted values for these aspects of performance were subsequently calculated by inputting parameters estimates relating to a specific match situation (Table 5.2) into the relevant equations. However, as these raw predicted values

Table 5.2 All possible match situations as a function of match location, opposition quality and match status.

Match Situation	Match Location	Opposition Quality	Match Status
1	Home	Strong	Winning
2	Home	Strong	Drawing
3	Home	Strong	Losing
4	Home	Weak	Winning
5	Home	Weak	Drawing
6	Home	Weak	Losing
7	Away	Strong	Winning
8	Away	Strong	Drawing
9	Away	Strong	Losing
10	Away	Weak	Winning
11	Away	Weak	Drawing
12	Away	Weak	Losing

could be misleading they were normalised as a percentage of total behaviours under that particular combination of situation variables (cf. Hughes and Bartlett, 2002a, 2004). To clarify, if 126 aerial challenges were predicted when playing at home against weak opposition and winning and overall 694 behaviours were forecast under these match conditions then aerial challenges would represent 18.2% of behaviours executed.

With respect to behaviour outcomes, predictive equations were produced by extending logit models into the above outlined general log-linear model (for more information see Norusis, 1993). However, a number of important differences need consideration when utilising this approach. Specifically, no model constant and only terms involving the dependent variable (i.e. behaviour outcome) are evident. Furthermore, following the summation of model parameter estimates there is a requirement to multiply them by a factor of two before taking the antilog (Norusis,

1993). Using similar notation to that presented by Knoke and Burke (1980) the regression-type equation for logit models is:

$$\Phi_{ijk}^{O} = 2\left(\beta^{O} + \beta_{i}^{OL} + \beta_{j}^{OQ} + \beta_{k}^{OS} + \beta_{ij}^{OLQ} + \beta_{ik}^{OLS} + \beta_{jk}^{OQS} + \beta_{ijk}^{OLQS}\right)$$

Where the log of the expected odds of success, Φ^{O}, is two times the summation of parameter estimates, β, for the main effects and interactions of behaviour outcome [O], match location [L], opposition quality [Q] and match status [S]. As this approach concerns odds rather than frequencies no further data normalisation was required (cf. Hughes and Bartlett, 2002a, 2004).

5.3 Data Screening

Prior to the commencement of analysis all transformed data were screened to ensure suitability for log-linear and logit modelling techniques based on the recommendations of Tabachnick and Fidell (2001). First, datum should be independent and thus should only contribute to the frequency of one cell in the crosstabulation of selected situation variables. Next, at least five times more cases than contingency table cells are required. Finally, the expected frequency counts for every cell within all possible two-way crosstabulations of selected analysis variables should be >1 with no more than 20% being <5. Following data screening, corners were excluded from Results 3a due to the ratio of cases to variables being too low. Furthermore, the behaviours of interceptions, losses of control, corners and free kicks were disregarded during Results 3b as the ratio of cases to variables and the expected frequency counts were problematic. No issues were evident for the Results 3c and all pitch areas were included in the analyses.

5.4 Results 3a – Soccer Behaviour Incidence

5.4.1 Models of Best Fit for Behaviour Incidence

Five distinct models were identified to account for the incidence of each behaviour as a function of match location, opposition quality and match status (Table 5.3). The most complex model, found for aerial challenges and passes, included all possible two-way interactions of the situation variables. In contrast, the model for dribbles only retained the two-way associations of Match Location X Opposition Quality and Match Location X Match Status. While these first two sets of models incorporated all three of the

situation variables, the models for the remaining behaviours excluded any influence of opposition quality. For example, the single interaction, Match Location X Match Status accounted for the incidence of clearances, losses of control, shots, tackles and times tackled. Match location and match status were also apparent within the models for the frequency of crosses, free kicks and throw-ins but in isolation rather than interaction. The remaining model indicated that the incidence of interceptions varied only according to match status.

Table 5.3 Models of best fit for behaviour incidence as a function of match location [L], opposition quality [Q] and match status [S] based upon 40 matches played by a professional British soccer team during the 2004-2005 and 2005-2006 domestic league seasons.

Behaviour	Model*	Likelihood ratio χ^2	df	p
Aerial Challenge	[LQ][LS][QS]	0.32	2	0.852
Clearance	[LS]	1.73	6	0.943
Cross	[L][S]	8.19	8	0.416
Dribble	[LQ][LS]	9.25	4	0.055
Interception	[S]	7.95	9	0.539
Loss of Control	[LS]	1.18	6	0.978
Pass	[LQ][LS][QS]	1.77	2	0.413
Shot	[LS]	6.99	6	0.322
Tackle	[LS]	3.12	6	0.794
Tackled	[LS]	4.12	6	0.660
Free Kick	[L][S]	3.88	8	0.868
Throw-In	[L][S]	7.60	8	0.473

*Interactions between variables are enclosed within square brackets (e.g. a two-way interaction between match location and match status would be signified by [LS]).

5.4.2 Evaluation of Behaviour Incidence Model Parameters

Unique parameter estimates were produced to provide a specific indication of whether particular situation variables, or interaction of variables, were associated with an increase or decrease in behaviour incidence (Table 5.4). As previously highlighted, the main effect of match status was present in every model, with a number of trends in the parameter estimate directions observed across its levels. First, positive estimates were apparent for all behaviours except for crosses, free kicks and throw-ins when winning,

Table 5.4 Parameter estimates relating to the main effects and interactions of match location [L], opposition quality [Q] and match status [S] within behaviour incidence models based upon 40 matches played by a professional British soccer team during the 2004-2005 and 2005-2006 domestic league seasons.

Model	Effect	Aerial Challenge	Clearance	Cross	Dribble	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Free Kick	Throw-In
θ	**Constant**	**4.247**	**3.577**	**2.702**	**3.759**	**2.501**	**2.114**	**5.356**	**2.538**	**4.132**	**2.735**	**2.179**	**3.217**
[L]	Home	0.004	-0.070	0.338*	0.121*	\	0.001	0.040*	0.214*	-0.040	-0.022	0.188*	0.120*
[Q]	Strong	0.007	\	\	-0.026	\	\	0.031	\	\	\	\	\
[S]	Winning	0.241*	0.428*	-0.252*	0.002	0.456*	0.119	0.002	0.239*	0.197*	0.101	-0.097	-0.022
	Drawing	-0.274*	-0.285*	-0.130	-0.198*	-0.280*	-0.173	-0.228*	-0.389*	-0.274*	-0.290*	-0.233	-0.203*
	Losing	0.033	-0.144*	0.382*	0.197*	-0.176	0.054	0.226	0.150	0.077	0.189	0.330*	0.225*
[LQ]	Home Strong	0.079*	\	\	-0.155*	\	\	-0.062*	\	\	\	\	\
[LS]	Home Winning	-0.224*	-0.163*	\	-0.186*	\	-0.404*	-0.256*	-0.248*	-0.290*	-0.395*	\	\
	Home Drawing	-0.007	0.027	\	-0.013	\	0.084	0.053	0.065	0.040	0.065	\	\
	Home Losing	0.231*	0.136	\	0.199*	\	0.320*	0.203*	0.183	0.249*	0.329*	\	\
[QS]	Strong Winning	-0.125*	\	\	\	\	\	0.064*	\	\	\	\	\
	Strong Drawing	0.112*	\	\	\	\	\	0.025	\	\	\	\	\
	Strong Losing	0.013	\	\	\	\	\	-0.089*	\	\	\	\	\
[LQS]	Home Strong Winning	\	\	\	\	\	\	\	\	\	\	\	\
	Home Strong Drawing	\	\	\	\	\	\	\	\	\	\	\	\
	Home Strong Losing	\	\	\	\	\	\	\	\	\	\	\	\

*$z > 1.96$ ($p<0.05$)

\ Effect not present in behaviour frequency model.

N.B. All omitted parameters (involving away match location and weak opposition) can be derived from others as estimates sum to zero across categories. Thus, for aerial challenges, the parameter estimate for away = -0.004, similarly the estimate for playing against weak opposition and winning = 0.125.

and clearances and interceptions when losing. In contrast, under drawing match status, every parameter was characterised by a negative estimate, indicating less behaviours than would be expected on average. With regard to the main effect of match location, the parameter estimate for each behaviour was generally identified as being positive, the only exceptions being clearances, tackles and times tackled. However, where match location interacted with match status, negative parameter estimates were produced for all behaviours when playing at home and winning, with the opposite true when playing at home and losing. Likewise, although only present in the aerial challenge and pass behaviour incidence models, the parameter estimates for the Opposition Quality X Match Status interaction were positive when drawing. For all remaining model effects less consistency in the directional trends of the parameter estimates across models were noted. For example, the main effect of opposition quality was characterised by a positive estimate for aerial challenges and a negative estimate for dribbles.

Examination of the z-scores associated with each parameter estimate (Appendix E) demonstrated that the main effect of opposition quality was not a significant influence on the incidence of any behaviour whereas match status was for all behaviours except loss of control. In contrast, the main effect of match location was associated with significant changes in the frequency of crosses, dribbles, passes, shots, free kicks and throw-ins performed but not for the remainder of behaviours. All two-way interactions of the situation variables were significant within the behavioural models that they appeared.

5.4.3 Behaviour Incidence Model Predictions

Through substituting appropriate parameter estimates into log-linear equations based upon the models of best fit (Appendix F) the incidence of each behaviour could be predicted given a particular combination of situation variables. Following data normalisation the prevalence of each behaviour was found to vary as a function of match circumstance (Table 5.5). Passing was the most common behaviour under all match conditions but represented 46.7% of total behaviours executed when playing home matches against weak opposition and losing yet only 32.8% of total behaviours when playing away from home against weak opposition and winning. The incidences of the remaining behaviours as a percentage of total behaviours performed were also inconsistent across varying match circumstances. However some stability was observed in the occurrence of each behaviour relative to all other behaviours within each match

Table 5.5 Predicted behaviour incidence normalised as a percentage of the total behaviours performed as a function of match location, opposition quality and match status.

Match Situation	Aerial Challenge	Clearance	Cross	Dribble	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Free kick	Throw-In
Home Match, Strong Opposition, Winning Match Status	14.2%	9.0%	3.4%	7.0%	4.0%	1.3%	36.6%	3.2%	11.3%	2.3%	2.0%	5.7%
Home Match, Strong Opposition, Drawing Match Status	14.5%	5.8%	4.1%	7.4%	2.1%	1.7%	41.4%	2.6%	10.7%	2.7%	1.9%	5.2%
Home Match, Strong Opposition, Losing Match Status	13.9%	4.6%	4.2%	8.3%	1.4%	1.7%	41.3%	3.0%	11.4%	3.5%	2.0%	4.8%
Home Match, Weak, Opposition, Winning Match Status	15.1%	8.8%	3.3%	9.8%	3.9%	1.3%	33.6%	3.2%	11.1%	2.3%	2.0%	5.6%
Home Match, Weak Opposition, Drawing Match Status	9.9%	5.9%	4.2%	10.7%	2.1%	1.7%	42.3%	2.6%	10.8%	2.7%	1.9%	5.2%
Home Match, Weak Opposition, Losing Match Status	10.1%	4.0%	3.7%	10.5%	1.3%	1.5%	46.7%	2.7%	10.2%	3.1%	1.8%	4.3%
Away Match, Strong Opposition, Winning Match Status	12.3%	9.4%	1.1%	7.1%	2.6%	1.9%	41.7%	2.3%	14.3%	3.5%	0.9%	2.9%
Away Match, Strong Opposition, Drawing Match Status	13.7%	6.9%	2.3%	8.9%	2.3%	1.6%	42.6%	1.6%	11.7%	2.7%	1.4%	4.5%
Away Match, Strong Opposition, Losing Match Status	11.2%	6.0%	3.2%	8.9%	2.1%	1.3%	43.2%	2.0%	11.3%	2.8%	2.1%	5.7%
Away Match, Weak, Opposition, Winning Match Status	19.6%	10.1%	1.2%	5.9%	2.8%	2.0%	32.8%	2.4%	15.3%	3.8%	1.0%	3.1%
Away Match, Weak Opposition, Drawing Match Status	14.3%	7.9%	2.6%	7.8%	2.6%	1.8%	38.2%	1.8%	13.2%	3.1%	1.6%	5.1%
Away Match, Weak Opposition, Losing Match Status	12.7%	6.1%	3.3%	7.0%	2.1%	1.3%	43.3%	2.1%	11.4%	2.9%	2.1%	5.8%

situation. For example, after passes, aerial challenges, clearances, dribbles and tackles were generally the most commonly performed behaviours regardless of the combinations of match location, opposition quality and match status with crosses, interceptions, losses of control, shots, times tackled and free kicks the least frequent behaviours.

5.5 Results 3b –Soccer Behaviour Outcomes

5.5.1 Models of Best Fit for Behaviour Outcomes

Five models were established to account for the observed behaviour outcomes as a function of match location, opposition quality and match status (Table 5.6). The saturated model was identified as the best fitting model for throw-in outcomes, with a model containing the interactions of Behaviour Outcome X Opposition Quality X Match Status and Match Outcome X Match Location best representing pass outcomes. Shots outcomes were only influenced by the situation variable of match status whereas aerial challenge outcomes were only influenced by opposition quality. The outcomes of the remaining behaviours (i.e. clearances, crosses, dribbles, tackles and times tackled) were found to be independent of any of the situation variables.

Table 5.6 Models of best fit for behaviour outcomes [O] as a function of match location [L], opposition quality [Q] and match status [S] based upon 40 matches played by a professional British soccer team during the 2004-2005 and 2005-2006 domestic league seasons.

Behaviour	Model*	Likelihood ratio χ^2	df	p
Aerial Challenge	[OQ]	6.12	10	0.805
Clearance	[O]	9.29	11	0.595
Cross	[O]	8.74	11	0.646
Dribble	[O]	9.12	11	0.611
Pass	[OQS][OL]	6.18	6	0.403
Shot	[OS]	5.36	9	0.802
Tackle	[O]	8.52	11	0.667
Tackled	[O]	3.53	11	0.982
Throw-In	[OLQS]	0.00	0	-

*Interactions between variables are enclosed within square brackets (e.g. a two-way interaction between match location and match status would be signified by [LS]).

5.5.2 Evaluation of Behaviour Outcome Model Parameters

As the models established for clearances, crosses, dribbles, tackles and times tackled failed to retain the effects of any situation variable a single parameter estimate relating to behaviour outcome was produced (Table 5.7). In the case of clearances, dribbles and tackles the positive parameter estimates indicated the prevalent successful nature of these behaviours with the opposite evident for crosses and times tackled. With regard to match location, playing at home had a positive effect on the success of passes but a negative influence on throw-ins. The parameter estimate for the main effect of opposition quality, present within the models for aerial challenges, passes and throw-ins, signified an increase in the odds of success when playing strong opposition. The interaction of Opposition Quality X Match Status was associated with increased odds of success for the relevant behaviours (i.e. passes and throw-ins) when winning but a detrimental effect was noted when losing, with mixed trends across behaviours when drawing. Similarly, the main effect of match status had an inconsistent influence on the odds of success across behaviours. For example, winning was associated with an increase in the odds of successful shot outcomes but a decrease in success for passes and throw-ins. The remaining model effects only related to throw-ins, with playing at home and winning, playing at home and losing and playing at home against strong opposition and drawing related to increased odds of success. Conversely, playing at playing at home against strong opposition, playing at home and drawing, playing at home against strong opposition and wining, and lastly, playing at home against strong opposition and losing were all associated with a decrease in the odds of success.

Assessment of parameter estimate z-scores (Appendix G) initially indicated that the difference in the proportion of successful and unsuccessful behaviour outcomes was significant within every model. The models for aerial challenges, shots, passes and throw-ins incorporate the influence of at least one situation variables but no trends in the significance of model effects were apparent. With reference to aerial challenges, opposition quality had a significant impact on behaviour outcome as did match status upon the results of shots. The outcomes of passes were also significantly influenced by match status and additionally by the interaction of Opposition Quality X Match Status. Lastly, the success rate of throw-ins was significantly affected by match status, the two-way interactions of Match Location X Match Status and Opposition Quality x Match Status as well as the three-way interaction between all situation variables.

Table 5.7 Parameter estimates for the outcomes [O] of on-the-ball behaviours performed by a professional British soccer team as a function of match location [L], opposition quality [Q] and match status [S] based upon 40 matches played by a professional British soccer team during the 2004-2005 and 2005-2006 domestic league seasons.

Model Effect		Aerial Challenge	Clearance	Cross	Dribble	Pass	Shot	Tackle	Tackled	Throw-In
[O]	Successful	0.141*	1.115*	-0.657*	0.565*	0.440*	-0.182*	0.615*	-0.153*	0.434*
[OL]	Successful Home	\	\	\	\	0.042	\	\	\	-0.011
[OQ]	Successful Strong	0.087*	\	\	\	0.040	\	\	\	0.128
[OS]	Successful Winning	\	\	\	\	-0.085*	0.396*	\	\	-0.029
	Successful Drawing	\	\	\	\	0.022	-0.242	\	\	-0.166
	Successful Losing	\	\	\	\	0.064*	-0.155	\	\	0.194*
[OLQ]	Successful Home Strong	\	\	\	\	\	\	\	\	-0.022
[OLS]	Successful Home Winning	\	\	\	\	\	\	\	\	0.120
	Successful Home Drawing	\	\	\	\	\	\	\	\	-0.232*
	Successful Home Losing	\	\	\	\	\	\	\	\	0.112
[OQS]	Successful Strong Winning	\	\	\	\	0.085*	\	\	\	0.074
	Successful Strong Drawing	\	\	\	\	-0.041	\	\	\	0.119
	Successful Strong Losing	\	\	\	\	-0.044	\	\	\	-0.192*
[OLQS]	Successful Home Strong Winning	\	\	\	\	\	\	\	\	-0.244*
	Successful Home Strong Drawing	\	\	\	\	\	\	\	\	0.272*
	Successful Home Strong Losing	\	\	\	\	\	\	\	\	-0.028

*$z > 1.96$ ($p<0.05$)

\ Effect not present in behaviour frequency model.

N.B. All omitted parameters (involving away match location and weak opposition) can be derived from others as estimates sum to zero across categories. Thus, for throw-ins, the parameter estimate for away = 0.011, similarly the estimate for playing at home against weak opposition and winning = 0.244.

5.5.3 Behaviour Outcome Model Predictions

Substitution of appropriate parameter estimates into the equations based upon the previously identified models of best fit (Appendix H) resulted in the predicted odds of success for each behaviour given any combination of the situation variables (Table 5.8). To aid interpretation, the probabilities of successful outcomes were also computed through the formula, probability = Odds/(1 + Odds) as presented by Nevill *et al.* (2002). As the outcomes of clearances, crosses, dribbles, tackles, and times tackled were not influenced by match location, opposition quality and match status the odds and probabilities of success for these behaviour remained constant across each match situation. For all other behaviours the odds of success varied depending upon the specific match conditions as defined by match location, opposition quality and match status. For example, although successful outcomes were always more likely than unsuccessful outcomes for aerial challenges and passes the actual odds ranged from 1.11-1.58 and 1.45-2.98 respectively (corresponding probability ranges: 0.53-0.61 and 0.59-0.75). Throw-ins were also predominantly successful (odds of success range: 2.46-5.41; probability of success range: 0.71-0.84) apart from when playing home matches against weak opposition while drawing and when playing away matches against weak opposition while winning (odds of success: 0.39 and 0.71; probabilities of success 0.28 and 0.42 respectively). In contrast, shots were predominantly unsuccessful under all match situations (odds of success range: 0.43-0.51, probability of success range: 0.30-0.34) except those associated with winning match status (odds of success: 1.53; probability of success: 0.61).

5.6 Results 3c – Occurrence of Soccer Behaviours Across the Pitch Surface

5.6.1 Models of Best Fit for the Occurrence of Behaviours across the Pitch Surface

Examination of the associations between the variables of match location, opposition quality and match status revealed that the saturated model was needed to account for the occurrence of behaviours performed within five areas of the soccer pitch (Table 5.9). For the four remaining pitch area models two-way interactions of the selected variables were retained. Specifically, the attacking third pitch right model consisted of all possible two-way interactions whereas the models for the midfield third pitch left, midfield third pitch centre and attacking third pitch left included the interactions of Match Location X Match Status and Opposition Quality X Match Status.

Table 5.8 Predicted odds and probabilities of success for behaviours performed by a professional British soccer team as a function of match location, opposition quality and match status.

Match Situation	Measure of Success	Aerial Challenge	Clearance	Cross	Dribble	Pass	Shot	Tackle	Tackled	Throw-In
Home Match, Strong Opposition, Winning Match Status	Odds	1.58	9.29	0.27	3.10	2.84	1.53	3.42	0.74	2.46
	Probability	*0.61*	*0.90*	*0.21*	*0.76*	*0.74*	*0.61*	*0.77*	*0.42*	*0.71*
Home Match, Strong Opposition, Drawing Match Status	Odds	1.58	9.29	0.27	3.10	2.73	0.43	3.42	0.74	2.84
	Probability	*0.61*	*0.90*	*0.21*	*0.76*	*0.73*	*0.30*	*0.77*	*0.42*	*0.74*
Home Match, Strong Opposition, Losing Match Status	Odds	1.58	9.29	0.27	3.10	2.95	0.51	3.42	0.74	3.42
	Probability	*0.61*	*0.90*	*0.21*	*0.76*	*0.75*	*0.34*	*0.77*	*0.42*	*0.77*
Home Match, Weak Opposition, Winning Match Status	Odds	1.11	9.29	0.27	3.10	2.42	1.53	3.42	0.74	3.19
	Probability	*0.53*	*0.90*	*0.21*	*0.76*	*0.71*	*0.61*	*0.77*	*0.42*	*0.76*
Home Match, Weak Opposition, Drawing Match Status	Odds	1.11	9.29	0.27	3.10	2.33	0.43	3.42	0.74	0.39
	Probability	*0.53*	*0.90*	*0.21*	*0.76*	*0.70*	*0.30*	*0.77*	*0.42*	*0.28*
Home Match, Weak Opposition, Losing Match Status	Odds	1.11	9.29	0.27	3.10	2.52	0.51	3.42	0.74	5.41
	Probability	*0.53*	*0.90*	*0.21*	*0.76*	*0.72*	*0.34*	*0.77*	*0.42*	*0.84*
Away Match, Strong Opposition, Winning Match Status	Odds	1.58	9.29	0.27	3.10	1.71	1.53	3.42	0.74	4.61
	Probability	*0.61*	*0.90*	*0.21*	*0.76*	*0.63*	*0.61*	*0.77*	*0.42*	*0.82*
Away Match, Strong Opposition, Drawing Match Status	Odds	1.58	9.29	0.27	3.10	2.72	0.43	3.42	0.74	2.76
	Probability	*0.61*	*0.90*	*0.21*	*0.76*	*0.73*	*0.30*	*0.77*	*0.42*	*0.73*
Away Match, Strong Opposition, Losing Match Status	Odds	1.58	9.29	0.27	3.10	2.98	0.51	3.42	0.74	2.79
	Probability	*0.61*	*0.90*	*0.21*	*0.76*	*0.75*	*0.34*	*0.77*	*0.42*	*0.74*
Away Match, Weak Opposition, Winning Match Status	Odds	1.11	9.29	0.27	3.10	1.45	1.53	3.42	0.74	0.71
	Probability	*0.53*	*0.90*	*0.21*	*0.76*	*0.59*	*0.61*	*0.77*	*0.42*	*0.42*
Away Match, Weak Opposition, Drawing Match Status	Odds	1.11	9.29	0.27	3.10	2.32	0.43	3.42	0.74	2.79
	Probability	*0.53*	*0.90*	*0.21*	*0.76*	*0.70*	*0.30*	*0.77*	*0.42*	*0.74*
Away Match, Weak Opposition, Losing Match Status	Odds	1.11	9.29	0.27	3.10	2.54	0.51	3.42	0.74	2.95
	Probability	*0.53*	*0.90*	*0.21*	*0.76*	*0.72*	*0.34*	*0.77*	*0.42*	*0.75*

Table 5.9 Models of best fit for behaviour occurrence within nine areas of the soccer pitch as a function of match location [L], opposition quality [Q] and match status [S] based upon 40 matches played by a professional British soccer team during the 2004-2005 and 2005-2006 domestic league seasons.

Pitch Area	Model*	Likelihood ratio χ^2	df	p
Defensive Third Left	[LQS]	0.00	0	-
Defensive Third Centre	[LQS]	0.00	0	-
Defensive Third Right	[LQS]	0.00	0	-
Midfield Third Left	[LS][QS]	3.02	3	0.388
Midfield Third Centre	[LS][QS]	3.42	3	0.331
Midfield Third Right	[LQS]	0.00	0	-
Attacking Third Left	[LS][QS]	3.04	3	0.385
Attacking Third Centre	[LQS]	0.00	0	-
Attacking Third Right	[LQ][LS][QS]	4.74	2	0.093

*Interactions between variables are enclosed within square brackets (e.g. a two-way interaction between match location and match status would be signified by [LS]).

5.6.2 Evaluation of Model Parameters for the Occurrence of Soccer Behaviours across the Pitch Surface

In relation to parameter estimates for the main effects of the situation variables a number of patterns were evident across the pitch area models (Table 5.10). First, for home matches, more behaviours than would be expected on average were executed within all areas of the attacking third and the left and right divisions of the midfield third, with decreases in the remaining sectors. Likewise, playing strong opposition was characterised by more behaviours than would be expected in all pitch areas except for the central sector of the attacking third. With reference to match status, increments in behaviour occurrence were identified for every pitch area, except the attacking third pitch centre and attacking third pitch right when winning, and the defensive third pitch centre while losing. In contrast, when drawing, fewer behaviours than would be expected on average were apparent in all pitch sectors. With regard to the interactions between the situation variables a number of trends were observed across the pitch area models. For example, positive parameter estimates were evident for all pitch areas when playing at home and losing, playing against strong opposition and drawing and also during home matches against strong opposition while winning. In addition, playing at

Table 5.10 Parameter estimates relating to the main effects and interactions of match location [L], opposition quality [Q] and match status [S] within models for the occurrence of behaviours in nine pitch areas based upon 40 matches played by a professional British soccer team during the 2004-2005 and 2005-2006 domestic league seasons.

Model Effect		Defensive Pitch Third			Midfield Pitch Third			Attacking Pitch Third		
		Left	Centre	Right	Left	Centre	Right	Left	Centre	Right
θ	**Constant**	**3.893**	**4.025**	**3.725**	**4.186**	**4.578**	**4.513**	**3.911**	**3.887**	**4.161**
[L]	Home	-0.035	-0.139*	-0.021	0.061	-0.014	0.024	0.127*	0.173*	0.204*
[Q]	Strong	0.070	0.014	0.047	0.051	0.051	0.090*	0.061	-0.013	0.084*
[S]	Winning	0.084	0.330*	0.168*	0.023	0.007	0.084	0.153*	-0.042	-0.095
	Drawing	-0.226*	-0.241*	-0.359*	-0.248*	-0.251*	-0.194*	-0.356*	-0.263*	-0.139*
	Losing	0.142*	-0.089	0.191*	0.225*	0.244*	0.110*	0.203*	0.305*	0.233*
[LQ]	Home Strong	0.068	0.095*	0.026	\	\	-0.030	\	0.131*	0.092*
[LS]	Home Winning	-0.271*	-0.249*	-0.190*	-0.277*	-0.290*	-0.295*	-0.187*	-0.189*	-0.186*
	Home Drawing	0.084	0.014	-0.044	0.108*	0.087	0.049	0.062	0.049	0.052
	Home Losing	0.188*	0.234*	0.235*	0.169*	0.204*	0.246*	0.125*	0.140*	0.134*
[QS]	Strong Winning	0.169*	0.035	0.023	0.122*	0.038	0.046	0.122*	-0.049	0.149*
	Strong Drawing	0.045	0.109	0.144*	0.053	0.067	0.090*	0.131*	0.094	0.030
	Strong Losing	-0.214*	-0.144*	-0.167*	-0.174*	-0.105*	-0.135*	-0.253*	-0.044	-0.179*
[LQS]	Home Strong Winning	0.200*	0.186*	0.170*	\	\	0.092*	\	0.199*	\
	Home Strong Drawing	-0.022	-0.021	-0.065	\	\	0.014	\	-0.065	\
	Home Strong Losing	-0.178*	-0.165*	-0.105	\	\	-0.106*	\	-0.134*	\

*$z > 1.96$ ($p<0.05$)

\ Effect not present in behaviour frequency model.

N.B. All omitted parameters (involving away match location and weak opposition) can be derived from others as estimates sum to zero across categories. Thus, for the defensive third pitch left, the parameter estimate for away = 0.035, similarly the estimate for playing at home against weak opposition and winning = -0.200.

home against strong opposition playing at home and drawing and playing strong opposition while winning were characterised by positive deviations in the majority of pitch areas. The parameter estimates relating to the remaining model interaction terms (e.g. home matches while winning, playing strong opposition and losing, home matches against strong opposition while drawing and home matches against strong opposition when losing) were predominantly negative and thus corresponded to a lower occurrence of behaviours than would be expected on average within the relevant pitch areas.

Examination of the pitch area model parameter estimate z-scores (Appendix I) displayed that the significance of the main effects of match location and opposition quality were inconsistent across the defined pitch areas. In contrast, the main effect of match status was found to be significant within all nine models. With reference to the two-way interactions of the situation variables, Match Location X Match Status was significant within all pitch area models. Opposition Quality X Match Status had a significant influence upon all areas except the attacking third pitch centre while trends were inconsistent when the Match Location X Opposition Quality interaction was examined. Lastly, the three-way interaction, Match Location X Opposition Quality X Match Status was significant within all models within which it was retained.

5.6.3 Model Predictions for the Occurrence of Soccer Behaviours across the Pitch Surface

Log-linear equations based upon the identified models of best fit (Appendix J) were utilised to predict behaviour occurrence within nine pitch areas according to match situation (Table 5.11). After data normalisation, the centre and the right of the midfield pitch thirds were generally found to account for the majority of behaviours executed under all match conditions. When playing away from home against weak opposition and winning however, the defensive third pitch centre was characterised by more behaviours (18.7%) than any other pitch sector yet contained just 6.1% of behaviours when playing home matches against strong opposition and losing. The attacking third pitch centre and left, together with the defensive third pitch left and right, contained least behaviours under the majority of match circumstances. Collectively the frequency of behaviours performed within each of the defined pitch areas appeared unique to particular match situation.

Table 5.11 Predicted behaviour occurrence within nine areas of the soccer pitch normalised as a percentage of the total behaviours performed as a function of match location, opposition quality and match status.

Match Situation	Defensive Pitch Third			Midfield Pitch Third			Attacking Pitch Third		
	Left	Centre	Right	Left	Centre	Right	Left	Centre	Right
Home Match, Strong Opposition, Winning Match Status	10.3%	11.6%	8.2%	10.2%	12.5%	14.5%	10.4%	9.5%	12.9%
Home Match, Strong Opposition, Drawing Match Status	8.4%	8.2%	5.5%	11.7%	15.9%	16.5%	8.9%	9.4%	15.4%
Home Match, Strong Opposition, Losing Match Status	6.7%	6.1%	6.7%	12.1%	18.8%	14.7%	8.6%	11.3%	14.9%
Home Match, Weak, Opposition, Winning Match Status	6.1%	9.8%	7.8%	11.7%	16.9%	15.9%	11.7%	9.0%	11.0%
Home Match, Weak Opposition, Drawing Match Status	8.3%	7.6%	5.5%	13.0%	17.2%	16.3%	8.3%	9.6%	14.0%
Home Match, Weak Opposition, Losing Match Status	8.7%	7.1%	7.8%	12.1%	16.3%	16.5%	9.8%	9.9%	11.7%
Away Match, Strong Opposition, Winning Match Status	9.1%	11.8%	6.9%	12.9%	18.8%	18.1%	9.6%	4.2%	8.6%
Away Match, Strong Opposition, Drawing Match Status	8.8%	11.5%	8.6%	10.6%	17.5%	18.8%	7.7%	6.7%	9.8%
Away Match, Strong Opposition, Losing Match Status	9.3%	8.7%	7.7%	11.5%	19.4%	16.9%	7.8%	9.1%	9.5%
Away Match, Weak, Opposition, Winning Match Status	9.7%	18.7%	8.9%	9.1%	15.7%	15.6%	6.7%	9.1%	6.4%
Away Match, Weak Opposition, Drawing Match Status	9.6%	13.1%	6.8%	10.8%	17.3%	15.9%	6.6%	8.2%	11.7%
Away Match, Weak Opposition, Losing Match Status	8.8%	8.6%	7.4%	12.9%	18.9%	12.4%	10.0%	8.9%	12.1%

5.7 Discussion

The aim of this study was to use log-linear and logit modelling techniques to examine examine the interactive effects of match location, opposition quality and match status upon the technical and tactical aspects of soccer performance within a professional soccer team. Support was found for the majority of hypotheses under investigation providing more specific insight into the influence of these situation variables on the technical and tactical components of soccer performance than has been achieved within previous soccer-based notational analysis literature.

The first objective was to examine potential interactions between the selected situation variables to identify the best fitting model to account for the observed behaviour incidences, outcomes and spatial distribution. The hypotheses that every model developed would retain the effects of all the selected situation variables and also an interaction between match location and opposition quality were not fully substantiated (e.g. Barnett and Hilditch, 1993; Clarke and Norman, 1995; Norman, 1998; Nevill and Holder, 1999; Sasaki *et al.*, 1999; Bloomfield *et al.*, 2005a; Jones *et al.*, 2004; Tucker *et al.*, 2005). The first set of models related to the technical component of performance and investigated the incidences of each analysed behaviour. Only the models for aerial challenges dribbles and passes corresponded with the hypotheses that all situation variables would be evident as well as the interaction of match location and opposition quality. All the remaining models did however, retain the influence of match location and match status, whether in isolation or interaction. The only exception was the interception behaviour where the incidence varied only according to match status. The presence of match status within every model implies a particular importance when examining behaviour incidence within soccer.

The second group of models focused upon the outcomes of the behaviours performed and thus were also associated with the technical component of soccer performance. The models for passes and throw-ins incorporated all situation variables, with the association between match location and opposition quality only evident for throw-ins. In contrast, the model for the outcomes of aerial challenges only retained the effect of opposition quality. Interestingly, the outcome models for the behaviours of clearances, crosses, dribbles, tackles and times tackled were distinct as the effects of match location, opposition quality and match status were not present. A possible explanation for this finding is that as the sampled team were of a professional standard the players were likely to be within the autonomous stage of learning. As a result

behaviour execution would be expected to be relatively consistent and probably be resistant to external influences such as those of the situation factors (Magill, 2003; Williams *et al.*, 2003a). Despite the plausibility of this explanation it remains unclear as to why the outcomes of aerial challenges, passes and throw-ins did vary according to particular match situations.

The final set of models studied the occurrence of behaviours within nine defined pitch areas and so corresponded to the tactical element of soccer performance. It was established that behaviour occurrence within each pitch areas was influenced by all situation variables. While the models predominantly incorporated a three-way interaction between match location, opposition quality and match status, the attacking third pitch right consisted instead of all possible two-way interactions. Furthermore, although the models for the midfield third pitch left, midfield third pitch centre and the attacking third pitch left also consisted of two-way interactions, the predicted association between match location and opposition quality was absent. Nonetheless, the evident complexity of the models for each pitch area demonstrates the limited insight provided by previous research of team strategy and tactics utilising the concept of behaviour distributions across the pitch surface. For example, while evidence suggests that soccer teams change strategies and tactics in relation to match location (Tucker *et al.*, 2005) and match status (Bloomfield *et al.* 2005a) the findings presented here demonstrate how the impact of differing match situations have not been fully addressed.

The second objective of this study was to determine the direction and magnitude of the situation variable main effects and interactions within each model. In line with previous findings more aerial challenges, crosses, dribbles, passes and shots were found to be performed during home matches than away matches although not all differences were significant (cf. Sasaki *et al.*, 1999; Tucker *et al.*, 2005). However, the prediction that more successful aerial challenges, crosses, passes and tackles would be performed during home matches was not entirely supported as match location was only present within the model for passing outcomes (cf. Tucker *et al.*, 2005). In this case playing at home did result in an increase in the odds of success although this trend was not significant. Finally, as expected the distribution of behaviours across the pitch surface were found to be discrepant according to match status (Bloomfield *et al.*, 2005a). For example, winning was associated with a significant increase in the frequency of behaviours performed within the defensive third pitch centre and right but a significant decrease when drawing. Overall, the findings relating to the direction and magnitude of

main effects of the situation variables concur with that of existing research. This suggests that while this investigation was based upon the study of a single team that the findings maybe applicable to other soccer teams as well.

The aforementioned model main effects, while interesting, offer limited information if confounded within higher-order interactions (Field, 2005). However, the relatively simple study designs and statistical procedures employed within existing soccer-based notational analysis literature has led to the consideration of situation variables in isolation (Sasaki *et al.*, 1999; O'Donoghue and Tenga, 2001; Shaw and O'Donoghue, 2004; Bloomfield *et al.*, 2005a,b; Tucker *et al.*, 2005). As a result, no hypotheses were generated with regard to the interactive effects of situation variables within this study. Overall, a number of trends in the direction and significance of interactive effects were found within the models for behaviour incidence, outcomes and spatial distribution. For example, in relation to directional effects, playing at home against strong opposition and winning was characterised by a increase in the frequency of behaviours performed within all areas of the pitch whereas the opposite was observed when playing at home against strong opposition and losing. Likewise, the interactions of Match Location X Opposition Quality, Match Location X Match Status and Opposition Quality X Match Status were all significant where present within the behavioural incidence models. Such information is evidently more important to the coach than that provided independently by each of the match location, opposition quality and match status variables. Additionally, the results suggest that the effects of match location, and to an extent opposition quality, are not restricted solely to global performance measures, but also include those at the behavioural level (Barnett and Hilditch, 1993; Clarke and Norman, 1995; Norman, 1998; Nevill and Holder, 1999; Sasaki *et al.*, 1999; Tucker *et al.*, 2005). These findings therefore reinforce the opinion of both soccer coaching and research literature that the influence of situation variables need to be accounted for when examining soccer performance at a behavioural level (e.g. Grehainge *et* al., 1997b; James *et al.*, 2002, 2003; Carling *et al.*, 2005; Tucker *et al.*, 2005)

The final objective was to employ the identified models to predict behaviour incidence, outcome and distribution across the pitch surface according to differing match circumstances. Based on the findings, the proposal that differences in the technical and tactical components of performance would be evident according to particular match situations was confirmed (Pollard, 1988; Dennis and Carron, 1999;

Kormelink and Seeverens, 1999; Carling *et al.*, 2005). For example, in relation to technical performance, it was apparent that shots represented 3.2% of all behaviours performed when playing at home against strong opposition and winning but only 1.6% of behaviours when playing away against strong opposition and drawing. Furthermore, the odds of a shot being successful under the first condition were 1.53 compared to 0.43 in the latter case. Similarly, when the tactical element of performance was examined as many as 19.4% of behaviours occurred within the midfield third pitch centre when playing away matches against strong opposition and losing compared to 12.5% when playing at home against strong opposition and winning. These variations potentially reflect strategic decision-making although it is unclear whether this would be prescribed by the coach either before or during the match or the result of another factor (Dennis and Carron, 1999; Bloomfield *et al.*, 2005a; Tucker *et al.*, 2005). Indeed, James *et al.* (2002) state that changes to strategy and tactics maybe necessitated by factors such as the strength of the opposition. It is therefore plausible that the observed performance discrepancies are an innate reaction to match situation.

Despite the variations noted in the technical and tactical components of performance as a function of the situation variables, some similarities with the findings of Study 1 and Study 2 were noted. For example, under all match situations passes, aerial challenges, dribbles and tackles were the most common behaviours and the majority of behaviours occurred within the midfield third of the pitch (e.g. Yamanaka *et al.*, 1997, 2002; James *et al.*, 2002; Bloomfield *et al.*, 2005a; Tucker *et al.*, 2005). Nonetheless, the results of the current study imply that such general summaries of performance fail to account for the obvious discrepancies in these aspects of performance under different match circumstances and as a result appear to have limited use in performance evaluations. Consequently, it appears that James *et al.*'s (2003) suggestion, made in relation to rugby union, that a general performance profiles may be inadequate is supported.

Collectively the findings of this study have expanded the previous soccer-based notational literature by providing greater insight into the technical and tactical aspects of performance. In particular the movement away from description to the development of predictive models (Potter and Hughes, 2001; McGarry and Franks, 2003; McGarry and Perl, 2004) provides soccer coaches and analysts a greater understanding of how performance varies as a function of match situation (Kormelink and Seeverens, 1999;

Carling *et al.*, 2005). The implications of these findings, together with those of Study 1 and Study 2 will be presented and discussed within the following chapter.

Chapter 6 – Concluding Discussion

The concluding discussion consists of three sections. First, the principal findings of the three studies conducted are discussed in relation to the overall thesis aims and objectives. Second, the practical implications of these thesis findings for coaches and analysts working within soccer are provided. Finally, the limitations of the thesis are explored with directions highlighted for future research in the area of performance profiling within soccer notation research.

6.1 Study Findings in Relation to the Thesis Aims and Objectives

The technical and tactical facets of performance have previously received interest within notational analysis literature but the production of detailed and representative profiles have not been achieved. The first two objectives of this thesis therefore, were to utilise rigorous methodologies to profile these respective aspects of soccer performance at the team, position and individual level. This was achieved during Study 1 through the use of behavioural and outcome profiles (i.e. technical), with spatial profiles and individual player zones of operation outlined during Study 2 (i.e. tactical). With regard to the whole team the findings generally concur with those of previous research. For example, when the technical performance elements were examined aerial challenges, clearances, dribbles, passes and tackles were the most commonly executed behaviours (Rico and Bangsbo, 1993; Yamanaka *et al.*, 1997, 2002; Eniseler *et al.*, 2001a, Ferit, 2001; Japeth and Hughes, 2001; Tucker *et al.*, 2005). In addition clearances, dribbles, passes and tackles were more often successful than unsuccessful (Dufour, 1993; Tiryaki *et al.*, 1997, 2001; Egesoy and Eniseler *et al.*, 2001; Eniseler *et al.*, 2001b; Tucker *et al.*, 2005) with aerial challenges failing to display a tendency to either successful or unsuccessful outcomes (Eniseler *et al.*, 2001b). As these findings have been supported across numerous studies that use diverse samples it would appear that the technical component of performance has a number of general and consistent characteristics. These general findings have important implications for the development of soccer-specific training programmes and also appear to provide an initial basis for evaluations of team performance. For example, if clearances were mostly unsuccessful during a match or over a series of matches this would represent an important discrepancy from the 'general' profile of technical performance and thus require further investigation.

The findings associated with the tactical aspect of team performance also supported existing research with behaviour occurrence distributed non-uniformly across the pitch surface, inferring strategic and tactical biases (e.g. Ali, 1988; Hughes *et al.*, 1988; Yamanaka *et al.*, 1993, 1997, 2002; Tiryaki *et al.*, 1997; Hook and Hughes, 2001; Hughes and Petit, 2001; Japheth and Hughes, 2001; James *et al.*, 2002; Brown and Hughes, 2004). In particular, it was observed that the behaviours executed by the sampled team were focused within central pitch areas within their own pitch half and directed towards wide areas, although most specifically the pitch right, within the opposition half. This highlights the importance of jointly examining the longitudinal and latitudinal pitch dimensions to obtain a detailed representation of team strategy and tactics (e.g. Ali *et al.*, 1988; Hughes *et al.*, 1988; Jinshan *et al.*, 1993; Tiryaki *et al.*, 1997; Grehainge *et al.*, 2002). Whilst this finding underlines the limitation of analysing the longitudinal or latitudinal aspects of the pitch independently (e.g. Bate, 1988; Garganta *et al.*, 1997) such information appears to provide useful supplementary data. Indeed, the majority of behaviours occurred in the midfield pitch third reinforcing the findings of previous research literature (James *et al.*, 2002; Bloomfield *et al.*, 2005a). This also verifies the assertion of James *et al.* (2002) that the midfield segment of the pitch reflects an area of particular strategic and tactical importance that requires particular attention during investigations of soccer performance.

The extant soccer research has failed to provide an adequate description of the technical and tactical components of soccer performance at playing position and individual player level. This is a particularly pertinent issue given the recommendation from applied settings that evaluations of soccer performance should not only be conducted with regard to the team as a whole but also its constituent parts (e.g. Kormelink and Seeverens, 1999; Carling *et al.*, 2005). Indeed, the findings of Study 1 and Study 2 collectively demonstrate that the technical and tactical components of soccer performance are not only unique across playing positions but also between individuals within these positions (cf. Grehaigne *et al.*, 1997b; Dunn *et al.*, 2003; James *et al.*, 2003; Williams *et al.*, 2003b; Hughes and Probert, 2006). This finding appears to relate to assigned roles, decision-making profiles and strengths and weaknesses at both playing position and individual player levels (James *et al.*, 2002, 2003). Although these inter- and intra-positional differences seem logical (cf. Reilly and Thomas, 1976) it is important to consider that this knowledge has, in the past, been based on anecdotal evidence such as coaches' intuition (Hughes and Probert, 2006) or conceptually and/or

methodologically limited empirical investigations (e.g. Grehaigne *et al.*, 1997b; Dunn *et al.*, 2003; Williams *et al.*, 2003b). The objective data presented here address these concerns and thus the need for sports performance preparation to be based upon scientific evidence (Williams *et al.*, 2003a).

The measures developed during Study 1 and Study 2 provide an objective framework upon which soccer coaches and analysts can evaluate and predict the technical and tactical components of performance. However, effective utilisation of the performance profiles for these purposes require that the factors influencing soccer performance are accounted for (Kormelink and Seeverens, 1999; Carling *et al.*, 2005; Reed and O'Donoghue, 2005). To this effect existing research into the technical and tactical components of performance have provided preliminary evidence for the effects of situation variables such as match location and match status upon soccer performance (Sasaki *et al.*, 1999; Jones *et al.*, 2004; Bloomfield *et al.*, 2005a,b; Tucker *et al.*, 2005). Despite these preliminary investigations, the situation variables have examined in isolation and therefore do not reflect the dynamic nature of soccer performance (Grehaigne *et al.*, 1997a; Kormelink and Seveerens, 1999; Grehaigne, 2001a; Nevill *et al.*, 2002; Carling *et al.*, 2005; Reed and O'Donoghue, 2005).

The findings of Study 3 provided partial support for the proposition that situation variables, specifically match location, opposition quality and match status, influence the technical and tactical aspects of performance both independently and interactively. The models developed for behaviour incidence (technical), except that for interceptions, included at least one interaction between two or more situation variables. Likewise, the models for behaviour occurrence within nine pitch areas (tactical) also contained interactions terms, but in this particular case incorporated all the situation variables. When these models were subsequently employed in a predictive manner it was evident that the technical and tactical aspects of performance were susceptible to change according to particular match circumstance. For example, 18.7% of behaviours occurred within the defensive third pitch centre when playing away from home against weak opposition and winning but only 6.1% of behaviours were executed within this pitch area when playing home matches against strong opposition and losing. Previous research has inferred that observed differences in the technical and tactical elements of performance as a function of match location and match status are indicative of modified team strategies (Bloomfield *et al.*, 2005a; Tucker *et al.*, 2005). The findings of Study 3 extend these findings by suggesting that strategic decision-making is a complex concept

influenced by numerous variables in an interactive nature (cf. Pollard, 1986, Dennis and Carron, 1999; Kormelink and Seeverens, 1999; Carling *et al.*, 2005).

With regard to the models constructed for the behaviour outcomes (technical) it was generally found that the influence of the situation variables, either independently of interactively, were not present. This was similar to the findings of Eom and Shultz (1992) who reported that skill execution in volleyball was resistant to the effects of extraneous variables. These findings correspond to the motor learning literature which states that athletes in the autonomous stage of learning, such as the players within the professional soccer team analysed in this thesis, are predominantly able to perform skilled behaviour consistently (Magill, 2003; Williams *et al.*, 2003a). This notion does, however, diverge from the findings of previous notational analysis studies examining behaviour outcomes with respect to match location (e.g. Sasaki *et al.*, 1999; Tucker *et al.*, 2005). The probable cause of these discrepancies being different operational definitions for behaviour outcomes and contrasting data analysis procedures. This highlights the importance of utilising appropriate methodologies and the need to present such information clearly.

Collectively, the findings of Study 3 reveal the significant influence of the situation variables of match location, opposition quality and match status upon the technical and tactical elements of performance. This has reinforced the findings of the previous research literature (e.g. Sasaki *et al.*, 1999; Jones *et al.*, 2004; Bloomfield *et al.*, 2005a; Tucker *et al.*, 2005) but also extended understanding of soccer performance through identifying the interactive effects of these variables. Consequently, match location, opposition quality and match status need to be accounted for during evaluations and predictions of soccer performance at a behavioural level (Kormelink and Seeverens, 1999; Carling *et al.*, 2005). This also supports the contention of James *et al.* (2003) that a general performance profile maybe insufficient for the analysis of performance in team sports. In this respect, however, it remains unresolved as to whether a universal profile with the effects of situation variables factored in or, as within Study 3, the production of match situation-specific profiles represent the most effective method for analysis.

6.2 Practical Implications

The detailed analysis of the technical and tactical components of performance together with the identified influence of situation variables provided by this thesis have a number

of implications for soccer coaches and analysts. Within the first two studies rigorous methodologies were employed to develop profiles of the technical and tactical aspects of soccer performance. These profiles facilitate objective appraisals of the technical and tactical elements of performance at the team, playing position and individual player level. Specifically, by utilising the measurement instruments outlined in this thesis soccer coaches and analysts can collect valid and reliable technical and tactical related performance data which can then be compared against, and incorporated into, existing behavioural, performance and spatial profiles as well as individual player zones of operation. This information can subsequently be used by coaches and analysts to assess the extent to which assigned strategy and tactics were implemented by the team and the fulfilment of playing position and/or individual player roles (cf. Eys *et al.*, 2006). To this effect technical and tactical profiles can also employed within a scouting capacity with the performance of opposition teams, playing positions and individual players being objectively monitored and appraised before prospective matches (Carling *et al.*, 2005).

A pertinent finding of both Study 1 and Study 2 was that the technical and tactical components of performance were discrepant between individuals within the same playing position. This has direct implications for the development of training programmes and also team selection. In the case of training programmes, the objective nature of the profiles generated provide a basis for team, playing position and particularly individual player-specific training programs rather than relying upon the traditional, but subjective, opinion of the coach (Williams *et al.*, 2003a; Franks, 2004). Furthermore, where elements of a player's technical or tactical profiles are identified as being substandard compared to other individuals within the same position appropriate interventions can be made. For example, the findings of Study 1 implied that Centre Back 4 was less efficient at performing aerial challenges than other players within this particular position and thus may require further training (aerial challenge success rates for the four analysed centre backs were 67.5%, 62.5%, 64.7% and 40.4% respectively). This information however, only suggests a weakness and would likely necessitate further investigation, such as qualitative assessment via the observations of match videos (cf. Bracewell, 2003), to identify possible explanations for this behaviour outcome. With reference to team selection, the technical and tactical profiles produced can be utilised by the coach to assess the relative strengths and weaknesses of each player and their ability to fulfil team strategy, positional responsibilities and individual

roles. If the coach opts for a defensive strategy, for example, then the midfield players could be picked according to the number of aerial challenges, clearances, tackles and interceptions they make, their success at performing these actions and their tendency towards appropriate areas of the pitch (cf. Grehaigne *et al.*, 1997b; James *et al.*, 2002; Wiemeyer, 2003; Thelwell, 2006).

The final study of the thesis found that match location, opposition quality and match status significantly influence the technical components of soccer performance. The principle implication of this finding is that where technical and tactical profiles are produced and evaluated in the abovementioned contexts of performance appraisals, scouting, training or team selection, there is a need to account for the influences of these situation variables through the production of numerous situation-specific profiles or via amendments to the general profiles (Kormelink and Seeverens, 1999; Carling *et al.*, 2005). In addition, the effects of the situation variables on soccer performance have further implications for the scouting process and training. First, Kormelink and Seeverens (1999) suggest that the scouting of upcoming opposition should be carried out under circumstances that are reflective of the conditions under which the future match will occur. For example, if Team A are to play an impending home fixture against Team B then scouts from the former team should observe the latter in away matches, and if possible against teams that are of a similar quality to Team A. However, such procedures are not pragmatic due to time and resource constraints (Hughes *et al.*, 2004a). Consequently, establishing the particular impact of situation variables on performance, allows teams to be observed as and when possible, with appropriate adjustments being made to analyses based upon knowledge of such effects. Second, from the viewpoint of training, where a coach or analyst has established that technical and tactical aspects of performance are adversely influenced by specific situation variables, then possible causes can be examined and match preparation focused towards reducing such effects. For example, in Study 3 of the thesis, drawing match status was found to be characterised by fewer successful shots than when winning or losing regardless of match location and opposition quality. The coach or analyst can therefore examine potential explanations from mental, physical, technical and tactical perspective before attempting to remedy the problem. Consequently, although situation factors are not controllable, the sentiment that they are the same for everybody and therefore not worth worrying about is challenged here as being both simplistic and naïve (i.e. Maynard, 2002).

6.3 Thesis Limitations and Recommendations for Future Research

This thesis has furthered understanding of the technical and tactical performance facets in professional soccer but several limitations are acknowledged. The following section will initially outline general thesis limitations and resultant directions for future research before focusing more specifically upon the individual studies conducted.

6.3.1 General Thesis Limitations and Recommendations for Future Research

This thesis adopted a 'fine-grained' approach to the study of the technical and tactical components of soccer performance by considering a single team's performances over a sustained time period (several playing seasons). This is in direct contrast to the previous soccer literature that has tended to combine and examine the performances of many teams within their analyses, thereby concealing potentially unique individual characteristics. Although case studies provide greater insight into a team's actual performance the limitation is that the findings may not be indicative of other teams and their respective playing positions and players. Future research should therefore determine if the technical and tactical profiles produced for the case team in this thesis, together with the influence of situation variables, are similar within other populations that have received interest in the soccer notation literature such as amateurs, women, youth players and teams within a variety of competitions and countries (e.g. Partridge *et al.*, 1993; Yamanaka *et al.*, 1993, 1997, 2002; Garganta and Goncalves, 1997; Dooan *et al.*, 2001; James *et al.*, 2002; Reilly, 2003a; Brown and Hughes, 2004; Shaw and O'Donoghue, 2004; Konstadinidou and Tsigilis, 2005; Burchill *et al.*, 2006). In particular goalkeepers should be examined as they were excluded from this thesis due to the specialised nature of their playing position (Hughes, 1999; Hughes and Probert, 2006). For example, the goalkeeper is governed by additional rules to those imposed upon 'outfield' players which results in unique technical behaviours such as catches and punches as well as the tendency to primarily perform within their assigned penalty area (Wooster and Hughes, 2001; Lawlor *et al.*, 2002; Morton and Court, 2002; Sainz de Baranda *et al.*, 2005a,b). Additionally, while this thesis addressed the predominant technical-tactical nature of soccer (Castagna *et al.*, 2003), there is a requirement to provide a more comprehensive analysis of the sport by extending the concepts and methodologies to consider the mental and physical components of performance (Robertson, 1999).

Data collection within this thesis was based upon numerous measures of the technical and tactical components of performance. These were validated by a panel of professional soccer coaches and subjected to rigorous reliability testing procedures in line with recommendations of extant notational analysis literature (Hughes *et al.*, 2002, 2004a). This approach has provided more valid insight into the technical and tactical aspects of soccer performance than previous soccer-based research where the justification for the selected performance measures (e.g. performance indicators, action zones) and system reliability have often not been reported (e.g. Ali, 1988; Partridge *et al.*, 1993; Garganta *et al.*, 1997; Dooan *et al.*, 2001; Egesoy and Eniseler, 2001; Ferit, 2001; Muniroglu, 2001; Kuhn, 2005; Suzuki and Nishijima, 2005). However, as data collection was conducted post-event from match videos employing a single camera source a number of related limitations are acknowledged. First, the camera angles within the video footage supplied by the participating soccer club were beyond the control of the author and thus only on-the-ball behaviours could be effectively assessed. As soccer coaching literature and to a lesser extent soccer-based notational analysis investigations have also highlighted the importance of some 'off-the-ball' behaviours, such as attacking runs and defensive positioning, these should be incorporated into future research (Harris and Reilly, 1988; Hughes, 1999; Kormelink and Seveerens, 1999; Suzuki and Nishijima, 204, 2005; Suzuki, 2005; Carling *et al.*, 2005). Secondly, the data associated with the tactical element of performance relied upon the identification of the specific pitch area within which each on-the-ball behaviour occurred. The use of a single camera source and the lack of visual clues such as pitch markings were problematic in this respect and resulted in the traditionally accepted level of <5.0% error during reliability testing being extended to <7.5% for the spatial data. Some justification for varying levels of reliability is present within existing notational analysis literature (e.g. Hughes *et al.*, 2002, 2004a) but it is recommended that future research should investigate methods for improving intra-observer and inter-observer agreement. In particular, the use of multiple camera sources and/or complex video-based player tracking systems would appear to provide a solution to this problem as well as being an effective method for examining off-the-ball behaviour (Carling *et al.*, 2005).

The findings presented within this thesis, in line with the rigour required for academic dissemination, have been subjected to appropriate statistical analyses (James *et al.*, 2003; James, 2006b). Furthermore, the implications of these results for soccer

coaches and analysts have also been highlighted. However, differences in performance, as determined via statistical criteria, maybe too stringent for the analysis of sport within applied contexts (cf. Hopkins *et al.*, 1999; Hughes *et al.*, 2004a). For example, within Study 1 the success rates for the shot outcomes of the three forwards were found to range from 5.4% - 20.0%. Although the chi-square statistic reported no significant difference in the proportions of successful and unsuccessful outcomes for this behaviour it likely that a coach would be concerned by such discrepant values. Indeed, Hughes *et al.* (2004a) noted that commonly utilised statistical techniques, such as the chi-square test of significance, might require a difference of 20.0 - 30.0% in the data before significance is reached. Hughes *et al.* (2004a) also reported that where most scores (e.g. the incidence of performance indicators) were close to their mean or median then it is probable that statistical tests like the Kruskal-Wallis, or the often inappropriately utilised ANOVA, would overlook those cases where a score was more extreme. This has important implications as it is often the outlying scores that would be of particular concern or an 'alarm' for further examination (Bracewell, 2003; Brillringer, 2007). Consequently, future research should investigate alternative methods for judging the significance of study findings from both a statistical and practical perspective. While this could be achieved by supplementing statistical information with expert opinion the inherent subjectivity and reported lack of agreement between coaches could prove problematic (e.g. Nicholls *et al.*, 1993; Norris and Jones, 1998; Wieymeyer, 2003; Jones, 2006).

The technical and tactical profiles constructed within this thesis and the highlighted influence of situation variables has extended knowledge of soccer performance. In particular, the use of advanced statistical techniques provide a method through which both the independent and interactive effects of the situation variables upon the technical and tactical components of performance can be investigated and thus more effectively address the dynamic nature of soccer performance (Grehaigne *et al.*, 1997a; Kormelink and Seveerens, 1999; Grehaigne, 2001a; Nevill *et al.*, 2002; Carling *et al.*, 2005; Reed and O'Donoghue, 2005). Despite this novel approach to analysis, a general limitation of the thesis, and indeed much notational analysis research, relates to the reductionist approach utilised. Reductionism concerns the understanding of complex behaviour by breaking it down into smaller components that can then be analysed and interpreted before being reconstructed to understand the whole (Thomas and Nelson, 2001). This approach has been questioned by a number of researchers due to the

complexity of performance in sports such as soccer where many interactions exist between players and teams and, as highlighted within this thesis, numerous factors can also influence performance (e.g. Grehaigne *et al.*, 1997a; Borrie and Jones, 1998; Grehaigne, 2001a; Borrie *et al.*, 2002). To date, alternative methods employed by notational analysis researchers within soccer and other sports to address these concerns have included the search for temporal patterns (Borrie *et al.*, 2002) and the use of artificial intelligence such as fuzzy logic and neural networks (Wieymeyer, 2003; Bartlett, 2004; Hughes, 2004; McGarry and Perl, 2004). Further, Potter and Hughes (2001) suggest that models based upon catastrophe theory and chaos theory may benefit the analysis of sport, although existing research has evidently neglected these theoretical concepts in favour of dynamical systems (e.g. McGarry and Franks, 1996, 2003; Grehaigne *et al.*, 1997a; Hughes *et al.*, 1998, 2001b,c; McGarry *et al.*, 1999, 2002; Grehaigne, 2001a; McGarry and Perl, 2004; Davids *et al.*, 2005; McGarry, 2005; Reed and Hughes, 2006). These innovative approaches to analysing sport performance are currently in their infancy within the notational analysis domain but do appear to provide prospective directions for researchers. A particular challenge for future investigations therefore is to determine the value of traditional notational analysis techniques in relation to the outlined contemporary approaches. This can be achieved by addressing a single problem, such as the identification of team strategy and tactics, through various methods and evaluating the respective results. However, the decisive factor in influencing the choice of procedures employed should ultimately be based upon the aims and objectives of analysis (Hughes and Franks, 2004).

6.3.2 Study-Specific Limitations and Recommendations for Future Research

Study 1 advanced knowledge of the technical component of soccer performance by producing behavioural profiles and outcome profiles for the whole team, playing positions and individual players. This is a significant addition to soccer-based notational analysis research as detailed profiles of the technical component of performance using rigorous methodologies have been neglected within existing literature. These technical profiles provide a framework upon which to base training programmes and predictions of future performance as well against which to appraise related aspects of performance. Although the behavioural profiles and outcome profiles provided relatively comprehensive representations of the on-the-ball behaviours executed it is acknowledged that additional insight could be beneficial to soccer coaches and analysts.

Specifically, future research could distinguish between the different techniques utilised to perform behaviours (e.g. whether clearances, shots and passes were performed with the foot or head) and expand the outcome measures beyond the successful/unsuccessful dichotomy (e.g. did an aerial challenge result in the team winning ball possession, the opposition winning ball possession, a free kick being conceded or a free kick being won). The difficulty in performing each behaviour could also be assessed to provide greater indication of player strengths and weaknesses and potentially team strategies (cf. James *et al.*, 2002). This could be achieved, for example, through recording the distances and directions of passes, the distance of shots from goal the opposition goal and also by evaluating the pressure under which techniques were performed (cf. Carey *et al.*, 2001; Hughes and Probert, 2006)

Study 2 focused upon the tactical aspect of performance and utilised similar profiling methodologies to those for developing the behavioural profiles within Study 1. In addition, individual player zones of operation were identified which, while similar to the concept of action areas outlined by Grehaigne *et al.* (1997b), provided detailed and reliable depiction of where upon the pitch each player performed their on-the-ball behaviours. These procedures enabled the occurrence of behaviours within specific pitch areas to be examined and are commonly utilised tools for assessing strategy and tactics within notational analysis studies (e.g. Hughes *et al.*, 1988; James *et al.*, 2002; Fleig and Hughes, 2004). However, as alluded to within the discussion of Study 2, future research should aim to distinguish between those behaviours that are related to attacking and defensive strategies (Kormelink and Seeverens, 1999; Carling *et al.*, 2005). Moreover, where large enough samples of matches can be obtained to provide meaningful results, the distributions of each individual behaviour across the pitch surface should also be investigated (cf. Tucker *et al.*, 2005). Indeed, future research of strategy and tactics at the team, playing position and individual player level should jointly consider the technical and tactical profiles, such as those developed in Study 1 and Study 2, to obtain greater insight into associated 'tactical behaviours' (James *et al.*, 2002).

The final study within this thesis utilised novel statistical procedures to evaluate the independent and interactive influence the situation variables of match location, opposition quality and match status upon the technical and tactical elements of soccer performance. This represents a significant departure from existing notational analysis literature where such variables have only been examined in isolation. Despite these

advances a number of issues provide directions for future research. First, as outlined in the introduction to Study 3, analyses were only conducted with regard to the whole team due to time and complexity constraints. Consequently, where large enough data sets can be collated, there is a requirement to establish if these situation variables have a significant influence upon the technical and tactical components of playing position and individual player performance. Second, while match location was divided into traditional home and away categories and match status logically into winning, losing and drawing, the dichotomy of opposition quality into 'strong' and 'weak' was rather more arbitrary. These particular categories ensured that enough data were available for the analyses conducted, but where larger match samples can be obtained, further classifications should be examined (e.g. high quality, medium quality and low quality). This would appear beneficial to analysis as teams would be more likely to be grouped with other teams of similar quality. For example, within this study a team finishing in 1st and 12th positions would both be classified as strong but arguably are not of equivalent quality. In addition, the quality of each opposition team was judged based upon their end of season position. The rationale for this decision was that final league placing best reflected their overall quality. It is acknowledged however that alternative approaches, such as the league standings of the opposition team at the time of the match and/or the relative quality of the two teams involved (e.g. both high quality, both low quality or one high quality and one low quality) could provide greater insight into the mechanisms underlying soccer performance and thus should be addressed by prospective research. Finally, only three situation variables were incorporated into the final study due to a paucity of previous empirical evidence. Nevertheless, both coaching and research literature have proffered numerous factors that may impinge upon soccer performance, with environmental variables such as the weather and pitch conditions a common concern (e.g. Ali, 1988; Kormelink and Seveerens, 1999; Maynard, 2002; Reilly, 2003b; Carling *et al.*, 2005). Researchers should therefore utilise log-linear and logit modelling techniques to study the effects of environmental factors, via objective metrological data (cf. Lee and Garraway, 2000), and additional situation variables upon all facets of soccer performance.

References

Abt, G.A., Dickson, G. and Mummery, W.K. (2002). Goal scoring patterns over the course of a match: An analysis of the Australian National Soccer League. In *Science and Football IV* (edited by W. Spinks, T. Reilly and A. Murphy), pp. 106-111. London: Routledge.

Ali, A.H. (1988). A statistical analysis of tactical movement patterns in soccer. In *Science and Football* (edited by T. Reilly, A. Lees, K. Davids and W. Murphy), pp. 302-308. London: E & FN Spon.

Bar-Eli, M., Tenenbaum, G. and Geister, S. (2006). Consequences of players' dismissal in professional soccer: A crisis-related analysis of group-size effects. *Journal of Sports Sciences*, 24, 1083-1094.

Barnett, V. and Hilditch, S. (1993). The effect of an artificial pitch surface on home team performance in football (soccer). *Journal of the Royal Statistical Society*, 156, 39-50.

Bartlett, R. (2001). Performance analysis: Can bringing together biomechanics and notational analysis benefit coaches? *International Journal of Performance Analysis of Sport,* 1(1), 122-126.

Bartlett, R. (2004). Artificial intelligence in technique analysis – Past, present and future. *International Journal of Performance Analysis of Sport*, 4(2), 4-19.

Bate, R. (1988). Football chance: Tactics and strategy. In *Science and Football* (edited by T. Reilly, A. Lees, K. Davids and W. Murphy), pp. 293-301. London: E & FN Spon.

Beetz, M. and Lames, M. (2006). Game analysis based on image recognition – A game of the German female soccer team. In *Proceedings of the 7th World Congress of*

Performance Analysis of Sport (edited by H. Dancs, M.D. Hughes and P. O'Donoghue), p. 73. Szombathely, Hungary: Daniel Berzsenyi College.

Bente, N. and Bolch, G. (2006). TotoWM - A programme for analysing and forecasting results of sports tournaments. In *Proceedings of the 7th World Congress of Performance Analysis of Sport* (edited by H. Dancs, M.D. Hughes and P. O'Donoghue), pp. 206-207. Szombathely, Hungary: Daniel Berzsenyi College.

Bishovets, A., Gadjiev, G. and Godik, M. (1993). Computer analysis of the effectiveness of collective technical and tactical moves of footballers in the matches of 1988 Olympics and 1990 World Cup. In *Science and Football II* (edited by T. Reilly, J. Clarys and A. Stibbe), pp. 232-238. London: E & FN Spon.

Bland, J.M. and Altman, D.G. (1986). Statistical methods for assessing agreement between two methods of clinical measurement. *The Lancet,* 1, 307-310.

Bland, J.M. and Altman, D.G. (1999). Measuring agreement in method comparison studies. *Statistical Methods in Medical Research,* 8, 135-160.

Blaze, A., Atkinson, G., Harwood, C. and Cale, A. (2004). Prevalence and perceptions of performance analysis in the English Premier Association Football League. In *Notational Analysis of Sport VI* (edited by P. O'Donoghue and M.D. Hughes), pp. 79-83. Cardiff: UWIC.

Bloomfield, J.R., Polman, R.C.J. and O'Donoghue, P.G. (2005a). Effects of score-line on team strategies in FA Premier League Soccer. *Journal of Sports Sciences*, 23, 192-193.

Bloomfield, J.R., Polman, R.C.J. and O'Donoghue, P.G. (2005b). Effects of score-line on intensity of play in midfield and forward players in the FA premier League. *Journal of Sports Sciences*, 23, 191-192.

Borrie, A. and Jones, K. (1998). 'It's not what you do it's the way that you do it': Is frequency of occurrence an adequate index of performance in observational analysis? *Journal of Sports Sciences,* 16, 14.

Borrie, A. and Knowles, Z. (2003). Coaching science and soccer. In *Science and Soccer* (Edited by T. Reilly and A.M. Williams), pp. 187-197. London: Routledge.

Borrie, A., Jonsson, G.K. and Magnusson, M.S. (2002). Temporal pattern analysis and its applicability in sport: An explanation and exemplar data. *Journal of Sports Sciences,* 20, 845-852.

Bracewell, P. (2003). Monitoring meaningful rugby ratings. *Journal of Sports Sciences*, 21, 611-620.

Bray, K. (2006). *How to Score: Science and the Beautiful Game.* London: Granta Publications.

Brillringer, D.R. (2007). A potential function approach to the flow of play in soccer. *Journal of Quantitative Analysis in Sports*, 3(1), 1-19.

Brown, S. and Hughes, M.D. (2004). The attacking playing patterns in offensive areas of European, South American, African and Asian teams in the 2002 World Cup for association football. In *Notational Analysis of Sport VI* (edited by P. O'Donoghue and M.D. Hughes), pp. 92-102. Cardiff: UWIC.

Burchill, J.K., Donovan, M.D. and Peters, D.M. (2006). The impact of data normalisation on the outcomes of a preliminary case study of passing sequences, shots and goals in U19 Premier Youth Academy football in England. In *Proceedings of the 7th World Congress of Performance Analysis of Sport* (edited by H. Dancs, M.D. Hughes and P. O'Donoghue), pp. 524-525. Szombathely, Hungary: Daniel Berzsenyi College.

Carey, D.P., Smith, G., Smith, D.T., Shepherd, J.W., Skriver, J., Ord, L. and Rutland, A. (2001). Footedness in world soccer: An analysis of France 98. *Journal of Sports Sciences,* 19, 855-864.

Carling, C. (2001). Sports science support at the French Football Federation. *Insight,* 4(4), 34-35.

Carling, C., Williams, A.M. and Reilly, T. (2005). *Handbook of Soccer Match Analysis: A Systematic Approach to Improving Performance.* Oxon: Routledge.

Carron, A.V., Loughhead, T.M. and Bray, S.R. (2005). The home advantage in sport competitons: Courneya and Carron's (1992) conceptual framework a decade later. *Journal of Sports Sciences,* 23, 395-407.

Castagna, C., D'Ottavio, S. and Abt, G. (2003). Activity profile of young soccer players during actual match play. *Journal of Strength and Conditioning Research,* 17, 775-780.

Chervenjakov, M. and Dimitrov, G. (1988). Assessment of the playing effectiveness of soccer players. In *Science and Football* (edited by T. Reilly, A. Lees, K. Davids and W. Murphy), pp. 288-292. London: E & FN Spon.

Choi, H., Kim, J., Kim, J., Hong, S. and Hughes, M.D. (2006). A study of valid contents for an evaluation of team performance in soccer. In *Proceedings of the 7th World Congress of Performance Analysis of Sport* (edited by H. Dancs, M.D. Hughes and P. O'Donoghue), pp. 92-99. Szombathely, Hungary: Daniel Berzsenyi College.

Clarke, S.R. and Norman, J.M. (1995). Home ground advantage of individual clubs in English soccer. *The Statistician,* 44(4), 509-521.

Courneya, K. and Carron, A. (1992). The home advantage in sport competitions: A literature review. *Journal of Sport and Exercise Psychology,* 14, 13-27.

Cox, R. (1998). *Sport Psychology: Concepts and Applications*. Boston: WCB McGraw-Hill.

Davids, K., Araujo., D. and Shuttleworth, R. (2005). Applications of dynamical systems theory to football. In *Science and Football V* (edited by T. Reilly, J. Cabri and D. Araujo), pp. 537-550. Oxford: Routledge.

Dennis, P. and Carron, A. (1999). Strategic decisions of ice hockey coaches as a function of game location. *Journal of Sports Sciences*, 17, 263-268.

Dobson, S.M. and Goddard, J.A. (2001). *The Economics of Football*. Cambridge: Cambridge University Press.

Dooan, B., Eniseler, N., Aydin, S., Morali, S. and Vakkas Ustun, S. (2001). The effects of the number of touching ball in the passing efficiency in professional and amateur soccer game and comparing them according to the league levels. In *Notational Analysis of Sport III* (edited by M.D. Hughes), pp. 163-166. Cardiff: UWIC.

Dufour, W. (1993). Computer-assisted scouting in soccer. In *Science and Football II* (edited by T. Reilly, J. Clarys and A. Stibbe), pp. 160-166. London: E & FN Spon.

Dunn, A., Ford, P. and Williams, M. (2003). A technical profile of different playing positions. *Insight,* 6(4), 41-45.

Edwards, J. (1979). The home-field advantage. In *Sports, Games and Play: Social and Psychological Viewpoints* (edited by J.H. Goldstein), pp. 409-438. New Jersey: Lawrence Erlbaum.

Egesoy, H. and Eniseler, N. (2001). Analysis of goals scored by the teams in the Turkish professional soccer leagues and comparing them according to league levels. In *Notational Analysis of Sport III* (edited by M.D. Hughes), pp. 149-154. Cardiff: UWIC.

Eniseler, N., Camhyer, H., Vakkas Ustun, S. and Aydin, S. (2001a). The analysis of some technique elements in a soccer game on determined areas of the football field and on certain time periods of the game. In *Notational Analysis of Sport III* (edited by M.D. Hughes), pp. 121-131. Cardiff: UWIC.

Eniseler, N., Dooan, B., Aydin, S., Vakkas Ustun, S., Tapkiran, Y. (2001b). Area and time analysis of duels in matches of the Turkish football team in elimination stages of the European Cup. In *Notational Analysis of Sport III* (edited by M.D. Hughes), pp. 100-107. Cardiff: UWIC.

Ensum, J., Taylor, S. and Williams, A.M. (2000). An analysis of attacking set plays in Euro 2000. *Insight*, 4(1), 68-72.

Ensum, J., Taylor, S. and Williams, A.M. (2002). A quantitative analysis of attacking set plays. *Insight*, 5(4), 68-72.

Ensum, J., Pollard, R. and Taylor, S. (2005). Applications of logistical regression to shots at goal in association football. In *Science and Football V* (edited by T. Reilly, J. Cabri and D. Araujo), pp. 211-218. Oxford: Routledge.

Eom, H.J. and Schutz, R.W. (1992). Transitional play in team performance of volleyball: A log-linear analysis. *Research Quarterly for Exercise and Sport*, 63, 261-269.

Eubank, M. and Gilbourne, D. (2003). Stress, performance and motivation theory. In *Science and Soccer* (edited by T. Reilly and M. Williams), pp. 214-229. London: Routledge.

Eys, M.A., Beauchamp, M.R. and Bray, S.R. (2006). A review of team roles in sport. In *Literature Reviews in Sports Psychology* (edited by S. Hanton and S.D. Mellalieu), pp. 227-255. Hauppauge, NY: Nova Science.

Ferit, M. (2001). A computerised post-event analysis of the technical and tactical events during the derby matches in the second half of the Turkish soccer First Division. In

Notational Analysis of Sport III (edited by M.D. Hughes), pp. 117-120. Cardiff: UWIC.

Field, A. (2005). *Discovering Statistics Using SPSS*. Sage Publications, London.

Fleig, G. and Hughes, M.D. (2004). Counter attacks in the World Cup for association football. In *Notational Analysis of Sport VI* (edited by P. O'Donoghue and M.D. Hughes), pp. 103-113. Cardiff: UWIC.

Ford, P., Williams, M. and Bate, D. (2004). A quantitative analysis of counter attacks from the defensive third. *Insight*, 7(3), 29-32.

Forrest, D., Beaumont, J., Goddard, J. and Simmons, R. (2005). Home advantage and the debate about competitive balance in professional sports leagues. *Journal of Sports Sciences*, 23, 439-445.

Franks, I.M. (2004). The need for feedback. In *Notational Analysis of Sport: Systems for Better Coaching and Performance in Sport* (edited by M.D. Hughes and I.M. Franks), pp. 8-16. New York: Routledge.

Franks, I.M. and Hanvey, T. (2001). From notation to training: Analysis of the penalty kick in association football. In *Notational Analysis of Sport III* (edited by M.D. Hughes), pp. 133-147. Cardiff: UWIC.

Franks, I.M. and Miller, G. (1986). Eyewitness testimony in sport. *Journal of Sport Behavior*, 9, 39-45.

Fujimura, A. and Sugihara, K. (2005). Geometric analysis and quantitative evaluation of sport teamwork. *Systems and Computers in Japan*, 36(6), 818-828.

Garganta, J. and Goncalves, G. (1997). Comparisons of successful attacking play in male and female Portuguese national soccer teams. In *Notational Analysis of Sport I & II* (edited by M.D. Hughes), pp. 79-84. Cardiff: UWIC.

Garganta, J., Maia, J. and Basto, F. (1997). Analysis of goal-scoring patterns in European top level soccer teams. In *Science and Football III* (edited by T. Reilly, J. Bangsbo and M.D. Hughes), pp. 246-250. London: E & FN Spon.

Gerisch, G. and Reichelt, M. (1993). Computer and video-aided analysis of football games. In *Science and Football II* (edited by T. Reilly, J. Clarys and A. Stibbe), pp. 167-173. London: E & FN Spon.

Gilbert, G.N. (1981). *Modelling Society: An Introduction to Loglinear Analysis for Social Researchers*. London: George Allen and Unwin.

Gill, D.L. (2000). *Psychological Dynamics of Sport and Exercise.* Champaign, IL:Human Kinetics.

Goldstein, J.H. (1979). Outcomes in professional team sports: Chance, skill and situational factors. In *Sports, Games and Play: Social and Psychological Viewpoints* (edited by J.H Goldstein), pp. 401-407. New Jersey: Lawrence Erlbaum.

Gould, P. and Gatrell, A. (1980). A structural analysis of a game: The Liverpool v Manchester United Cup Final of 1977. *Social Networks*, 2, 253-273.

Grant, A.G. and Williams, A.M. (1998). Analysis of sendings-off during season 1997-98 in the FA Premier League. *Insight*, 2(2), 17-18.

Grant, A.G., Williams, A.M. and Reilly, T. (1999a). An analysis of the successful and unsuccessful teams in the 1998 World Cup. *Journal of Sports Sciences*, 17, 827.

Grant, A.G., Williams, A.M. and Reilly, T. (1999b). Analysis of goals scored in the 1998 World Cup. *Journal of Sports Sciences,* 17, 826-827.

Grant, A.G., Williams, A.M. and Hocking, M. (1999c). Analysis of successful and unsuccessful teams in the 1999 Women's World Cup. *Insight*, 3(1), 10-12.

Grehaigne, J.F. (2001a). Systematic approach and soccer. In *Notational Analysis of Sport III* (edited by M.D. Hughes), pp. 2-9. Cardiff: UWIC.

Grehaigne, J.F. (2001b). Time distribution of goals in soccer: Some championships and the 1998 World Cup. In *Notational Analysis of Sport IV* (edited by M.D. Hughes and F. Tavares), pp. 41-51. Portugal: University of Porto.

Grehaigne, J.F., Bouthier, D. and David, B. (1997a). Dynamic-system analysis of opponent relationships in collective actions in soccer. *Journal of Sports Sciences*, 15, 137-149.

Grehaigne, J., Bouthier, D. and David, B. (1997b). Soccer: The players' action zone in a team. In *Notational Analysis of Sport I & II* (edited by M.D. Hughes), pp. 61-68. Cardiff: UWIC.

Grehaigne, J.F., Gadbout, P. and Bouthier, D. (1999). The foundations of tactics and strategy in team sports. *Journal of Teaching in Physical Education*, 18, 159-174.

Grehaigne, J.F., Mahut, B. and Fernandez, A. (2001). Qualitative observation tools to analyse soccer. *International Journal of Performance Analysis of Sport*, 1(1), 52-61.

Grehaigne, J.F., Marchal, D. and Duprat, E. (2002). Regaining possession of the ball in the defensive area in soccer. In *Science and Football IV* (edited by W. Spinks, T. Reilly and A. Murphy), pp. 112-120. London: Routledge.

Groom, R. and Cushion, C. (2005). Using of video based coaching with players: A case study. *International Journal of Performance Analysis of Sport*, 5(3), 40-46.

Harris, S. and Reilly, T. (1988). Space, teamwork and attacking success in soccer. In *Science and Football* (edited by T. Reilly, A. Lees, K. Davids and W. Murphy), pp. 322-328. London: E & FN Spon.

Hendrickx, J. (2004). Using standardised tables for interpreting loglinear models. *Quality and Control*, 38, 603-620.

Hewer, L. and James, N. (2004). Goal scoring strategies of a top Premiership team in Europe and British competitions. In *Notational Analysis of Sport VI* (edited by P. O'Donoghue and M.D. Hughes), pp. 71-74. Cardiff: UWIC.

Hill, A. and Hughes, M.D. (2001). Corners in the European Championships for association football 2000. In *Performance Analysis, Sports Science and Computers (PASS.COM)* (edited by M.D. Hughes and I. Franks), pp. 284-294. Cardiff: UWIC.

Hook, C. and Hughes, M.D. (2001). Patterns of play leading to shots in 'Euro 2000'. In *Performance Analysis, Sports Science and Computers (PASS.COM)* (edited by M.D. Hughes and I. Franks.), pp. 295-302. Cardiff: UWIC.

Hopkins, W.G., Hawley, J.A. and Burke, L.M. (1999). Design and analysis of research on sport performance enhancement. *Medicine and Science in Sport and Exercise*, 31, 472-485.

Hughes, C. (1999). *Football Tactics and Teamwork.* Harpenden: Queen Anne Press.

Hughes M.D. (2004). Performance analysis – A 2004 perspective. *International Journal of Performance Analysis of Sport*, 4(1), 103-109.

Hughes M.D. and Bartlett, R.M. (2002a). The use of performance indicators in performance analysis. *Journal of Sports Sciences*, 20, 739-754.

Hughes M.D. and Bartlett, R.M. (2002b). Performance analysis. *Journal of Sports Sciences,* 20, 735-737.

Hughes M.D. and Bartlett, R.M. (2004). The use of performance indicators in performance analysis. In *Notational Analysis of Sport: Systems for Better Coaching and Performance in Sport* (edited by M.D. Hughes and I.M. Franks), pp. 166-188. New York: Routledge.

Hughes, M.D. and Churchill, S. (2005). Attacking profiles of successful and unsuccessful teams in Copa America 2001. In *Science and Football V* (edited by T. Reilly, J. Cabri and D. Araujo), pp. 219-224. Oxford: Routledge.

Hughes, M.D. and Franks, I.M. (2004). Sports analysis. In *Notational Analysis of Sport: Systems for Better Coaching and Performance in Sport* (edited by M.D. Hughes and I.M. Franks), pp. 107-117. New York: Routledge.

Hughes, M.D. and Franks, I.M. (2005). Analysis of passing sequences, shots and goals in soccer. *Journal of Sports Sciences*, 23, 509-514.

Hughes, M.D. and Petit, A. (2001). Patterns of play in the 1986 and 1998 World Cups for soccer. In *Performance Analysis, Sports Science and Computers (PASS.COM)* (edited by M.D. Hughes and I. Franks), pp. 267-276. Cardiff: UWIC.

Hughes, M.D. and Probert, G. (2006). A technical analysis of elite male soccer players by position and success. In *Proceedings of the 7th World Congress of Performance Analysis of Sport* (edited by H. Dancs, M.D. Hughes and P. O'Donoghue), pp. 76-91. Szombathely, Hungary: Daniel Berzsenyi College.

Hughes, M.D. and Snook, N. (2006). Effectiveness of attacking play in the 2004 European Championship. In *Proceedings of the 7th World Congress of Performance Analysis of Sport* (edited by H. Dancs, M.D. Hughes and P. O'Donoghue), pp. 46-62. Szombathely, Hungary: Daniel Berzsenyi College.

Hughes, M.D. and Wells, J. (2002). Analysis of penalties taken in shoot-outs. *International Journal of Performance Analysis of Sport*, 2(1), 55-72.

Hughes, M.D., Robertson, K. and Nicholson, A. (1988). An analysis of the 1986 World Cup of association football. In *Science and Football* (edited by T. Reilly, A. Lees, K. Davids and W. Murphy), pp. 363-367. London: E & FN Spon.

Hughes, M.D., Dawkins, N., David, R. and Mills, J. (1998). The perturbation effect and goal opportunities in soccer. *Journal of Sports Sciences*, 16, 20.

Hughes, M.D., Evans, S. and Wells, J. (2001a). Establishing normative profiles in performance analysis. *International Journal of Performance Analysis of Sport*, 1(1), 1-26.

Hughes, M.D., David, R. and Dawkin, N. (2001b) Critical incidents leading to shooting in soccer. In *Notational Analysis of Sport III* (edited by M.D. Hughes), pp. 149-154. Cardiff: UWIC.

Hughes, M.D., Langridge, C. and Dawkin, N. (2001c). Perturbations leading to shooting in soccer. In *Notational Analysis of Sport* IV (edited by M.D. Hughes and F. Tavares), pp. 23-32. Portugal: University of Porto.

Hughes, M.D., Cooper, S. and Nevill, A. (2002). Analysis procedures for non-parametric data from performance analysis. *International Journal of Performance Analysis of Sport*, 2(1), 6-20.

Hughes, M.D., Cooper, S. and Nevill, A. (2004a). Analysis of notation data: Reliability. In *Notational Analysis of Sport: Systems for Better Coaching and Performance in Sport* (edited by M.D. Hughes and I.M. Franks), pp. 189-205. New York: Routledge.

Hughes, M.D., Evans, S. and Wells, J. (2004b). Establishing normative profiles in performance analysis. In *Notational Analysis of Sport: Systems for Better Coaching and Performance in Sport* (edited by M.D. Hughes and I.M. Franks), pp. 205-226. New York: Routledge.

James, N. (2006a). Notational analysis in soccer: Past, present and future. *International Journal of Performance Analysis of Sport*, 6(2), 67-81.

James, N. (2006b). The role of notational analysis in soccer coaching. *International Journal of Sports Science and Coaching*, 1, 185-194.

James, N., Mellalieu, S.D. and Holley, C. (2002). Analysis of strategies in soccer as a function of European and domestic competition. *International Journal of Performance Analysis of Sport*, 2(1), 85-103.

James, N., Mellalieu, S.D. and Jones, N.M.P. (2003). The development of position-specific performance indicators in professional rugby union. *Journal of Sports Sciences*, 23, 63-72.

James, N., Taylor, J.B. and Stanley, S. (2007). Reliability procedures for categorical data in performance analysis. *International Journal of Performance Analysis of Sport*, 7(1), 1-11.

Japheth, A. and Hughes, M.D. (2001). The playing patterns of France and their opponents in the World Cup for association football, 1998, and the European Championships, 2000. In *Performance Analysis, Sports Science and Computers (PASS.COM)* (edited by M.D. Hughes and I. Franks), pp. 277-284. Cardiff: UWIC.

Jinshan, X., Xiaoke, K., Yammanaka, K. and Matsumoto, M. (1993). Analysis of goals in the 14th World Cup In *Science and Football II* (edited by T. Reilly, J. Clarys and A. Stibbe), pp. 203-205. London: E & FN Spon.

Jones, N.M.P. (2006). *Methodological Advances for Assessing Individual and Team Performance in Elite Rugby Union*. Unpublished doctoral thesis, University of Wales Swansea.

Jones, P.D., James, N. and Mellalieu, S.D. (2004). Possession as a performance indicator in soccer. *International Journal of Performance Analysis of Sport*, 4(1), 98-102.

Knoke, D. and Burke, P.J. (1980). *Log-Linear Models*. London: SAGE Publications.

Konstadinidou, X. and Tsigilis, N. (2005). Offensive playing profiles of football teams from the 1999 Women's World Cup finals. *International Journal of Performance Analysis of Sport*, 5(1), 61-71.

Kormelink, H. and Seeverens, T. (1999). *Match Analysis and Game Preparation.* Pennsylvania: Reedswain.

Kuhn, W. (2005). Changes in professional soccer: A qualitative and quantitative study. In *Science and Football V* (edited by T. Reilly, J. Cabri and D. Araujo), pp. 194-200. Oxford: Routledge.

Lanham, N. (1993). Figures do not cease to exist because they are not counted. In *Science and Football* (edited by T. Reilly, A. Lees, K. Davids and W. Murphy), pp. 180-185. London: E & FN Spon.

Lanham, N. (2005). The goal complete: The winning difference. In *Science and Football V* (edited by T. Reilly, J. Cabri and D. Araujo), pp. 194-200. Oxford: Routledge.

Larsen, O., Zoglowek, H. and Rafoss, K. (2001). An analysis of team performance for the Norwegian women soccer team in the Olympics in Atlanta 1996. In *Notational Analysis of Sport III* (edited by M.D. Hughes), pp. 171-185. Cardiff: UWIC.

Lawlor, J., Thomas, M., Riley, P., Carron, J. and Isaacson, M. (2002). Goalkeeper distribution. *Insight*, 5(4), 78-80.

Lee, A.J. and Garraway, W.M. (2000). The influence of environmental factors on rugby football injuries. *Journal of Sports Sciences*, 18, 91-95.

Lees, A. (2002). Technique analysis in sports: A critical review. *Journal of Sports Sciences*, 20, 813-218.

Lees, A. (2003). Biomechanics applied to soccer skills. In *Science and Soccer* (edited by T. Reilly and A.M. Williams), pp.109-119. London: Routledge.

Lees, A. and Nolan, L. (1998). The biomechanics of soccer: A review. *Journal of Sports Sciences*, 16, 211-234.

Lemonie, A., Jullien, H. and Ahmaidi, S. (2005). Technical and tactical analysis of one-touch playing in soccer – Study of the production of information. *International Journal of Performance Analysis of Sport*, 5(1), 83-103.

Leser, R. (2006). Applied video and game analysis in professional soccer. In *Proceedings of the 7th World Congress of Performance Analysis of Sport* (edited by H. Dancs, M.D. Hughes and P. O'Donoghue), pp. 20-29. Szombathely, Hungary: Daniel Berzsenyi College.

Low, D., Taylor, S. and Williams, M. (2002). A quantitative analysis of successful and unsuccessful teams. *Insight*, 5(4), 86-88.

Luhtanen, P.H. (1993). A statistical evaluation of offensive actions in soccer at World Cup level in Italy 1990. In *Science and Football* (edited by T. Reilly, A. Lees, K. Davids and W. Murphy), pp. 215-220. London: E & FN Spon.

Luhtanen, P.H., Korhonen, V. and Ilkka, A. (1997). A new notational analysis system with special reference to the comparison of Brazil and its opponents in the World Cup 1994. In *Science and Football III* (edited by T. Reilly, J. Bangsbo and M.D. Hughes), pp. 229-232. London: E & FN Spon.

Luhtanen, P.H., Belinskij, A., Hayrinen, M. and Vanttinen, T. (2001a). A comparative tournament analysis between the EURO 1996 and 2000 in soccer. *International Journal of Performance Analysis of Sport*, 1(1), 74-82.

Luhtanen, P.H., Valovirta, E., Blomqvist, M. and Brown, E.W. (2001b). Game understanding and game performance in soccer and modified soccer in Finnish youth players. In *Notational Analysis of Sport IV* (edited by M.D. Hughes and F. Tavares), pp. 78-87. Portugal: University of Porto.

Lyons, K. (2001). The long and direct road: Charles Reep's analysis of association football. In *Notational Analysis of Sport III* (edited by M.D. Hughes), pp. 75-81. Cardiff: UWIC.

Madrigal, R. and James, J. (1999). Team quality and the home advantage. *Journal of Sport Behavior*, 22, 381-398.

Magill, R.A. (2003). *Motor Learning: Concepts and Applications*. USA: McGraw-Hill.

Marascuilo, L.A. and Busk, P.L. (1987). Loglinear models: A way to study main effects and interactions for multidimensional contingency tables with categorical data. *Journal of Counselling Psychology*, 34(4), 443-455.

Maynard, I. (2002). Professional attitude development in football. *Insight*, 5(4), 32-33.

McGarry, T. (1998). On the design of sports tournaments. In *Statistics in Sport* (edited by J. Bennett), pp. 199-218. London: Arnold.

McGarry, T. (2005). Soccer as a dynamical system: Some theoretical considerations. In *Science and Football V* (edited by T. Reilly, J. Cabri and D. Araujo), pp. 551-560. Oxford: Routledge.

McGarry, T. and Franks, I.M. (1996). In search of invariant athletic behaviour in sport: An example from championship squash match-play. *Journal of Sports Sciences*, 14, 445-456.

McGarry, T. and Franks, I.M. (2000). On winning the penalty shoot-out in soccer. *Journal of Sports Sciences*, 18, 401-409.

McGarry, T. and Franks, I.M. (2003). The science of match analysis. In *Science and Soccer* (edited by T. Reilly and M. Williams), pp. 265-275. London: Routledge.

McGarry, T. and Perl, J. (2004). Models of sports contests - Markov processes, dynamical systems and neural networks. In *Notational Analysis of Sport: Systems for Better Coaching and Performance in Sport* (edited by M.D. Hughes and I.M. Franks), pp. 227-242. New York: Routledge.

McGarry, T., Khan, M.A. and Franks, I.M. (1999). On the presence and absence of behavioural traits in sport: An example from championship squash match play. *Journal of Sports Sciences,* 17, 297-311.

McGarry, T., Anderson, D.I., Wallace, S.A., Hughes, M.D. and Franks, I.M. (2002). Sport competition as a dynamical self-organising system. *Journal of Sports Sciences*, 20, 771-781.

Miyamura, S., Seto, S. and Kobayashi, H. (1997). A time analysis of men's and women's soccer. In *Science and Football III* (edited by T. Reilly, J. Bangsbo and M.D. Hughes), pp. 251-257. London: E & FN Spon.

Montgomery, D.C. (1997). *Introduction to Statistical Quality Control.* New York: Wiley.

Morton, J. and Court, M. (2002). Analysis of goalkeepers' distribution in academy football. *Insight*, 3(5), 20-22.

Morya, E., Bigatao, H., Lees, A. and Ranvaud, R. (2005). Evolving penalty kick strategies: World Cup and club matches 2000-2002. In *Science and Football V* (edited by T. Reilly, J. Cabri and D. Araujo), pp. 237-242. Oxford: Routledge.

Mosteller, F. (1979). A resistant analysis of 1971 and 1972 professional football. In *Sports, Games and Play: Social and Psychological Viewpoints* (edited by J.H. Goldstein), pp. 371-399. New Jersey: Lawrence Erlbaum.

Muniroglu, S. (2001). A research related to comparative manual match analyses in football. In *Notational Analysis of Sport III* (edited by M.D. Hughes), pp. 84-93. Cardiff: UWIC.

Nevill, A. and Holder, R. (1999). Home advantage in sport: An overview of studies on the advantage of playing at home. *Sports Medicine*, 28, 221-236.

Nevill, A.M., Atkinson, G., Hughes, M.D. and Cooper, S.M. (2002). Statistical methods for analysing discrete and categorical data recorded in performance analysis. *Journal of Sports Sciences*, 20, 829-844.

Nicholls, G., McMorris, T. and Carr, C. (1993). An investigation into the use of centrality as a criterion for stacking studies in soccer. In *Science and Football II* (edited by T. Reilly, J. Clarys and A. Stibbe), pp. 190-193. London: E & FN Spon.

Norman, J.M. (1998). Soccer. In *Statistics in Sport* (edited by J. Bennett), pp. 105-118. London: Arnold.

Norris, J. and Jones, R.L. (1998). Towards a clearer definition and application of the centrality hypothesis in English professional soccer. *Journal of Sports Behavior*, 21, 181-195.

Norusis, M.J. (1993). *SPSS for Windows Advanced Statistics Release 6.0.* Chicago: SPSS inc.

Ntoumanis, N. (2001). *A Step-by-Step Guide to SPSS for Sport and Exercise Studies.* London: Routledge.

O'Donoghue, P. (2004). Sources of variability in time-motion data; Measurement error and within player variability in work-rate. *International Journal of Performance Analysis of Sport*, 4(2), 42-48.

O'Donoghue, P. (2005). Normative profiles of sports performance. *International Journal of Performance Analysis of Sport*, 5(1), 104-119.

O'Donoghue, P. and Parker, D. (2001). Time-motion analysis of the FA Premier League soccer competition. In *Performance Analysis, Sports Science and Computers (PASS.COM)* (edited by M.D. Hughes and I. Franks), pp. 263-266. Cardiff: UWIC.

O'Donoghue, P. and Ponting, R. (2005). Equations for the number of matches required for stable performance profiles. *International Journal of Computer Science in Sport*, 4(2), 48-55.

O'Donoghue, P. and Tenga, A. (2001). The effect of score-line on work rate in elite soccer. *Journal of Sports Sciences*, 19, 25-26.

Olsen, E. (1988). An analysis of goal scoring strategies in the World Championships in Mexico 1986. In *Science and Football* (edited by T. Reilly, A. Lees, K. Davids and W. Murphy), pp. 373-376. London: E & FN Spon.

Olsen, E. and Larsen, O. (1997). Use of match analysis by coaches. In *Science and Football III* (edited by T. Reilly, J. Bangsbo and M.D. Hughes), pp. 209-220. London: E & FN Spon.

Partridge, D. and Franks, I.M. (1989a). A detailed analysis of crossing opportunities in the 1986 World Cup (Part I). *Soccer Journal*, May/June, 47-50.

Partridge, D. and Franks, I.M. (1989b). A detailed analysis of crossing opportunities in the 1986 World Cup (Part II). *Soccer Journ*al, June/July, 45-48.

Partridge, D. and Franks, I.M. (1996). The use of computer-video interactive analysis in the sport of soccer: Changing individual performance by providing quantitative and qualitative feedback. In *Notational Analysis of Sport I & II* (edited by M.D. Hughes), pp. 99-111. Cardiff: UWIC.

Partridge, D., Mosher, R.E. and Franks, I.M. (1993). A computer assisted analysis of technical performance – A comparison of the 1990 World Cup and intercollegiate soccer. In *Science and Football II* (edited by T. Reilly, J. Clarys and A. Stibbe), pp. 221-231. London: E & FN Spon.

Pearce, M. and Hughes, M.D. (2001). Substitutions in Euro 2000. In *Performance Analysis, Sports Science and Computers (PASS.COM)* (edited by M.D. Hughes and I. Franks), pp. 303-315. Cardiff: UWIC.

Peiser, B.J. and Madsen, T. (1997). Physical play, foul play and violence in football: Comparative analysis of violent play among professional soccer players in Italy and England. In *Science and Football III* (edited by T. Reilly, J. Bangsbo and M.D. Hughes), pp. 295-297. London: E & FN Spon.

Pietersen, B. (2001). The winning formula: A gem not to be found in modern strategy and tactics. *Insight*, 5(1), 32-35.

Pollard, R. (1986). Home advantage in soccer: A retrospective analysis. *Journal of Sports Sciences*, 4, 237-248.

Pollard, R. and Pollard, G. (2005). Long-term trends in home advantage in professional sports in North America and England (1876-2003). *Journal of Sports Sciences*, 23, 337-350.

Pollard, R. and Reep, C. (1997). Measuring the effectiveness of playing strategies at soccer. *Statistician*, 46, 541-550.

Pollard, R., Reep, C. and Hartley, S. (1988). The qualitative comparisons of playing styles in soccer. In *Science and Football* (edited by T. Reilly, A. Lees, K. Davids and W. Murphy), pp. 309-315. London: E & FN Spon.

Potter, G. and Hughes, M.D. (2001). Modelling in competitive sports. In *Notational Analysis of Sport III* (edited by M.D. Hughes), pp. 58-74. Cardiff: UWIC.

Reed, D. and Hughes, M.D. (2006). An exploration of team sport as a dynamical system. In *Proceedings of the 7th World Congress of Performance Analysis of Sport* (edited by H. Dancs, M.D. Hughes and P. O'Donoghue), pp. 63-72. Szombathely, Hungary: Daniel Berzsenyi College.

Reed, D. and O'Donoghue, P. (2005). Development and application of computer-based prediction methods. *International Journal of Performance Analysis of Sport*, 5(3), 12-28.

Reep, C. and Benjamin, B. (1968). Skill and chance in association football. *Journal of the Royal Statistics Society*, 131, 581-585.

Reilly, T. (2001). Assessment of sports performance with particular reference to field games. *European Journal of Sport Science*, 1(3), 1-12.

Reilly, T. (2003a). Different populations. In *Science and Soccer* (edited by T. Reilly and A.M. Williams), pp. 96-105. London: Routledge.

Reilly, T. (2003b). Environmental stress. In *Science and Soccer* (edited by T. Reilly and A.M. Williams), pp. 165-184. London: Routledge.

Reilly, T. and Gilbourne, D. (2003). Science and football: A review of applied research in the football codes. *Journal of Sports Sciences*, 21, 693-705.

Reilly, T. and Thomas, V. (1976). A motion analysis of work rate in different positional roles in professional football match play. *Journal of Human Movement Studies*, 2, 87-97.

Reilly, T. and Williams, A.M. (2003). Introduction to science and soccer. In *Science and Soccer* (edited by T. Reilly and A.M. Williams), pp.1-6. London: Routledge.

Reilly, T., Lees, A., Davids, K. and Murphy, W. (eds.) (1988). *Science and Football.* London: E & FN Spon.

Reilly, T., Clarys, J. and Stibbe, A. (1993). *Science and Football II.* London: E & FN Spon.

Reilly, T., Bangsbo, J. and Hughes M.D. (eds.) (1997). *Science and Football III.* London: E & FN Spon.

Reilly, T., Williams, A.M. and Richardson, D. (2003). Identifying talented players. In *Science and Soccer* (edited by T. Reilly and A.M. Williams), pp. 307-326. London: Routledge.

Reilly, T., Cambri, J. and Araujo, D. (eds.) (2005a). *Science and Football V.* Oxford: Routledge.

Reilly, T., Farrelly, K., Edwards, B. and Waterhouse, J. (2005b). Effects of time of day on the performance of soccer-specific motor skills. In *Science and Football V* (edited by T. Reilly, J. Cambri and D. Araujo), pp. 268-270. Oxford: Routledge.

Reilly, T., Farrelly, K., Edwards, B. and Waterhouse, J. (2005c). Time of day and performance tests in male football. In *Science and Football V* (edited by T. Reilly, J. Cambri and D. Araujo), pp. 271-275. Oxford: Routledge.

Richardson, D. and Riley, P. (2003). The role of the sports scientist within professional football. *Insight*, 3(6), 52-53.

Rico, J. and Bangsbo, J. (1996). Coding system to evaluate actions with the ball during a soccer match. In *Notational Analysis of Sport I & II* (edited by M.D. Hughes), pp. 85-90. Cardiff: UWIC.

Ridder, G., Cramer, J.S. and Hopstaken, P. (1994). Down to ten: Estimating the effect of a red card in soccer. *Journal of the American Statistical Association*, 89, 1124-1127.

Robertson, K. (1999). *Observation, Analysis and Video*. Leeds: The National Coaching Foundation.

Sainz de Baranda, P., Ortega, E. and Palao, J.M. (2004a). Analysis of the action and participation of the goalkeeper in attack in the World Cup in Korea and Japan 2002. In *Performance Analysis of Sport VI* (edited by P. O'Donoghue and M.D. Hughes), pp. 45-52. Cardiff: UWIC.

Sainz de Baranda, P., Ortega, E. and Palao, J.M. (2004b). Study of the goalkeeper's actions and participation in the World Cup in Korea and Japan 2002. In *Performance Analysis of Sport VI* (edited by P. O'Donoghue and M.D. Hughes), pp. 53-64. Cardiff: UWIC.

Sasaki, Y., Nevill, A. and Reilly, T. (1999). Home advantage: A case study of Ipswich Town Football Club during the 1996-97 season. *Journal of Sports Sciences*, 17, 831.

Schwartz, B. and Barsky, S. (1977). The home advantage. *Social Forces*, 55, 641-661.

Scott, D., Roach, N.K. and Donovan, M. (2001). Analysis of the goals scored during the 1999 women's soccer World Cup finals. *Journal of Sports Sciences*, 19, 656.

Scoulding, A., James, N. and Taylor, J.B. (2004). Passing in the soccer World Cup 2002. *International Journal of Performance Analysis of Sport*, 4(2), 36-41.

Seabra, F. and Dantas, L.E.B.P.T. (2006). Space definition for match analysis in soccer. In *Proceedings of the 7th World Congress of Performance Analysis of Sport* (edited by H. Dancs, M.D. Hughes and P. O'Donoghue), pp. 30-45. Szombathely, Hungary: Daniel Berzsenyi College.

Shaw, J. and O'Donoghue, P. (2004). The effect of scoreline on work rate in amateur soccer. In *Notational Analysis of Sport VI* (edited by P. O'Donoghue and M.D. Hughes), pp. 84-91. Cardiff: UWIC.

Sousa, T. and Garganta, J. (2001). The importance of set-plays in soccer. In *Notational Analysis of Sport IV* (edited by M.D. Hughes and F. Tavares), pp. 53-57. Portugal: University of Porto.

Spiegel, M.R. and Stephens, L.J. (1999). *Statistics*. Singapore: McGraw and Hill.

Spinks, W., Reilly, T. and Murphy, A. (eds.) (2002). *Science and Football IV*. London: Routledge.

Stanhope, J. (2001). An investigation into possession with respect to time. In *Notational Analysis of Sport III* (edited by M.D. Hughes), pp. 155-162. Cardiff: UWIC.

Starosta, W. (1988). Symmetry and asymmetry in shooting demonstrated by elite soccer players. In *Science and Football* (edited by T. Reilly, A. Lees, K. Davids and W. Murphy), pp. 346-355. London: E & FN Spon.

Starosta, W. and Bergier, J. (1993). Pattern of a sport technique in football based on the symmetry of movements. In *Science and Football II* (edited by T. Reilly, J. Clarys and A. Stibbe), pp. 194-200. London: E & FN Spon.

Strudwick, T. and Reilly, T. (2001). Work-rate profiles of elite Premier League football players. *Insight*, 4(2), 28-29.

Suzuki, K. (2005). Cross-validation of the soccer defending skill scale (SDSS). *International Journal of Performance Analysis of Sport*, 5(3), 47-61.

Suzuki, K. and Nishijima, T. (2004). Validity of a soccer defending skill scale (SDSS) using game performances. *International Journal of Sport and Health Science*, 2, 34-49.

Suzuki, K. and Nishijima, T. (2005). Measurement of a soccer defending skill using game performances. In *Science and Football V* (edited by T. Reilly, J. Cabri and D. Araujo), pp. 253-261. Oxford: Routledge.

Tabachnick, B.G. and Fidell, L.S. (2001). *Using Multivariate Statistics*. Boston: Allyn and Bacon.

Tansey, R., White, M., Long R.G. and Smith, M. (1996). A comparison of loglinear modelling and logistical regression in management research. *Journal of Management*, 22(2), 339-358.

Taylor, S. and Williams, A.M. (2002). A quantitative analysis of Brazil's performances. *Insight*, 5(4), 29-32.

Taylor, J.B., James, N. and Mellalieu, S.D. (2005). Notational analysis of corner kicks in English Premier League soccer. In *Science and Football V* (edited by T. Reilly, J. Cabri and D. Araujo), pp. 225-230. Oxford: Routledge.

Tenga, A. and Larsen, O. (2001). A new method for the comprehensive analysis of a soccer match-play. In *Notational Analysis of Sport IV* (edited by M.D. Hughes and F. Tavares), pp. 71-77. Portugal: University of Porto.

Tenga, A. and Larsen, O. (2003). Testing the validity of match analysis to describe playing styles in football. *International Journal of Performance Analysis of Sport*, 3(2), 90-102.

Thelwell, R.C., Greenless, I.A. and Weston, N.J.V. (2006). Using psychological skills training to develop soccer performance. *Journal of Applied Sports Psychology*, 18, 254-270.

Thomas, J.R. and Nelson, J.K. (2001). *Research Methods in Physical Activity.* Champaign, IL: Human Kinetics.

Tiryaki, G., Cicek, S., Erdogan, A.T., Kalay, F., Atalay, A.T. and Tuncel, F. (1997). The analysis of the offensive patterns of the Switzerland soccer team in the World Cup 1994. In *Notational Analysis of Sport I & II* (edited by M.D. Hughes), pp. 91–98. Cardiff: UWIC.

Tiryaki, G., Atalay, A.T. and Kin, A. (2001). The performance of the Turkish national soccer team during the European Cup elimination matches and the final matches. In *Notational Analysis of Sport III* (edited by M.D. Hughes), pp. 94-99. Cardiff: UWIC.

Tucker, W., Mellalieu, S.D., James, N. and Taylor, J.B. (2005). Game location effects in professional soccer: A case study. *International Journal of Performance Analysis of Sport*, 5(2), 23-35.

Verlinden, M., Goosssens, R. and Vercammen, L. (2001a). The description of a set of football techno-tactical variables, obtained through observation of the motor behaviour using CAMAS, with respect to the combination of 1/1 situations and passing type actions. In *Notational Analysis of Sport IV* (edited by M.D. Hughes and F. Tavares), pp. 220-222. Portugal: University of Porto.

Verlinden, M., Van Onsem, D., Michils, F. and Goosssens, R. (2001b). The existence of techno-tactical contingent operational lines along the fields' longitudinal axis as opposed to predefined strategic spatial planned lines along the fields' width axis in soccer. In *Performance Analysis, Sports Science and Computers (PASS.COM)* (edited by M.D. Hughes and I. Franks), pp. 241-253. Cardiff: UWIC.

Verlinden, M., Eeckhout, A., Van Camp, J., Somers, P., De Decker, S. and Goossens, R. (2005). The effect of configuration and context of pre-shooting ball possession

sequences upon scoring. In *Science and Football V* (edited by T. Reilly, J. Cabri and D. Araujo), pp. 614-621. Oxford: Routledge.

Vincent, W.J. (1999). *Statistics in Kinesiology*. Leeds: Human Kinetics.

Vukičević, D., Trninić, S. and Dizdar, D. (2006). Formal model for assessing the suitability of a competition system in basketball. *International Journal of Fundamental and Applied Kinesiology*, 38(1), 49-56.

Weinberg, R.S. and Gould, D. (2003). *Foundations of Sport and Exercise Psychology*. Champaign, IL: Human Kinetics.

Wells, J., O'Donoghue, P.G. and Hughes, M. (2004). The need to use representative player data from multiple matches in performance analysis. In *Notational Analysis of Sport VI* (edited by P. O'Donoghue and M.D. Hughes), pp. 241-244. Cardiff: UWIC.

Wesson, J. (2002). *The Science of Soccer*. Oxon: Taylor and Francis.

Wiemeyer, J. (2003). Who should play in which position in soccer? Empirical evidence and unconventional modelling. *International Journal of Performance Analysis of Sport*, 3(1), 1-18.

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

Williams, A.M. and Reilly, T. (2000). Talent identification and development in soccer. *Journal of Sports Sciences*, 18, 657-667.

Williams, A.M., Horn, R.R. and Hodges, N.J. (2003a). Skill acquisition. In *Science and Soccer* (Edited by T. Reilly and A.M. Williams), pp. 198-213. London: Routledge.

Williams, A.M., Williams, M. and Horn, R. (2003b). Physical and technical demands of different playing positions. *Insight*, 6(2), 24-28.

Williams, A.M., Ward, P. and Smeeton, N.J. (2004). Perceptual and cognitive expertise in sport: Implications for skill acquisition and performance enhancement. In *Skill Acquisition in Sport* (Edited by A.M. Williams, and N.J. Hodges), pp. 328-347. London: Routledge.

Williams. A.M., Ward, P., Herron, K. and Smeeton, N.J. (2005). Using situational probabilities to train perceptual and cognitive skill in novice soccer players. In *Science and Football V* (edited by T. Reilly, J. Cabri and D. Araujo). pp. 337-340. Oxford: Routledge.

Wilson, K. and Barnes, C.A. (1998). Reliability and validity of a computer based notational analysis system for competitive table tennis. In *Science and Racket Sports II* (Edited by A. Lees, I. Maynard, M.D. Hughes and T. Reilly), pp. 265-268. London: E & FN Spon.

Wooster, B. and Hughes, M.D. (2001). Playing patterns ensuing from the distribution of goalkeepers in elite association football. In *Performance Analysis, Sports Science and Computers (PASS.COM)* (edited by M.D. Hughes and I. Franks), pp. 317-324. Cardiff: UWIC.

Yamanaka, K., Hughes, M.D. and Lott, M. (1993). An analysis of playing patterns in the 1990 World Cup for association football. In *Science and Football II* (edited by T. Reilly, J. Clarys and A. Stibbe), pp. 206-214. London: E & FN Spon.

Yamanaka, K., Liang, D.Y. and Hughes, M.D. (1997). An analysis of the playing patterns of the Japan national team in the 1994 World Cup qualifying match for Asia. In *Science and Football III* (edited by T. Reilly, J. Bangsbo and M.D. Hughes), pp. 221-228. London: E & FN Spon.

Yamanaka, K., Nishikawa, T., Yamanaka, T. and Hughes, M.D. (2002). An analysis of the playing patterns of the Japan national team in the 1998 World Cup for soccer. In *Science and Football IV* (edited by W. Spinks, T. Reilly and A. Murphy), pp. 101-105. London: Routledge.

Yiannakos, A. and Armatas, V. (2006). Evaluation of the goal scoring patterns in European Championship in Portugal 2004. *International Journal of Performance Analysis of Sport*, 6(1), 178-187.

Zar, J.H. (1999). *Biostatistical Analysis*. New Jersey: Prentice-Hall, Inc.

APPENDICES

APPENDIX A

Ethical Approval

UNIVERSITY OF WALES SWANSEA

DEPARTMENT OF SPORTS SCIENCE
DEPARTMENTAL ETHICS ADVISORY COMMITTEE

APPLICATION FOR ETHICAL COMMITTEE APPROVAL OF A RESEARCH PROJECT

In accordance with Departmental Safety Policy, all research undertaken in the department must be approved by the Departmental Ethics Advisory Committee **prior to** data collection. **Applications for approval should be typewritten on this form using the template available in the Public Folders.** The researcher(s) should complete the form in consultation with the project supervisor. Where appropriate, the application must include the following appendices:
(A) subject information sheet;
(B) subject consent form;
(C) subject health questionnaire.

After completing sections 1-12 of the form, seven copies of the form should be handed into the Department Administrator who will submit the application for consideration by the Departmental Ethics Advisory Committee. The applicant(s) will be informed of the decision of the Committee in due course.

1. DRAFT TITLE OF PROJECT
Profiling the Technical and Tactical Components of Performance in Professional Soccer

2. NAMES AND STATUS OF RESEARCH TEAM
Joseph Taylor – Postgraduate Student
Stephen Mellalieu – Supervisor
Nic James - Supervisor

3. RATIONALE
Soccer has received much interest within the existing notational analysis literature with particular focus upon the predominant technical and tactical components of performance (e.g. Bishovets *et al.*, 1993; Verlinden *et al.*, 2001a,b). However, much of this research has been limited by conceptual and methodological issues. For example, commonly employed nomothetic study designs appear flawed while reliability testing is often neglected or inadequate (Hughes *et al.*, 2002; James *et al.*, 2002). Further pertinent problems have included a disproportionate focus upon the team as a whole and the failure of researchers to ensure that the data presented are representative of performance (Hughes *et al.*, 2001). Rigorous approaches to performance profiling have been developed to address this final concern yet, to date, have not been utilised within soccer (e.g. Hughes *et al.*, 2001). The construction of performance profiles are beneficial as they are suggested to provide the basis for performance predictions and thereby move beyond the traditionally descriptive nature of notational analysis literature (Potter and Hughes, 2001). Nonetheless, effective performance predictions and evaluations necessitate that the variables potentially 'confounding' performance are accounted for (Goldstein, 1979; Mosteller, 1979; Kormelink and Seeverens, 1999; Potter and Hughes, 2001). The soccer coaching literature has proffered a number of factors that are suggested to influence performance but previous research has neglected to examine many of these variables, particularly at a behavioural level (Kormelink and Seeverens, 1999; Maynard, 2002). Moreover, where the factors influencing performance have been investigated this has generally occurred in isolation, therefore the interactive effects that appear to more accurately reflect the dynamic nature of soccer have not been addressed.

4. REFERENCES
Bishovets, A., Gadjiev, G. and Godik, M. (1993). Computer analysis of the effectiveness of collective technical and tactical moves of footballers in the matches of 1988 Olympics and 1990 World Cup. In *Science and Football II* (edited by T. Reilly, J. Clarys and A. Stibbe), pp. 232-238. London: E & FN Spon.

Goldstein, J.H. (1979). Outcomes in professional team sports: Chance, skill and situational factors. In *Sports, Games and Play: Social and Psychological Viewpoints* (edited by J.H. Goldstein), pp. 401-407. New Jersey: Lawrence Erlbaum.

Hughes, M.D., Evans, S. and Wells, J. (2001). Establishing normative profiles in performance analysis. *International Journal of Performance Analysis of Sport*, 1(1), 1-26.

Hughes, M.D., Cooper, S. and Nevill, A. (2002). Analysis procedures for non-parametric data from performance analysis. *International Journal of Performance Analysis of Sport*, 2(1), 6-20.

James, N., Mellalieu, S.D. and Holley, C. (2002). Analysis of strategies in soccer as a function of European and domestic competition. *International Journal of Performance Analysis of Sport*, 2(1), 85-103.

Kormelink, H. and Seeverens, T. (1999). *Match Analysis and Game Preparation.* Pennsylvania: Reedswain.

Maynard, I. (2002). Professional attitude development in football. *Insight*, 5(4), 32-33.

Mosteller, F. (1979). A resistant analysis of 1971 and 1972 professional football. In *Sports, Games and Play: Social and Psychological Viewpoints* (edited by J.H. Goldstein), pp. 371-399. New Jersey: Lawrence Erlbaum.

Nevill, A.M., Atkinson, G., Hughes, M.D. and Cooper, S.M. (2002). Statistical methods for analysing discrete and categorical data recorded in performance analysis. *Journal of Sports Sciences*, 20, 829-844.

Potter, G. and Hughes, M.D. (2001). Modelling in competitive sports. In *Notational Analysis of Sport III* (edited by M.D. Hughes), pp. 58-74. Cardiff: UWIC.

Verlinden, M., Goosssens, R. and Vercammen, L. (2001a). The description of a set of football techno-tactical variables, obtained through observation of the motor behaviour using CAMAS, with respect to the combination of 1/1 situations and passing type actions. In *Notational Analysis of Sport IV* (edited by M.D. Hughes and F. Tavares), pp. 220-222. Portugal: University of Porto.

Verlinden, M., Van Onsem, D., Michils, F. and Goosssens, R. (2001b). The existence of techno-tactical contingent operational lines along the fields' longitudinal axis as opposed to predefined strategic spatial planned lines along the fields' width axis in soccer. In *Performance Analysis, Sports Science and Computers (PASS.COM)* (edited by M.D. Hughes and I. Franks), pp. 241-253. Cardiff: UWIC.

5. AIMS and OBJECTIVES

The aim of the proposed study is to examine profiling of the technical and tactical performance components within a professional soccer team through the use of rigorous methodologies.

The proposed study has three objectives. First, to construct and examine performance profiles relating to the technical facet of soccer performance at the team, playing position and individual player level. Second, to develop and investigate performance profiles in relation to the tactical aspect of soccer performance at the team, playing position and individual player level. Finally, to determine the potential independent and interactive effects of the variables influencing the technical and tactical components of soccer performance.

6. METHODOLOGY

6.1 Study Design

A computerised notational analysis system will be developed to examine the technical and tactical components of performance via a case study of a professional British soccer team. The suitability of the general technical and tactical profiles will be assessed by investigating the effects of potentially confounding variables.

6.2 Experimental Procedures

VHS recordings of matches will obtained directly from the participating soccer club and copied using two video recorders (Panasonic NV-HS820B) and a television (Panasonic TX-21JT1). The original match footage will then be returned to the soccer club while the duplicated VHS recording will be converted to

an MPEG format on the hard drive of a Dell Inspiron 5100 laptop computer via a Fast Multimedia Clipmaster MPEG converter (Fast Multimedia AG, 1999). All match recordings are to be observed using Noldus Observer Video Pro 4.1 behavioural measurement package (Noldus Information Technology, 2002) upon the aforementioned laptop computer. Data collection will employ technical and tactical measures identified and developed from existing notational analysis research and be subject to validation by professional soccer coaches and notational analysts with experience of soccer-based investigations. It is initially proposed that the technical facet of performance will be examined through the observed incidence of behaviours and their associated outcomes whilst the tactical aspects will consider the distribution of behaviours across the soccer pitch surface. This data will be entered in to the Noldus Observer Video Pro 4.1 behavioural measurement package using pre-defined coding structures that employ specific keystrokes to represent the required information. The use of the computerised notation system will be subject to a pilot study and reliability testing conducted before the commencement of actual data collection for the proposed study. All raw data collected during the course of the intended study will be compiled in the Statistical Package for Social Scientists (SPSS inc.) for further statistical analysis.

6.3 Data Analysis Techniques

6.3.1 Reliability

Both intra- and inter-observer reliability testing procedures will be implemented using the percentage error method (Hughes *et al.*, 2002). While <5.0% error will be deemed acceptable for the data relating to the technical aspects of performance this level will be extended to <7.5% for the tactical element of performance due to the potential difficulty associated with identifying pitch areas.

6.3.2 Study

Due to the categorical and discrete nature of the data being collected appropriate non-parametric statistical techniques will be employed. The technical and tactical data will be compared utilising chi-square tests of significance with the effects of potential confounding variables being assessed through the use of more advanced statistical procedures such as log-linear and logit modelling (Nevill *et al.*, 2002).

7. LOCATION OF THE PREMISES WHERE THE RESEARCH WILL BE CONDUCTED.

Notational Analysis Laboratory, University of Wales Swansea.
Cognition and Behaviour in Sports Performance Postgraduate Centre, University of Wales Swansea

8. SUBJECT RISKS AND DISCOMFORTS

None as a direct result of the study.

9. INFORMATION SHEET AND INFORMED CONSENT

Have you included a Subject Information Sheet for the participants of the study?
NO

Have you included a Subject Consent Form for the participants of the study?
NO

Written consent will not be obtained from the subjects being analysed in this experiment as data will be collected from video footage of soccer matches and therefore the subjects will not be directly involved in, or necessarily aware of, the research. However, as the recordings will be obtained directly from a participating soccer club consent for their use will be obtained. To this effect the identity of the participating soccer club, their players and the specific matches analysed will remain anonymous and be treated in the strictest confidence. Furthermore, the original recordings of the match will be returned to the participating soccer club after being copied with all duplicate footage being destroyed following the completion of data collection and analysis.

10. COMPUTERS

Are computers to be used to store data? YES

If so, is the data registered under the Data Protection Act? YES

NB : For UWS students, the answer to this question is YES, but the question has been included in order to stress the importance of adherence to the Data Protection Act in research activity

11. STUDENT DECLARATION

Please read the following declarations carefully and provide details below of any ways in which your project deviates from them. Having done this, each student listed in section 2 is required to sign where indicated.

1. I have ensured that there will be no active deception of participants.
2. I have ensured that no data will be personally identifiable.
3. I have ensured that no participant should suffer any undue physical or psychological discomfort
4. I certify that there will be no administration of potentially harmful drugs, medicines or foodstuffs.
5. I will obtain written permission from an appropriate authority before recruiting members of any outside institution as participants.
6. I certify that the participants will not experience any potentially unpleasant stimulation or deprivation.
7. I certify that any ethical considerations raised by this proposal have been discussed in detail with my supervisor.
8. I certify that the above statements are true with the following exception(s):

Student signature: Date:

12. SUPERVISOR'S DECLARATION

In the supervisor's opinion, this project (delete those that do not apply):

- Does not raise any significant issues.
- Raises some ethical issues, but I consider that appropriate steps and precautions have been taken and I have approved the proposal.
- Raises ethical issues that need to be considered by the Departmental Ethics Committee.
- Raises ethical issues such that it should not be allowed to proceed in its current form.

Supervisor's signature: Date:

13. ETHICS COMMITTEE DECISION (COMMITTEE USE ONLY)

ETHICAL APPROVAL: GRANTED REJECTED (delete as appropriate)

The ethical issues raised by this project have been considered by members of the Departmental Ethical Approval Committee who made the following comments:

.....

.....

.....

.....

Please ensure that you take account of these comments and prepare a revised submission that should be shown to your supervisor/ resubmitted to the Department Ethical Approval Committee (delete as appropriate).

Signed: Date:

(Chair, Departmental Ethics Advisory Committee)

APPENDIX B

Operational Definitions

All analysed behaviours and associated outcomes were considered and provided with an operation definition to allow accurate identification7 and coding. During analysis the team being studied was referred to as the notated, analysed or sampled team and other teams as the opposition. Data was only collected for the notated team. For the full rules and regulations of soccer readers are guided towards the website of the world governing body (Fédération Internationale de Football Association - www.fifa.com).

Appendix B1: Operational Definition for the Aerial Challenge Behaviour and Associated Outcomes

Behaviour	Outcome	Definition
Aerial Challenge An aerial challenge occurs when at least one player from each team jump together in an attempt to contact a ball in flight with their head.	Successful	• A player from the notated team makes first contact with the ball. • All players competing in the aerial challenge fail to contact the ball but the notated team gain or retain possession. • A player from the notated team is fouled and is awarded a free kick.
	Unsuccessful	• A player from the opposition team makes first contact with the ball. • All players involved with the aerial challenge fail to contact the ball and possession is subsequently gained or retained by the opposition team. • A player from the notated team commits a breach of the rules.

Appendix B2: Operational Definition for the Clearance Behaviour and Associated Outcomes

Behaviour	Outcome	Definition
Clearance Clearances are attempts by the notated team to direct the ball out of play or up the pitch to avert a direct threat upon goal. A clearance is distinguished from a pass in that there is no obvious intent to find a team mate.	Successful	• The ball is played over one of the pitch boundary lines and therefore is out of play. • The ball is played into the opposition half. • The ball is played out of the penalty area and remains in the notated teams half but possession is gained by a player from the notated team. • The ball is played out of the penalty area and remains in the notated teams half and an opposition player gains possession. However this opposition player does not immediately pass, dribble or cross the ball into the notated team's penalty area or does not take an immediate shot.
	Unsuccessful	• The ball is not cleared out of the notated team's penalty area. • The ball is cleared but remains in the notated teams half but possession is gained by an opposition player who immediately passes, dribbles or crosses the ball back into the penalty area or takes a shot. • Any other situation where the ball is not deemed to have been cleared to the extent where the danger on goal is averted. • The player commits a breach of the rules during the course of the clearance.

Appendix B3: Operational Definition for the Cross Behaviour and Associated Outcomes

Behaviour	Outcome	Definition
Cross An attempt by a player from the notated team to play the ball from a wide area of the midfield or attacking third into the opposition's penalty area.	Successful	• The ball enters the opposition penalty area and is contacted by a player from the notated team.
	Unsuccessful	• The ball fails to enter the opposition penalty area due to going out of play or being blocked by an opposition player. • The ball enters the opposition penalty area but subsequent contact is made by an opposition player. • The player commits a breach of the rules during the course of the cross.

Appendix B4: Operational Definition for the Dribble Behaviour and Outcomes

Behaviour	Outcome	Definition
Dribble Dribbles are identified as a player moving with intent while having the ball under control at their feet.	Successful	• The player retains possession of the ball and is able to perform a further behaviour. • The dribbling player is fouled and awarded a free kick. • The dribbling player is tackled but the notated team retains possession, including being awarded a corner, goal kick or throw-in.
	Unsuccessful	• Control of the ball is lost and possession is gained by the opposition team, including the ball going out of play with the opposition being awarded a corner, goal kick, or throw-in. • The dribbling player is tackled and loses possession including if the ball goes out of play and the opposition are awarded a corner, goal kick or throw-in . • The dribbling player is adjudged to have committed a breach of the rules.

Appendix B5: Operational Definition for the Interception Behaviour and Associated Outcomes

Behaviour	Outcome	Definition
Interception Any attempt by a player on the notated team to capture or impede the progress of the ball while it is in possession of the opposition team (not including tackles).	Successful	• Any opposition clearance, cross, shot, corner or free kick that is blocked by a player on the notated team. • A player from the notated team intercepts an opposition pass and gains possession of the ball.
	Unsuccessful	• A player from the notated team intercepts an opposition pass but, due to a lack of control, possession is retained by the opposition team. • During the course of the interception the player commits a breach of the rules.

Appendix B6: Operational Definition for the Loss of Control Behaviour and Associated Outcomes

Behaviour	Outcome	Definition
Loss Of Control A player from the notated team receives the ball, normally from a pass, but fails to control it.	Successful	• The player initially fails to control the ball but subsequently touches it before any opposition player. • The player fails to control the ball but it is next touched by another player from the notated team.
	Unsuccessful	• The player fails to control the ball and the next ball contact is made by the opposition team. • During the course of the loss of control the player breaches the rules.

Appendix B7: Operational Definition for the Pass Behaviour and Associated Outcomes

Behaviour	Outcome	Definition
Pass A controlled attempt by a player on the notated team to play the ball to a team-mate.	Successful	• The passed ball is next touched by a team mate.
	Unsuccessful	• An opponent touches the ball first or the ball leaves the field of play resulting in an incomplete pass. • The player executing or receiving the pass commits breach of the rules.

Appendix B8: Operational Definition for the Shot Behaviour and Associated Outcomes

Behaviour	Outcome	Definition
Shot A player from the notated team attempts to play the ball into the opposition's goal. This category was also deemed to include penalties awarded to the notated team.	Successful	• The ball enters the opposition's goal directly or is deflected off another player into the goal. • The ball is saved by the opposition goalkeeper either as the direct result of a shot or due to a deflection. The save may result in the goalkeeper gaining possession of the ball, the ball leaving the pitch and being adjudged as out of play, or the ball re-entering open play.
	Unsuccessful	• The shot is intercepted or blocked (not deflected) by an opposition player (not including the goalkeeper) and possession is gained by the opposition team. • The shot goes high/wide of the goal either directly or due to a deflection. • The shot hits the goal post/bar and deflects either back into play or over a pitch boundary line. • The player shooting commits a breach of the rules.

Appendix B9: Operational Definition for the Tackle Behaviour and Associated Outcomes

Behaviour	Outcome	Definition
Tackle An attempt by a player from the notated team to dispossess an opposition player of ball possession.	Successful	• The opposition player is dispossessed of the ball (the ball may still be retained by the opposition or may be obtained by the notated team). • The player from the notated team (tackler) is fouled.
	Unsuccessful	• The tackling player fails to dispossess the opposition player of the ball. • The tackling player commits a breach of the rules.

Appendix B10: Operational Definition for the Tackled Behaviour and Associated Outcomes

Behaviour	Outcome	Definition
Tackled A player from the notated team is in possession of the ball but gets tackled by an opponent. This differs from being tackled during a dribble, as the player is not in motion. In many cases it is the result of the player from the notated team lacking awareness.	Successful	• The player is dispossessed of possession by an opposition player but the ball is subsequently retained by the notated team. • The player from the notated team is fouled while being tackled by an opposition player.
	Unsuccessful	• The player is dispossessed of possession by an opposition player and the ball is subsequently gained by the opposition team. • During the course of being tackled the player from the notated team commits a breach of the rules.

Appendix B11: Operational Definition for the Corner Behaviour and Associated Outcomes

Behaviour	Outcome	Definition
Corner A corner is awarded when the whole of the ball, having last touched a player on the opposition team, crosses the goal line in the opposition half either along the ground or in the air but not actually entering into the goal.	Successful	• Following the execution of the corner the next ball contact is made by a player on the notated team. • Following the execution of the corner the ball enters directly into the opposition's goal. • During the course of the corner a player on the notated team is fouled by a player on the opposition team.
	Unsuccessful	• Following the execution of the corner the next ball contact is made by the an opposition player. • Following execution of the corner the ball passes over a pitch boundary line and is deemed as out of play. • During the course of the corner a player on the notated team commits a breach of the rules.

Appendix B12: Operational Definition for the Free Kick Behaviour and Associated Outcomes

Behaviour	Outcome	Definition
Free Kick A free kick is awarded to the notated team when the opposition have committed a breach of the rules. The free kick represents a method of restarting play and can be declared as direct or indirect. While the specific type of free kick is not coded (direct vs. indirect) both require consideration due to possible variations in outcomes. A direct free kick can be struck directly into the goal. In contrast an indirect free kick cannot be struck directly into the goal, having to be contacted by another player from either team first. Indirect free kicks are indicated by the referee holding an outstretched arm above their head. This stance is maintained until the free kick has been taken and a player other than the one executing the free kick makes contact with the ball or the ball leaves the field of play. In contrast, no specific signal is used to indicate a direct free kick.	Successful	DIRECT FREE KICK (DFK) • The DFK results in a successful cross or pass (see Appendix B3 and B7). • The DFK consists of a successful shot (see appendix B8). • During the course of the DFK a player from the notated team is fouled by an opposition player. INDIRECT FREE KICK (IFK): • The next ball contact following the IFK is by another player on the notated team. • During the course of the IFK a player from the notated team is fouled by an opposition player.
	Unsuccessful	DIRECT FREE KICK (DFK): • The DFK results in an unsuccessful cross or pass (see Appendix B3 and B7). • The DFK consists of an unsuccessful shot (see appendix B8) including striking any defensive wall. • Following the DFK the ball crosses a pitch boundary line and deemed as out of play. • During the course of the DFK a player from the notated team commits a rule breach. INDIRECT FREE KICK (IFK): • The next ball contact following the IFK is by an opposition player. • Following the IFK the ball crosses a pitch boundary line and is deemed as out of play. • The ball enters directly into the oppositions goal. • The ball enters directly into the team's own goal. • During the course of the IFK a player from he notated team commits a rule breach.

Appendix B13: Operational Definition for the Throw-In Behaviour and Associated Outcomes

Behaviour	Outcome	Definition
Throw-In A throw-in is awarded to the notated team when the whole ball passes over a pitch side line, either along the ground or in the air having last been contacted by an opposition player. The resulting throw-in is taken at the point where the ball left play.	Successful	• The throw-in is taken by a player from the notated team and is next contacted by another player from the notated team. • During the course of the throw-in a rule breach occurs resulting in a free kick for the notated team.
	Unsuccessful	• The throw-in is taken by a player from the notated team but is next contacted by a player from the opposition team. • A foul throw-in is performed by a player from the notated team. • During the course of the throw-in a rule breach occurs and results in a free kick to the opposition team.

APPENDIX C

Study 1 Intra- and Inter-Observer Reliability Testing Results

Appendix C1: Intra-Observer Reliability – Identification of Players 1 - 17.

Player ID		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Match 1	Observation 1 (O1)	60	87	0	55	0	0	0	0	44	0	36	0	0	0	60	70	5
	Observation 2 (O2)	61	87	0	55	0	0	0	0	42	0	36	0	0	0	62	72	5
	mod[O1-O2]	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*2*	*2*	*0*
Match 2	Observation 1 (O1)	65	71	66	0	0	59	60	64	51	0	0	0	70	72	0	0	0
	Observation 2 (O2)	66	71	68	0	0	59	60	64	53	0	0	0	73	73	0	0	0
	mod[O1-O2]	*1*	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*0*	*0*	*3*	*1*	*0*	*0*	*0*
Match 3	Observation 1 (O1)	53	60	0	0	58	0	59	0	36	29	0	77	0	31	81	0	16
	Observation 2 (O2)	52	60	0	0	56	0	59	0	37	30	0	77	0	31	79	0	16
	mod[O1-O2]	*1*	*0*	*0*	*0*	*2*	*0*	*0*	*0*	*1*	*1*	*0*	*0*	*0*	*0*	*2*	*0*	*0*
Match 4	Observation 1 (O1)	66	0	0	0	52	0	0	62	0	45	63	0	0	0	0	37	0
	Observation 2 (O2)	66	0	0	0	55	0	0	61	0	45	62	0	0	0	0	36	0
	mod[O1-O2]	*0*	*0*	*0*	*0*	*3*	*0*	*0*	*1*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*1*	*0*
Match 5	Observation 1 (O1)	0	65	0	0	0	54	56	0	0	39	58	2	0	0	54	37	40
	Observation 2 (O2)	0	66	0	0	0	53	56	0	0	40	56	2	0	0	54	38	40
	mod[O1-O2]	*0*	*1*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*1*	*2*	*0*	*0*	*0*	*0*	*1*	*0*
	Σmod[O1-O2]	**3**	**1**	**2**	**0**	**5**	**1**	**0**	**1**	**5**	**2**	**3**	**0**	**3**	**1**	**4**	**4**	**0**
	Σ[O1+O2]/2	**489**	**567**	**134**	**110**	**221**	**225**	**350**	**251**	**263**	**228**	**311**	**158**	**143**	**207**	**390**	**290**	**122**
	Overall Error	**0.6%**	**0.2%**	**1.5%**	**0.0%**	**2.3%**	**0.4%**	**0.0%**	**0.4%**	**1.9%**	**0.9%**	**1.0%**	**0.0%**	**2.1%**	**0.5%**	**1.0%**	**1.4%**	**0.0%**

Appendix C2: Intra-Observer Reliability – Identification of Players 18 - 34.

Player ID		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Match 1	Observation 1 (O1)	75	0	15	0	0	67	0	0	0	0	0	0	12	0	0	0	48
	Observation 2 (O2)	76	0	16	0	0	66	0	0	0	0	0	0	13	0	0	0	48
	mod[O1-O2]	*1*	*0*	*1*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*
Match 2	Observation 1 (O1)	0	0	0	0	0	42	0	0	0	0	76	0	0	0	0	0	0
	Observation 2 (O2)	0	0	0	0	0	42	0	0	0	0	77	0	0	0	0	0	0
	mod[O1-O2]	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*
Match 3	Observation 1 (O1)	0	58	0	0	0	0	0	0	0	0	0	55	0	0	58	0	0
	Observation 2 (O2)	0	56	0	0	0	0	0	0	0	0	0	55	0	0	58	0	0
	mod[O1-O2]	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Match 4	Observation 1 (O1)	61	0	0	0	0	0	30	66	0	0	0	0	35	24	0	60	0
	Observation 2 (O2)	58	0	0	0	0	0	30	66	0	0	0	0	34	25	0	61	0
	mod[O1-O2]	*3*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*1*	*0*	*1*	*0*
Match 5	Observation 1 (O1)	0	0	0	52	48	0	0	0	72	25	0	16	0	0	0	0	0
	Observation 2 (O2)	0	0	0	50	49	0	0	0	73	25	0	16	0	0	0	0	0
	mod[O1-O2]	*0*	*0*	*0*	*2*	*1*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
	Σmod[O1-O2]	**4**	**2**	**1**	**2**	**1**	**1**	**0**	**0**	**1**	**0**	**1**	**0**	**2**	**1**	**0**	**1**	**0**
	Σ[O1+O2]/2	**270**	**114**	**31**	**102**	**97**	**217**	**60**	**132**	**145**	**50**	**153**	**142**	**94**	**49**	**116**	**121**	**96**
	Overall Error	**1.5%**	**1.8%**	**3.2%**	**2.0%**	**1.0%**	**0.5%**	**0.0%**	**0.0%**	**0.7%**	**0.0%**	**0.7%**	**0.0%**	**2.1%**	**2.0%**	**0.0%**	**0.8%**	**0.0%**

Appendix C3: Inter-Observer Reliability – Identification of Player 1 – 17 (Observer 1 vs. Observer 2).

Player ID		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Match 1	Observer 1 (O1)	60	87	0	55	0	0	0	0	44	0	36	0	0	0	60	70	5
	Observer 2 (O2)	60	87	0	55	0	0	0	0	44	0	36	0	0	0	60	64	5
	mod[O1-O2]	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*6*	*0*
Match 2	Observer 1 (O1)	65	71	66	0	0	59	60	64	51	0	0	0	70	72	0	0	0
	Observer 2 (O2)	65	69	63	0	0	59	61	64	50	0	0	0	68	70	0	0	0
	mod[O1-O2]	*0*	*2*	*3*	*0*	*0*	*0*	*1*	*0*	*1*	*0*	*0*	*0*	*2*	*2*	*0*	*0*	*0*
Match 3	Observer 1 (O1)	53	60	0	0	58	0	59	0	36	29	0	77	0	31	81	0	16
	Observer 2 (O2)	52	60	0	0	57	0	59	0	36	29	0	77	0	35	78	0	16
	mod[O1-O2]	*1*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*4*	*3*	*0*	*0*
Match 4	Observer 1 (O1)	66	0	0	0	52	0	0	62	0	45	63	0	0	0	0	37	0
	Observer 2 (O2)	65	0	0	0	52	0	0	63	0	45	63	0	0	0	0	37	0
	mod[O1-O2]	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Match 5	Observer 1 (O1)	0	65	0	0	0	54	56	0	0	39	58	2	0	0	54	37	40
	Observer 2 (O2)	0	65	0	0	0	54	56	0	0	41	56	2	0	0	54	35	40
	mod[O1-O2]	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2*	*2*	*0*	*0*	*0*	*0*	*2*	*0*
	Σmod[O1-O2]	**2**	**2**	**3**	**0**	**1**	**0**	**1**	**1**	**1**	**2**	**2**	**0**	**2**	**6**	**3**	**8**	**0**
	Σ[O1+O2]/2	**486**	**564**	**129**	**110**	**219**	**226**	**351**	**253**	**261**	**228**	**312**	**158**	**138**	**208**	**387**	**280**	**122**
	Overall Error	**0.4%**	**0.4%**	**2.3%**	**0.0%**	**0.5%**	**0.0%**	**0.3%**	**0.4%**	**0.4%**	**0.9%**	**0.6%**	**0.0%**	**1.5%**	**2.9%**	**0.8%**	**2.9%**	**0.0%**

Appendix C4: Inter-Observer Reliability – Identification of Player 18 – 34 (Observer 1 vs. Observer 2).

Player ID		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Match 1	Observer 1 (O1)	75	0	15	0	0	67	0	0	0	0	0	0	12	0	0	0	48
	Observer 2 (O2)	75	0	14	0	0	68	0	0	0	0	0	0	11	0	0	0	45
	mod[O1-O2]	*0*	*0*	*1*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*3*
Match 2	Observer 1 (O1)	0	0	0	0	0	42	0	0	0	0	76	0	0	0	0	0	0
	Observer 2 (O2)	0	0	0	0	0	46	0	0	0	0	74	2	0	0	0	0	0
	mod[O1-O2]	*0*	*0*	*0*	*0*	*0*	*4*	*0*	*0*	*0*	*0*	*2*	*2*	*0*	*0*	*0*	*0*	*0*
Match 3	Observer 1 (O1)	0	58	0	0	0	0	0	0	0	0	0	55	0	0	58	0	0
	Observer 2 (O2)	0	60	0	0	0	0	0	0	0	0	0	57	0	0	60	0	0
	mod[O1-O2]	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*0*	*2*	*0*	*0*
Match 4	Observer 1 (O1)	61	0	0	0	0	0	30	66	0	0	0	0	35	24	0	60	0
	Observer 2 (O2)	62	0	0	0	0	0	30	66	0	0	0	0	38	24	2	60	0
	mod[O1-O2]	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*3*	*0*	*2*	*0*	*0*
Match 5	Observer 1 (O1)	0	0	0	52	48	0	0	0	72	25	0	16	0	0	0	0	0
	Observer 2 (O2)	0	0	0	52	48	0	0	0	72	23	0	16	0	0	0	0	0
	mod[O1-O2]	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
	Σmod[O1-O2]	**1**	**2**	**1**	**0**	**0**	**5**	**0**	**0**	**0**	**2**	**2**	**4**	**4**	**0**	**4**	**0**	**3**
	Σ[O1+O2]/2	**273**	**118**	**29**	**104**	**96**	**223**	**60**	**132**	**144**	**48**	**150**	**146**	**96**	**48**	**120**	**120**	**93**
	Overall Error	**0.4%**	**1.7%**	**3.5%**	**0.0%**	**0.0%**	**2.2%**	**0.0%**	**0.0%**	**0.0%**	**4.2%**	**1.3%**	**2.7%**	**4.2%**	**0.0%**	**3.3%**	**0.0%**	**3.2%**

Appendix C5: Inter-Observer Reliability – Identification of Player 1 – 17 (Observer 1 vs. Observer 3).

Player ID		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Match 1	Observer 1 (O1)	60	87	0	55	0	0	0	0	44	0	36	0	0	0	60	70	5
	Observer 3 (O3)	60	87	0	55	0	0	0	0	44	1	36	0	0	0	61	70	5
	mod[O1-O3]	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*1*	*0*	*0*
Match 2	Observer 1 (O1)	65	71	66	0	0	59	60	64	51	0	0	0	70	72	0	0	0
	Observer 3 (O3)	65	71	62	0	0	59	60	64	52	5	0	0	69	72	0	0	0
	mod[O1-O3]	*0*	*0*	*4*	*0*	*0*	*0*	*0*	*0*	*1*	*5*	*0*	*0*	*1*	*0*	*0*	*0*	*0*
Match 3	Observer 1 (O1)	53	60	0	0	58	0	59	0	36	29	0	77	0	31	81	0	16
	Observer 3 (O3)	53	60	0	0	58	0	59	0	38	29	0	77	0	29	82	0	16
	mod[O1-O3]	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*0*	*0*	*0*	*2*	*1*	*0*	*0*
Match 4	Observer 1 (O1)	66	0	0	0	52	0	0	62	0	45	63	0	0	0	0	37	0
	Observer 3 (O3)	66	8	0	0	52	0	0	62	0	45	61	0	0	0	0	37	0
	mod[O1-O3]	*0*	*8*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*0*
Match 5	Observer 1 (O1)	0	65	0	0	0	54	56	0	0	39	58	2	0	0	54	37	40
	Observer 3 (O3)	0	60	0	0	0	55	56	0	0	39	58	2	0	0	53	37	40
	mod[O1-O3]	*0*	*5*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*
	Σmod[O1-O3]	**0**	**13**	**4**	**0**	**0**	**1**	**0**	**0**	**3**	**6**	**2**	**0**	**1**	**2**	**3**	**0**	**0**
	Σ[O1+O3]/2	**488**	**569**	**128**	**110**	**220**	**227**	**350**	**252**	**265**	**232**	**312**	**158**	**139**	**204**	**391**	**288**	**122**
	Overall Error	**0.0%**	**2.3%**	**3.1%**	**0.0%**	**0.0%**	**0.4%**	**0.0%**	**0.0%**	**1.1%**	**2.6%**	**0.6%**	**0.0%**	**0.7%**	**1.0%**	**0.8%**	**0.0%**	**0.0%**

Appendix C6: Inter-Observer Reliability – Identification of Player 18 – 34 (Observer 1 vs. Observer 3).

Player ID		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Match 1	Observer 1 (O1)	75	0	15	0	0	67	0	0	0	0	0	0	12	0	0	0	48
	Observer 3 (O3)	75	0	14	0	0	66	0	0	0	0	0	0	9	0	0	0	48
	mod[O1-O3]	*0*	*0*	*1*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*3*	*0*	*0*	*0*	*0*
Match 2	Observer 1 (O1)	0	0	0	0	0	42	0	0	0	0	76	0	0	0	0	0	0
	Observer 3 (O3)	0	0	0	0	0	46	0	0	0	0	76	0	0	0	0	0	0
	mod[O1-O3]	*0*	*0*	*0*	*0*	*0*	*4*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Match 3	Observer 1 (O1)	0	58	0	0	0	0	0	0	0	0	0	55	0	0	58	0	0
	Observer 3 (O3)	0	60	0	0	0	0	0	0	0	0	0	55	0	0	56	0	0
	mod[O1-O3]	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*0*
Match 4	Observer 1 (O1)	61	0	0	0	0	0	30	66	0	0	0	0	35	24	0	60	0
	Observer 3 (O3)	61	0	0	0	0	0	30	64	0	0	0	0	35	24	0	60	0
	mod[O1-O3]	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Match 5	Observer 1 (O1)	0	0	0	52	48	0	0	0	72	25	0	16	0	0	0	0	0
	Observer 3 (O3)	0	0	0	55	48	0	0	0	73	25	0	16	0	0	0	0	0
	mod[O1-O3]	*0*	*0*	*0*	*3*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
	Σmod[O1-O3]	**0**	**2**	**1**	**3**	**0**	**5**	**0**	**2**	**1**	**0**	**0**	**0**	**3**	**0**	**2**	**0**	**0**
	Σ[O1+O3]/2	**272**	**118**	**29**	**107**	**96**	**221**	**60**	**130**	**145**	**50**	**152**	**142**	**91**	**48**	**114**	**120**	**96**
	Overall Error	**0.0%**	**1.7%**	**3.5%**	**2.8%**	**0.0%**	**2.6%**	**0.0%**	**1.5%**	**0.7%**	**0.0%**	**0.0%**	**0.0%**	**3.3%**	**0.0%**	**1.8%**	**0.0%**	**0.0%**

Appendix C7: Intra-Observer Reliability – Playing Position.

Playing Position		Fullback	Centre Back	Midfield	Forward
Match 1	Observation 1 (O1)	211	55	252	116
	Observation 2 (O2)	217	61	245	116
	mod[O1-O2]	*6*	*6*	*7*	*0*
Match 2	Observation 1 (O1)	227	121	211	137
	Observation 2 (O2)	235	125	209	137
	mod[O1-O2]	*8*	*4*	*2*	*0*
Match 3	Observation 1 (O1)	159	145	193	175
	Observation 2 (O2)	162	140	187	177
	mod[O1-O2]	*3*	*5*	*6*	*2*
Match 4	Observation 1 (O1)	199	65	207	130
	Observation 2 (O2)	200	70	205	126
	mod[O1-O2]	*1*	*5*	*2*	*4*
Match 5	Observation 1 (O1)	258	56	199	105
	Observation 2 (O2)	250	59	199	110
	mod[O1-O2]	*8*	*3*	*0*	*5*
	Σmod[O1-O2]	**26**	**23**	**17**	**11**
	Σ[O1+O2]/2	**2118**	**897**	**2107**	**1329**
	Overall Error	**1.2%**	**2.6%**	**0.8%**	**0.8%**

Appendix C8: Inter-Observer Reliability – Playing Position (Observer 1 vs. Observer 2).

Playing Position		Fullback	Centre Back	Midfield	Forward
Match 1	Observer 1 (O1)	211	55	252	116
	Observer 2 (O2)	208	66	243	105
	mod[O1-O2]	*3*	*11*	*9*	*11*
Match 2	Observer 1 (O1)	227	121	211	137
	Observer 2 (O2)	219	115	211	146
	mod[O1-O2]	*8*	*6*	*0*	*9*
Match 3	Observer 1 (O1)	159	145	193	175
	Observer 2 (O2)	163	142	198	173
	mod[O1-O2]	*4*	*3*	*5*	*2*
Match 4	Observer 1 (O1)	199	65	207	130
	Observer 2 (O2)	195	67	209	132
	mod[O1-O2]	*4*	*2*	*2*	*2*
Match 5	Observer 1 (O1)	258	56	199	105
	Observer 2 (O2)	250	58	201	105
	mod[O1-O2]	*8*	*2*	*2*	*0*
	Σmod[O1-O2]	**27**	**24**	**18**	**24**
	Σ[O1+O2]/2	**2089**	**890**	**2124**	**1324**
	Overall Error	**1.3%**	**2.7%**	**0.9%**	**1.8%**

Appendix C9: Inter-Observer Reliability – Playing Position (Observer 1 vs. Observer 3).

Playing Position		Fullback	Centre Back	Midfield	Forward
Match 1	Observer 1 (O1)	211	55	252	116
	Observer 3 (O3)	209	54	256	112
	mod[O1-O3]	*2*	*1*	*4*	*4*
Match 2	Observer 1 (O1)	227	121	211	137
	Observer 3 (O3)	231	115	222	133
	mod[O1-O3]	*4*	*6*	*11*	*4*
Match 3	Observer 1 (O1)	159	145	193	175
	Observer 3 (O3)	159	145	195	171
	mod[O1-O3]	*0*	*0*	*2*	*4*
Match 4	Observer 1 (O1)	199	65	207	130
	Observer 3 (O3)	193	66	204	142
	mod[O1-O3]	*6*	*1*	*3*	*12*
Match 5	Observer 1 (O1)	258	56	199	105
	Observer 3 (O3)	248	65	201	103
	mod[O1-O3]	*10*	*9*	*2*	*2*
	Σmod[O1-O3]	**22**	**17**	**22**	**26**
	Σ[O1+O3]/2	**2094**	**887**	**2140**	**1324**
	Overall Error	**1.1%**	**1.9%**	**1.0%**	**2.0%**

Appendix C10: Intra-Observer Reliability – Behaviour Performed.

Behaviour		Aerial Challenge	Clearance	Cross	Dribble	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Corner	Free Kick	Throw-in
Match 1	Observation 1 (O1)	55	50	20	62	38	13	279	11	53	12	4	10	27
	Observation 2 (O2)	54	52	20	62	37	12	284	11	54	12	4	10	27
	mod[O1-O2]	*1*	*2*	*0*	*0*	*1*	*1*	*5*	*0*	*1*	*0*	*0*	*0*	*0*
Match 2	Observation 1 (O1)	81	46	24	60	39	12	308	14	48	12	7	10	35
	Observation 2 (O2)	81	47	24	60	39	11	312	14	53	13	7	11	34
	mod[O1-O2]	*0*	*1*	*0*	*0*	*0*	*1*	*4*	*0*	*5*	*1*	*0*	*1*	*1*
Match 3	Observation 1 (O1)	52	39	29	84	34	11	294	8	54	12	5	15	35
	Observation 2 (O2)	53	38	28	84	33	12	295	8	49	11	5	15	35
	mod[O1-O2]	*1*	*1*	*1*	*0*	*1*	*1*	*1*	*0*	*5*	*1*	*0*	*0*	*0*
Match 4	Observation 1 (O1)	73	55	23	44	30	12	245	11	50	11	6	11	30
	Observation 2 (O2)	70	53	24	45	31	12	246	11	49	11	6	11	30
	mod[O1-O2]	*3*	*2*	*1*	*1*	*1*	*0*	*1*	*0*	*1*	*0*	*0*	*0*	*0*
Match 5	Observation 1 (O1)	79	43	16	47	25	14	257	16	54	9	8	12	38
	Observation 2 (O2)	79	42	16	45	26	14	260	16	54	9	7	12	38
	mod[O1-O2]	*0*	*1*	*0*	*2*	*1*	*0*	*3*	*0*	*0*	*0*	*1*	*0*	*0*
	Σmod[O1-O2]	**5**	**7**	**2**	**3**	**4**	**3**	**14**	**0**	**12**	**2**	**1**	**1**	**1**
	Σ[O1+O2]/2	**677**	**465**	**224**	**593**	**332**	**123**	**2780**	**120**	**518**	**112**	**59**	**117**	**329**
	Overall Error	**0.7%**	**1.5%**	**0.9%**	**0.5%**	**1.2%**	**2.4%**	**0.5%**	**0.0%**	**2.3%**	**1.8%**	**1.7%**	**0.9%**	**0.3%**

Appendix C11: Inter-Observer Reliability – Behaviour Performed (Observer 1 vs. Observer 2).

Behaviour		Aerial Challenge	Clearance	Cross	Dribble	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Corner	Free Kick	Throw-in
Match 1	Observer 1 (O1)	55	50	20	62	38	13	279	11	53	12	4	10	27
	Observer 2 (O2)	54	47	20	64	37	12	275	11	47	13	4	11	27
	mod[O1-O2]	*1*	*3*	*0*	*2*	*1*	*1*	*4*	*0*	*6*	*1*	*0*	*1*	*0*
Match 2	Observer 1 (O1)	81	46	24	60	39	12	308	14	48	12	7	10	35
	Observer 2 (O2)	76	43	22	63	33	12	310	14	53	12	7	10	36
	mod[O1-O2]	*5*	*3*	*2*	*3*	*6*	*0*	*2*	*0*	*5*	*0*	*0*	*0*	*1*
Match 3	Observer 1 (O1)	52	39	29	84	34	11	294	8	54	12	5	15	35
	Observer 2 (O2)	53	37	26	87	29	13	299	8	55	11	6	17	35
	mod[O1-O2]	*1*	*2*	*3*	*3*	*5*	*2*	*5*	*0*	*1*	*1*	*1*	*2*	*0*
Match 4	Observer 1 (O1)	73	55	23	44	30	12	245	11	50	11	6	11	30
	Observer 2 (O2)	73	50	23	52	30	13	247	10	49	10	6	11	29
	mod[O1-O2]	*0*	*5*	*0*	*8*	*0*	*1*	*2*	*1*	*1*	*1*	*0*	*0*	*1*
Match 5	Observer 1 (O1)	79	43	16	47	25	14	257	16	54	9	8	12	38
	Observer 2 (O2)	78	43	16	49	25	15	256	16	51	7	8	12	38
	mod[O1-O2]	*1*	*0*	*0*	*2*	*0*	*1*	*1*	*0*	*3*	*2*	*0*	*0*	*0*
	Σmod[O1-O2]	**8**	**13**	**5**	**18**	**12**	**5**	**14**	**1**	**16**	**5**	**1**	**3**	**2**
	Σ[O1+O2]/2	**674**	**453**	**219**	**612**	**320**	**127**	**2770**	**119**	**514**	**109**	**61**	**119**	**330**
	Overall Error	**1.2%**	**2.9%**	**2.3%**	**2.9%**	**3.8%**	**3.9%**	**0.5%**	**0.8%**	**3.1%**	**4.6%**	**1.6%**	**2.5%**	**0.6%**

Appendix C12: Inter-Observer Reliability – Behaviour Performed (Observer 1 vs. Observer 3).

Behaviour		Aerial Challenge	Clearance	Cross	Dribble	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Corner	Free Kick	Throw-in
Match 1	Observer 1 (O1)	55	50	20	62	38	13	279	11	53	12	4	10	27
	Observer 3 (O3)	50	52	21	60	36	15	278	11	53	13	4	11	27
	mod[O1-O3]	*5*	*2*	*1*	*2*	*2*	*2*	*1*	*0*	*0*	*1*	*0*	*1*	*0*
Match 2	Observer 1 (O1)	81	46	24	60	39	12	308	14	48	12	7	10	35
	Observer 3 (O3)	80	47	24	61	40	11	311	14	49	12	7	10	35
	mod[O1-O3]	*1*	*1*	*0*	*1*	*1*	*1*	*3*	*0*	*1*	*0*	*0*	*0*	*0*
Match 3	Observer 1 (O1)	52	39	29	84	34	11	294	8	54	12	5	15	35
	Observer 3 (O3)	51	37	30	86	36	10	287	7	57	13	6	15	35
	mod[O1-O3]	*1*	*2*	*1*	*2*	*2*	*1*	*7*	*1*	*3*	*1*	*1*	*0*	*0*
Match 4	Observer 1 (O1)	73	55	23	44	30	12	245	11	50	11	6	11	30
	Observer 3 (O3)	75	53	24	46	31	11	249	11	47	13	5	10	30
	mod[O1-O3]	*2*	*2*	*1*	*2*	*1*	*1*	*4*	*0*	*3*	*2*	*1*	*1*	*0*
Match 5	Observer 1 (O1)	79	43	16	47	25	14	257	16	54	9	8	12	38
	Observer 3 (O3)	79	41	15	48	25	13	260	15	54	8	8	12	39
	mod[O1-O3]	*0*	*2*	*1*	*1*	*0*	*1*	*3*	*1*	*0*	*1*	*0*	*0*	*1*
	Σmod[O1-O3]	**9**	**9**	**4**	**8**	**6**	**6**	**18**	**2**	**7**	**5**	**2**	**2**	**1**
	Σ[O1+O3]/2	**675**	**463**	**226**	**598**	**334**	**122**	**2768**	**118**	**519**	**115**	**60**	**116**	**331**
	Overall Error	**1.3%**	**1.9%**	**1.8%**	**1.3%**	**1.8%**	**4.9%**	**0.7%**	**1.7%**	**1.3%**	**4.3%**	**3.3%**	**1.7%**	**0.3%**

Appendix C13: Intra-Observer Reliability – Behaviour Outcome.

Behaviour Outcome		Successful	Unsuccessful
Match 1	Observation 1 (O1)	443	191
	Observation 2 (O2)	454	185
	mod[O1-O2]	*11*	*6*
Match 2	Observation 1 (O1)	459	237
	Observation 2 (O2)	480	226
	mod[O1-O2]	*21*	*11*
Match 3	Observation 1 (O1)	457	215
	Observation 2 (O2)	449	217
	mod[O1-O2]	*8*	*2*
Match 4	Observation 1 (O1)	426	175
	Observation 2 (O2)	422	179
	mod[O1-O2]	*4*	*4*
Match 5	Observation 1 (O1)	414	204
	Observation 2 (O2)	407	211
	mod[O1-O2]	*7*	*7*
	Σmod[O1-O2]	**51**	**30**
	Σ[O1+O2]/2	**4411**	**2040**
	Overall Error	**1.2%**	**1.5%**

Appendix C14: Inter-Observer Reliability – Behaviour Outcome (Observer 1 vs. Observer 2).

Behaviour Outcome		Successful	Unsuccessful
Match 1	Observer 1 (O1)	443	191
	Observer 2 (O2)	458	176
	mod[O1-O2]	*15*	*15*
Match 2	Observer 1 (O1)	459	237
	Observer 2 (O2)	450	241
	mod[O1-O2]	*9*	*4*
Match 3	Observer 1 (O1)	457	215
	Observer 2 (O2)	450	226
	mod[O1-O2]	*7*	*11*
Match 4	Observer 1 (O1)	426	175
	Observer 2 (O2)	430	173
	mod[O1-O2]	*4*	*2*
Match 5	Observer 1 (O1)	414	204
	Observer 2 (O2)	420	194
	mod[O1-O2]	*6*	*10*
	Σmod[O1-O2]	**41**	**42**
	Σ[O1+O2]/2	**4407**	**2032**
	Overall Error	**0.9%**	**2.1%**

Appendix C15: Inter-Observer Reliability – Behaviour Outcome (Observer 1 vs. Observer 3).

Behaviour Outcome		Successful	Unsuccessful
Match 1	Observer 1 (O1)	443	191
	Observer 3 (O3)	438	193
	mod[O1-O3]	*5*	*2*
Match 2	Observer 1 (O1)	459	237
	Observer 3 (O3)	447	254
	mod[O1-O3]	*12*	*17*
Match 3	Observer 1 (O1)	457	215
	Observer 3 (O3)	449	221
	mod[O1-O3]	*8*	*6*
Match 4	Observer 1 (O1)	426	175
	Observer 3 (O3)	440	165
	mod[O1-O3]	*14*	*10*
Match 5	Observer 1 (O1)	414	204
	Observer 3 (O3)	408	209
	mod[O1-O3]	*6*	*5*
	Σmod[O1-O3]	**45**	**40**
	Σ[O1+O3]/2	**4381**	**2064**
	Overall Error	**1.0%**	**1.9%**

APPENDIX D

Study 2 Intra- and Inter-Observer Reliability Testing Results

Appendix D1: Intra-Observer Reliability – Identification of Players 1 - 15.

Player ID		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Match 1	Observation 1 (O1)	0	36	83	60	13	42	47	41	59	0	0	72	58	0	0
	Observation 2 (O2)	0	34	81	59	13	42	47	41	60	0	0	74	60	0	0
	mod[O1-O2]	*0*	*2*	*2*	*1*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*2*	*2*	*0*	*0*
Match 2	Observation 1 (O1)	60	0	58	100	78	30	0	0	71	72	0	81	40	0	0
	Observation 2 (O2)	60	0	58	97	81	31	0	0	73	72	0	81	42	0	0
	mod[O1-O2]	*0*	*0*	*0*	*3*	*3*	*1*	*0*	*0*	*2*	*0*	*0*	*0*	*2*	*0*	*0*
Match 3	Observation 1 (O1)	56	0	53	30	74	77	0	77	63	72	0	94	0	0	5
	Observation 2 (O2)	55	0	53	31	74	74	0	77	64	72	0	95	0	0	5
	mod[O1-O2]	*1*	*0*	*0*	*1*	*0*	*3*	*0*	*0*	*1*	*0*	*0*	*1*	*0*	*0*	*0*
Match 4	Observation 1 (O1)	61	58	0	41	0	76	73	5	59	0	61	0	0	0	0
	Observation 2 (O2)	61	55	0	41	0	75	73	8	59	0	59	0	0	0	0
	mod[O1-O2]	*0*	*3*	*0*	*0*	*0*	*1*	*0*	*3*	*0*	*0*	*2*	*0*	*0*	*0*	*0*
Match 5	Observation 1 (O1)	85	0	68	65	0	74	75	0	80	36	0	0	1	69	29
	Observation 2 (O2)	85	0	65	68	0	70	76	0	81	36	0	0	1	69	29
	mod[O1-O2]	*0*	*0*	*3*	*3*	*0*	*4*	*1*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*
	Σmod[O1-O2]	**1**	**5**	**5**	**8**	**3**	**9**	**1**	**3**	**5**	**0**	**2**	**3**	**4**	**0**	**0**
	Σ[O1+O2]/2	**523**	**183**	**519**	**592**	**333**	**591**	**391**	**249**	**669**	**360**	**120**	**497**	**202**	**138**	**68**
	Overall Error	**0.2%**	**2.7%**	**1.0%**	**1.4%**	**0.9%**	**1.5%**	**0.3%**	**1.2%**	**0.8%**	**0.0%**	**1.7%**	**0.6%**	**2.0%**	**0.0%**	**0.0%**

Appendix D2: Intra-Observer Reliability – Identification of Players 16 - 30.

Player ID		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Match 1	Observation 1 (O1)	0	64	0	0	0	0	0	0	0	0	0	0	0	0	65
	Observation 2 (O2)	0	65	0	0	0	0	0	0	0	0	0	0	0	0	68
	mod[O1-O2]	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*3*
Match 2	Observation 1 (O1)	31	0	0	0	0	0	0	3	0	41	0	34	68	0	0
	Observation 2 (O2)	31	0	0	0	0	0	0	3	0	41	0	34	68	0	0
	mod[O1-O2]	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Match 3	Observation 1 (O1)	0	0	40	59	62	0	0	0	0	0	0	0	0	0	0
	Observation 2 (O2)	0	0	40	60	60	0	0	0	0	0	0	0	0	0	0
	mod[O1-O2]	*0*	*0*	*0*	*1*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Match 4	Observation 1 (O1)	52	0	46	14	0	44	23	0	0	0	0	0	0	52	0
	Observation 2 (O2)	52	0	45	16	0	44	23	0	0	0	0	0	0	52	0
	mod[O1-O2]	*0*	*0*	*1*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Match 5	Observation 1 (O1)	15	52	58	0	0	0	0	0	61	0	72	0	0	0	0
	Observation 2 (O2)	13	52	61	0	0	0	0	0	63	0	73	0	0	0	0
	mod[O1-O2]	*2*	*0*	*3*	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*1*	*0*	*0*	*0*	*0*
	Σmod[O1-O2]	**2**	**1**	**4**	**3**	**2**	**0**	**0**	**0**	**2**	**0**	**1**	**0**	**0**	**0**	**3**
	Σ[O1+O2]/2	**194**	**233**	**290**	**149**	**122**	**88**	**46**	**6**	**124**	**82**	**145**	**68**	**136**	**104**	**133**
	Overall Error	**1.0%**	**0.4%**	**1.4%**	**2.0%**	**1.6%**	**0.0%**	**0.0%**	**0.0%**	**1.6%**	**0.0%**	**0.7%**	**0.0%**	**0.0%**	**0.0%**	**2.3%**

Appendix D3: Inter-Observer Reliability – Identification of Player 1 – 15 (Observer 1 vs. Observer 2).

Player ID		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Match 1	Observer 1 (O1)	0	36	83	60	13	42	47	41	59	0	0	72	58	0	0
	Observer 2 (O2)	0	34	80	62	13	43	48	43	62	2	0	72	62	0	0
	mod[O1-O2]	*0*	*2*	*3*	*2*	*0*	*1*	*1*	*2*	*3*	*2*	*0*	*0*	*4*	*0*	*0*
Match 2	Observer 1 (O1)	60	0	58	101	78	30	0	0	71	72	0	81	40	0	0
	Observer 2 (O2)	60	0	59	96	78	25	0	0	71	70	0	81	40	0	0
	mod[O1-O2]	*0*	*0*	*1*	*5*	*0*	*5*	*0*	*0*	*0*	*2*	*0*	*0*	*0*	*0*	*0*
Match 3	Observer 1 (O1)	56	0	53	30	74	77	0	77	63	72	0	94	0	0	5
	Observer 2 (O2)	56	0	48	31	74	79	0	80	61	74	0	96	0	0	5
	mod[O1-O2]	*0*	*0*	*5*	*1*	*0*	*2*	*0*	*3*	*2*	*2*	*0*	*2*	*0*	*0*	*0*
Match 4	Observer 1 (O1)	61	58	0	41	0	76	73	5	59	0	61	0	0	0	0
	Observer 2 (O2)	61	56	0	46	0	76	70	9	58	0	60	0	0	0	0
	mod[O1-O2]	*0*	*2*	*0*	*5*	*0*	*0*	*3*	*4*	*1*	*0*	*1*	*0*	*0*	*0*	*0*
Match 5	Observer 1 (O1)	85	0	68	65	0	74	75	0	80	36	0	0	1	69	29
	Observer 2 (O2)	80	0	70	65	0	75	72	0	80	36	0	0	2	72	29
	mod[O1-O2]	*5*	*0*	*2*	*0*	*0*	*1*	*3*	*0*	*0*	*0*	*0*	*0*	*1*	*3*	*0*
	Σmod[O1-O2]	**5**	**4**	**11**	**13**	**0**	**9**	**7**	**9**	**6**	**6**	**1**	**2**	**5**	**3**	**0**
	Σ[O1+O2]/2	**519**	**184**	**519**	**597**	**330**	**597**	**385**	**255**	**664**	**362**	**121**	**496**	**203**	**141**	**68**
	Overall Error	**1.0%**	**2.2%**	**2.1%**	**2.2%**	**0.0%**	**1.5%**	**1.8%**	**3.5%**	**0.9%**	**1.7%**	**0.8%**	**0.4%**	**2.5%**	**2.1%**	**0.0%**

Appendix D4: Inter-Observer Reliability – Identification of Player 16 – 30 (Observer 1 vs. Observer 2).

Player ID		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Match 1	Observer 1 (O1)	0	64	0	0	0	0	0	0	0	0	0	0	0	0	65
	Observer 2 (O2)	0	61	0	0	0	0	0	0	0	0	0	0	0	1	67
	mod[O1-O2]	*0*	*3*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*2*
Match 2	Observer 1 (O1)	31	0	0	0	0	0	0	2	0	41	0	34	68	0	0
	Observer 2 (O2)	31	0	0	0	0	0	0	2	0	39	0	32	73	0	0
	mod[O1-O2]	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*2*	*5*	*0*	*0*
Match 3	Observer 1 (O1)	0	0	40	59	62	0	0	0	0	0	0	0	0	0	0
	Observer 2 (O2)	0	0	40	62	62	0	0	0	0	0	0	0	0	0	0
	mod[O1-O2]	*0*	*0*	*0*	*3*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Match 4	Observer 1 (O1)	52	0	46	14	0	44	23	0	0	0	0	0	0	52	0
	Observer 2 (O2)	55	0	49	15	0	44	23	0	0	0	0	0	0	55	0
	mod[O1-O2]	*3*	*0*	*3*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*3*	*0*
Match 5	Observer 1 (O1)	15	52	58	0	0	0	0	0	61	0	72	0	0	0	0
	Observer 2 (O2)	13	54	59	0	0	0	0	0	63	0	70	0	0	0	0
	mod[O1-O2]	*2*	*2*	*1*	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*2*	*0*	*0*	*0*	*0*
	Σmod[O1-O2]	**5**	**5**	**4**	**4**	**0**	**0**	**0**	**0**	**2**	**2**	**2**	**2**	**5**	**4**	**2**
	Σ[O1+O2]/2	**197**	**231**	**292**	**150**	**124**	**88**	**46**	**4**	**124**	**80**	**142**	**66**	**141**	**108**	**132**
	Overall Error	**2.5%**	**2.2%**	**1.4%**	**2.7%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**1.6%**	**2.5%**	**1.4%**	**3.0%**	**3.6%**	**3.7%**	**1.5%**

Appendix D5: Inter-Observer Reliability – Identification of Player 1 – 15 (Observer 1 vs. Observer 3).

Player ID		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Match 1	Observer 1 (O1)	0	36	83	60	13	42	47	41	59	0	0	72	58	0	0
	Observer 3 (O3)	0	35	83	61	13	42	49	39	59	0	0	72	57	0	0
	mod[O1-O3]	*0*	*1*	*0*	*1*	*0*	*0*	*2*	*2*	*0*	*0*	*0*	*0*	*1*	*0*	*0*
Match 2	Observer 1 (O1)	60	0	58	101	78	30	0	0	71	72	0	81	40	0	0
	Observer 3 (O3)	57	0	62	98	76	29	0	0	73	72	0	80	41	0	0
	mod[O1-O3]	*3*	*0*	*4*	*3*	*2*	*1*	*0*	*0*	*2*	*0*	*0*	*1*	*1*	*0*	*0*
Match 3	Observer 1 (O1)	56	0	53	30	74	77	0	77	63	72	0	94	0	0	5
	Observer 3 (O3)	56	0	55	31	74	77	2	75	62	72	0	94	0	0	5
	mod[O1-O3]	*0*	*0*	*2*	*1*	*0*	*0*	*2*	*2*	*1*	*0*	*0*	*0*	*0*	*0*	*0*
Match 4	Observer 1 (O1)	61	58	0	41	0	76	73	5	59	0	61	0	0	0	0
	Observer 3 (O3)	61	56	0	43	0	76	73	5	59	0	63	1	0	0	0
	mod[O1-O3]	*0*	*2*	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*2*	*1*	*0*	*0*	*0*
Match 5	Observer 1 (O1)	85	0	68	65	0	74	75	0	80	36	0	0	1	69	29
	Observer 3 (O3)	80	0	70	65	0	75	74	0	81	37	0	0	2	69	27
	mod[O1-O3]	*5*	*0*	*2*	*0*	*0*	*1*	*1*	*0*	*1*	*1*	*0*	*0*	*1*	*0*	*2*
	Σmod[O1-O3]	**8**	**3**	**8**	**7**	**2**	**2**	**5**	**4**	**4**	**1**	**2**	**2**	**3**	**0**	**2**
	Σ[O1+O3]/2	**516**	**185**	**532**	**595**	**328**	**598**	**393**	**242**	**666**	**361**	**124**	**494**	**199**	**138**	**66**
	Overall Error	**1.5%**	**1.6%**	**1.5%**	**1.2%**	**0.6%**	**0.3%**	**1.3%**	**1.7%**	**0.6%**	**0.3%**	**1.6%**	**0.4%**	**1.5%**	**0.0%**	**3.0%**

Appendix D6: Inter-Observer Reliability – Identification of Player 16 – 30 (Observer 1 vs. Observer 3).

Player ID		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Match 1	Observer 1 (O1)	0	64	0	0	0	0	0	0	0	0	0	0	0	0	65
	Observer 3 (O3)	0	65	0	0	0	0	0	0	0	0	0	0	0	0	67
	mod[O1-O3]	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2*
Match 2	Observer 1 (O1)	31	0	0	0	0	0	0	2	0	41	0	34	68	0	0
	Observer 3 (O3)	32	0	0	0	0	0	0	2	0	38	1	35	67	0	0
	mod[O1-O3]	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*3*	*1*	*1*	*1*	*0*	*0*
Match 3	Observer 1 (O1)	0	0	40	59	62	0	0	0	0	0	0	0	0	0	0
	Observer 3 (O3)	0	0	41	60	64	0	0	0	0	0	0	0	0	0	0
	mod[O1-O3]	*0*	*0*	*1*	*1*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Match 4	Observer 1 (O1)	52	0	46	14	0	44	23	0	0	0	0	0	0	52	0
	Observer 3 (O3)	52	0	45	14	0	43	21	0	0	0	0	0	0	54	0
	mod[O1-O3]	*0*	*0*	*1*	*0*	*0*	*1*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*2*	*0*
Match 5	Observer 1 (O1)	15	52	58	0	0	0	0	0	61	0	72	0	0	0	0
	Observer 3 (O3)	14	52	56	1	0	0	0	0	58	0	72	0	0	0	0
	mod[O1-O3]	*1*	*0*	*2*	*1*	*0*	*0*	*0*	*0*	*3*	*0*	*0*	*0*	*0*	*0*	*0*
	Σmod[O1-O3]	**2**	**1**	**4**	**2**	**2**	**1**	**2**	**0**	**3**	**3**	**1**	**1**	**1**	**2**	**2**
	Σ[O1+O3]/2	**196**	**233**	**286**	**148**	**126**	**87**	**44**	**4**	**119**	**79**	**145**	**69**	**135**	**106**	**132**
	Overall Error	**1.0%**	**0.4%**	**1.4%**	**1.4%**	**1.6%**	**1.2%**	**4.6%**	**0.0%**	**2.5%**	**3.8%**	**0.7%**	**1.5%**	**0.7%**	**1.9%**	**1.5%**

Appendix D7: Intra-Observer Reliability – Playing Position.

Playing Position		Fullback	Centre Back	Midfield	Forward
Match 1	Observation 1 (O1)	201	111	246	82
	Observation 2 (O2)	207	109	238	90
	mod[O1-O2]	*6*	*2*	*8*	*8*
Match 2	Observation 1 (O1)	236	139	261	131
	Observation 2 (O2)	242	134	253	143
	mod[O1-O2]	*6*	*5*	*8*	*12*
Match 3	Observation 1 (O1)	218	174	267	103
	Observation 2 (O2)	215	169	273	103
	mod[O1-O2]	*3*	*5*	*6*	*0*
Match 4	Observation 1 (O1)	189	102	237	137
	Observation 2 (O2)	187	107	237	132
	mod[O1-O2]	*2*	*5*	*0*	*5*
Match 5	Observation 1 (O1)	240	132	304	164
	Observation 2 (O2)	232	134	309	167
	mod[O1-O2]	*8*	*2*	*5*	*3*
	Σmod[O1-O2]	**25**	**19**	**27**	**28**
	Σ[O1+O2]/2	**2167**	**1311**	**2625**	**1252**
	Overall Error	**1.2%**	**1.4%**	**1.0%**	**2.2%**

Appendix D8: Inter-Observer Reliability – Playing Position (Observer 1 vs. Observer 2).

Playing Position		Fullback	Centre Back	Midfield	Forward
Match 1	Observer 1 (O1)	201	111	246	82
	Observer 2 (O2)	195	123	243	89
	mod[O1-O2]	*6*	*12*	*3*	*7*
Match 2	Observer 1 (O1)	236	139	261	131
	Observer 2 (O2)	229	143	258	127
	mod[O1-O2]	*7*	*4*	*3*	*4*
Match 3	Observer 1 (O1)	218	174	267	103
	Observer 2 (O2)	220	178	263	107
	mod[O1-O2]	*2*	*4*	*4*	*4*
Match 4	Observer 1 (O1)	189	102	237	137
	Observer 2 (O2)	187	98	245	147
	mod[O1-O2]	*2*	*4*	*8*	*10*
Match 5	Observer 1 (O1)	240	132	304	164
	Observer 2 (O2)	243	137	299	161
	mod[O1-O2]	*3*	*5*	*5*	*3*
	Σmod[O1-O2]	**20**	**29**	**23**	**28**
	Σ[O1+O2]/2	**2158**	**1337**	**2623**	**1248**
	Overall Error	**0.9%**	**2.2%**	**0.9%**	**2.2%**

Appendix D9: Inter-Observer Reliability – Playing Position (Observer 1 vs. Observer 3).

Playing Position		Fullback	Centre Back	Midfield	Forward
Match 1	Observer 1 (O1)	201	111	246	82
	Observer 3 (O3)	192	113	256	81
	mod[O1-O3]	*9*	*2*	*10*	*1*
Match 2	Observer 1 (O1)	236	139	261	131
	Observer 3 (O3)	243	131	250	139
	mod[O1-O3]	*7*	*8*	*11*	*8*
Match 3	Observer 1 (O1)	218	174	267	103
	Observer 3 (O3)	215	178	265	110
	mod[O1-O3]	*3*	*4*	*2*	*7*
Match 4	Observer 1 (O1)	189	102	237	137
	Observer 3 (O3)	186	108	243	129
	mod[O1-O3]	*3*	*6*	*6*	*8*
Match 5	Observer 1 (O1)	240	132	304	164
	Observer 3 (O3)	243	131	296	163
	mod[O1-O3]	*3*	*1*	*8*	*1*
	Σmod[O1-O3]	**25**	**21**	**37**	**25**
	Σ[O1+O3]/2	**2163**	**1319**	**2625**	**1239**
	Overall Error	**1.2%**	**1.6%**	**1.4%**	**2.0%**

Appendix D10: Intra-Observer Reliability – Behaviour Performed.

Behaviour		Aerial Challenge	Clearance	Cross	Dribble	Dribble Continued	Dribble End	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Corner	Free Kick	Throw-in
Match 1	Observation 1 (O1)	97	26	23	71	18	45	10	10	197	23	49	11	8	23	29
	Observation 2 (O2)	94	24	23	73	17	48	11	10	203	23	49	9	8	23	29
	mod[O1-O2]	*3*	*2*	*0*	*2*	*1*	*3*	*1*	*0*	*6*	*0*	*0*	*2*	*0*	*0*	*0*
Match 2	Observation 1 (O1)	78	52	20	64	33	52	24	9	268	18	80	17	6	16	30
	Observation 2 (O2)	79	54	21	65	31	53	25	9	270	18	77	18	6	16	30
	mod[O1-O2]	*1*	*2*	*1*	*1*	*2*	*1*	*1*	*0*	*2*	*0*	*3*	*1*	*0*	*0*	*0*
Match 3	Observation 1 (O1)	86	53	28	83	34	62	19	9	226	22	73	13	11	16	27
	Observation 2 (O2)	88	54	29	80	35	64	17	9	219	22	74	13	12	16	28
	mod[O1-O2]	*2*	*1*	*1*	*3*	*1*	*2*	*2*	*0*	*7*	*0*	*1*	*0*	*1*	*0*	*1*
Match 4	Observation 1 (O1)	61	32	23	74	30	44	21	10	238	19	53	6	6	17	31
	Observation 2 (O2)	59	30	22	74	31	43	22	9	240	19	54	6	6	17	31
	mod[O1-O2]	*2*	*2*	*1*	*0*	*1*	*1*	*1*	*1*	*2*	*0*	*1*	*0*	*0*	*0*	*0*
Match 5	Observation 1 (O1)	89	46	20	88	15	16	10	8	352	19	90	10	8	21	48
	Observation 2 (O2)	89	46	19	89	15	17	10	7	354	19	91	10	8	21	47
	mod[O1-O2]	*0*	*0*	*1*	*1*	*0*	*1*	*0*	*1*	*2*	*0*	*1*	*0*	*0*	*0*	*1*
	Σmod[O1-O2]	**8**	**7**	**4**	**7**	**5**	**8**	**5**	**2**	**19**	**0**	**6**	**3**	**1**	**0**	**2**
	Σ[O1+O2]/2	**820**	**417**	**228**	**761**	**259**	**444**	**169**	**90**	**2567**	**202**	**690**	**113**	**79**	**186**	**330**
	Overall Error	**1.0%**	**1.7%**	**1.8%**	**0.9%**	**1.9%**	**1.8%**	**3.0%**	**2.2%**	**0.7%**	**0.0%**	**0.9%**	**2.7%**	**1.3%**	**0.0%**	**0.6%**

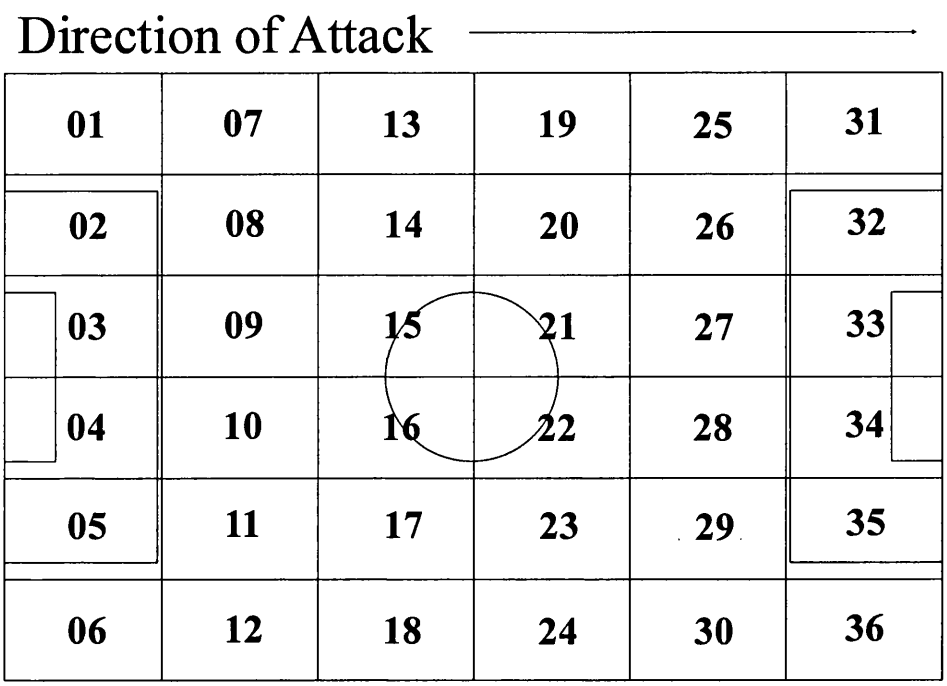
Appendix D11: Inter-Observer Reliability – Behaviour Performed (Observer 1 vs. Observer 2).

Behaviour		Aerial Challenge	Clearance	Cross	Dribble	Dribble Continued	Dribble End	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Corner	Free Kick	Throw-in
Match 1	Observer 1 (O1)	97	26	23	71	18	45	10	10	197	23	49	11	8	23	29
	Observer 2 (O2)	100	25	21	75	18	45	11	8	206	23	47	11	8	23	29
	mod[O1-O2]	*3*	*1*	*2*	*4*	*0*	*0*	*1*	*2*	*9*	*0*	*2*	*0*	*0*	*0*	*0*
Match 2	Observer 1 (O1)	78	52	20	64	33	52	23	10	268	18	80	17	6	16	30
	Observer 2 (O2)	77	52	23	61	34	56	25	10	260	18	74	15	6	16	30
	mod[O1-O2]	*1*	*0*	*3*	*3*	*1*	*4*	*2*	*0*	*8*	*0*	*6*	*2*	*0*	*0*	*0*
Match 3	Observer 1 (O1)	86	53	28	83	34	62	21	9	226	22	71	13	11	16	27
	Observer 2 (O2)	87	51	26	82	36	60	22	10	239	22	69	13	10	16	25
	mod[O1-O2]	*1*	*2*	*2*	*1*	*2*	*2*	*1*	*1*	*13*	*0*	*2*	*0*	*1*	*0*	*2*
Match 4	Observer 1 (O1)	61	32	23	74	30	44	21	10	238	19	53	6	6	17	31
	Observer 2 (O2)	61	34	21	76	31	45	19	9	245	19	57	8	6	16	30
	mod[O1-O2]	*0*	*2*	*2*	*2*	*1*	*1*	*2*	*1*	*7*	*0*	*4*	*2*	*0*	*1*	*1*
Match 5	Observer 1 (O1)	89	46	20	88	15	16	10	8	352	19	90	10	8	21	48
	Observer 2 (O2)	89	45	21	87	14	19	8	8	355	19	88	9	8	22	48
	mod[O1-O2]	*0*	*1*	*1*	*1*	*1*	*3*	*2*	*0*	*3*	*0*	*2*	*1*	*0*	*1*	*0*
	Σmod[O1-O2]	**5**	**6**	**10**	**11**	**5**	**10**	**8**	**4**	**40**	**0**	**16**	**5**	**1**	**2**	**3**
	Σ[O1+O2]/2	**825**	**416**	**226**	**761**	**263**	**444**	**170**	**92**	**2586**	**202**	**678**	**113**	**77**	**186**	**327**
	Overall Error	**0.6%**	**1.4%**	**4.4%**	**1.4%**	**1.9%**	**2.3%**	**4.7%**	**4.3%**	**1.5%**	**0.0%**	**2.4%**	**4.4%**	**1.3%**	**1.1%**	**0.9%**

Appendix D12: Inter-Observer Reliability – Behaviour Performed (Observer 1 vs. Observer 3).

Behaviour		Aerial Challenge	Clearance	Cross	Dribble	Dribble Continued	Dribble End	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Corner	Free Kick	Throw-in
Match 1	Observer 1 (O1)	97	26	23	71	18	45	10	10	197	23	49	11	8	23	29
	Observer 3 (O3)	100	24	22	72	17	47	12	11	196	21	52	9	8	22	29
	mod[O1-O3]	*3*	*2*	*1*	*1*	*1*	*2*	*2*	*1*	*1*	*2*	*3*	*2*	*0*	*1*	*0*
Match 2	Observer 1 (O1)	78	52	20	64	33	52	23	10	268	18	80	17	6	16	30
	Observer 3 (O3)	80	49	22	67	31	50	24	10	266	18	78	15	6	17	30
	mod[O1-O3]	*2*	*3*	*2*	*3*	*2*	*2*	*1*	*0*	*2*	*0*	*2*	*2*	*0*	*1*	*0*
Match 3	Observer 1 (O1)	86	53	28	83	34	62	21	9	226	22	71	13	11	16	27
	Observer 3 (O3)	89	52	27	82	35	62	22	11	231	23	68	12	11	16	27
	mod[O1-O3]	*3*	*1*	*1*	*1*	*1*	*0*	*1*	*2*	*5*	*1*	*3*	*1*	*0*	*0*	*0*
Match 4	Observer 1 (O1)	61	32	23	74	30	44	21	10	238	19	53	6	6	17	31
	Observer 3 (O3)	61	33	23	74	31	45	20	9	236	19	55	6	6	17	31
	mod[O1-O3]	*0*	*1*	*0*	*0*	*1*	*1*	*1*	*1*	*2*	*0*	*2*	*0*	*0*	*0*	*0*
Match 5	Observer 1 (O1)	89	46	20	88	15	16	10	8	352	19	90	10	8	21	48
	Observer 3 (O3)	89	46	18	90	15	14	10	8	350	19	89	10	8	20	47
	mod[O1-O3]	*0*	*0*	*2*	*2*	*0*	*2*	*0*	*0*	*2*	*0*	*1*	*0*	*0*	*1*	*1*
	Σmod[O1-O3]	**8**	**7**	**6**	**7**	**5**	**7**	**5**	**4**	**12**	**3**	**11**	**5**	**0**	**3**	**1**
	Σ[O1+O3]/2	**830**	**413**	**226**	**765**	**259**	**437**	**173**	**96**	**2560**	**201**	**685**	**109**	**78**	**185**	**329**
	Overall Error	**1.0%**	**1.7%**	**2.7%**	**0.9%**	**1.9%**	**1.6%**	**2.9%**	**4.2%**	**0.5%**	**1.5%**	**1.6%**	**4.6%**	**0.0%**	**1.6%**	**0.3%**

Appendix D13: Pitch Area Identification Numbers.



When considering the data in relation to nine areas:

- Areas 1, 2, 7 and 8 were grouped as defensive third pitch left
- Areas 3, 4, 9 and 10 were grouped as defensive third pitch centre
- Areas 5, 6, 11 and 12 were grouped as defensive third pitch right
- Areas 13, 14, 19 and 20 were grouped as midfield third pitch left
- Areas 15, 16, 21 and 22 were grouped as midfield third pitch centre
- Areas 17, 18, 23 and 24 were grouped as midfield third pitch right
- Areas 25, 26, 31 and 32 were grouped as attacking third pitch left
- Areas 27, 28, 33 and 34 were grouped as attacking third pitch centre
- Areas 29, 30, 35 and 36 were grouped as attacking third pitch right

Appendix D14: Intra-Observer Reliability – Pitch Area 1 – 18.

Pitch Area		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Match 1	Observation 1 (O1)	11	3	28	37	8	12	7	25	19	17	13	21	25	17	17	23	17	15
	Observation 2 (O2)	10	3	30	37	8	11	7	24	19	18	13	21	24	17	17	21	17	15
	mod[O1-O2]	*1*	*0*	*2*	*0*	*0*	*1*	*0*	*1*	*0*	*1*	*0*	*0*	*1*	*0*	*0*	*2*	*0*	*0*
Match 2	Observation 1 (O1)	15	10	41	47	7	9	33	40	18	35	24	16	22	19	30	27	17	20
	Observation 2 (O2)	15	11	42	47	7	9	33	42	18	35	24	17	23	17	32	27	15	20
	mod[O1-O2]	*0*	*1*	*1*	*0*	*0*	*0*	*0*	*2*	*0*	*0*	*0*	*1*	*1*	*2*	*2*	*0*	*2*	*0*
Match 3	Observation 1 (O1)	17	8	25	43	7	10	20	38	31	23	19	11	21	17	15	19	18	14
	Observation 2 (O2)	16	9	25	43	8	10	20	38	31	23	19	11	21	17	15	19	18	14
	mod[O1-O2]	*1*	*1*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Match 4	Observation 1 (O1)	5	6	25	30	7	5	29	32	22	24	14	19	18	21	21	16	20	21
	Observation 2 (O2)	5	6	25	30	8	3	30	32	24	20	14	19	20	21	21	16	17	18
	mod[O1-O2]	*0*	*0*	*0*	*0*	*1*	*2*	*1*	*0*	*2*	*4*	*0*	*0*	*2*	*0*	*0*	*0*	*3*	*3*
Match 5	Observation 1 (O1)	11	10	29	35	10	15	26	39	24	32	25	26	18	17	19	46	34	38
	Observation 2 (O2)	10	9	30	34	10	15	28	39	25	32	23	26	18	20	19	47	35	38
	mod[O1-O2]	*1*	*1*	*1*	*1*	*0*	*0*	*2*	*0*	*1*	*0*	*2*	*0*	*0*	*3*	*0*	*1*	*1*	*0*
	Σmod[O1-O2]	**3**	**3**	**4**	**1**	**2**	**3**	**3**	**3**	**3**	**5**	**2**	**1**	**4**	**5**	**2**	**3**	**6**	**3**
	Σ[O1+O2]/2	**115**	**75**	**300**	**383**	**80**	**99**	**233**	**349**	**231**	**259**	**188**	**187**	**210**	**183**	**206**	**261**	**208**	**213**
	Overall Error	**2.6%**	**4.0%**	**1.3%**	**0.3%**	**2.5%**	**3.0%**	**1.3%**	**0.9%**	**1.3%**	**1.9%**	**1.1%**	**0.5%**	**1.9%**	**2.7%**	**1.0%**	**1.2%**	**2.9%**	**1.4%**

Appendix D15: Intra-Observer Reliability – Pitch Area 19 – 36.

Pitch Area		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Match 1	Observation 1 (O1)	17	13	17	24	30	13	22	16	11	32	27	20	15	11	13	13	14	17
	Observation 2 (O2)	17	13	17	24	30	15	22	16	11	32	27	20	17	12	13	13	16	17
	mod[O1-O2]	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*2*	*1*	*0*	*0*	*2*	*0*
Match 2	Observation 1 (O1)	23	17	31	23	22	13	24	21	24	21	16	20	17	21	8	15	8	13
	Observation 2 (O2)	21	17	31	21	22	13	22	21	25	21	17	23	17	21	9	15	8	14
	mod[O1-O2]	*2*	*0*	*0*	*2*	*0*	*0*	*2*	*0*	*1*	*0*	*1*	*3*	*0*	*0*	*1*	*0*	*0*	*1*
Match 3	Observation 1 (O1)	19	14	21	15	21	20	39	22	20	25	32	27	14	9	16	15	24	53
	Observation 2 (O2)	19	14	20	15	18	23	36	23	19	25	33	28	14	10	16	13	24	53
	mod[O1-O2]	*0*	*0*	*1*	*0*	*3*	*3*	*3*	*1*	*1*	*0*	*1*	*1*	*0*	*1*	*0*	*2*	*0*	*0*
Match 4	Observation 1 (O1)	22	11	21	21	14	23	28	21	23	26	20	25	16	10	12	10	11	16
	Observation 2 (O2)	22	13	21	19	14	23	28	21	23	30	20	25	16	8	11	10	13	17
	mod[O1-O2]	*0*	*2*	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*4*	*0*	*0*	*0*	*2*	*1*	*0*	*2*	*1*
Match 5	Observation 1 (O1)	19	13	29	52	40	31	13	13	20	30	24	37	11	9	12	9	10	14
	Observation 2 (O2)	19	13	29	52	40	30	13	13	20	30	24	37	12	9	12	7	10	14
	mod[O1-O2]	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*2*	*0*	*0*
	Σmod[O1-O2]	**2**	**2**	**1**	**4**	**3**	**6**	**5**	**1**	**2**	**4**	**2**	**4**	**3**	**4**	**2**	**4**	**4**	**2**
	Σ[O1+O2]/2	**198**	**138**	**237**	**266**	**251**	**204**	**247**	**187**	**196**	**272**	**240**	**262**	**149**	**120**	**122**	**120**	**138**	**228**
	Overall Error	**1.0%**	**1.4%**	**0.4%**	**1.5%**	**1.2%**	**2.9%**	**2.0%**	**0.5%**	**1.0%**	**1.5%**	**0.8%**	**1.5%**	**2.0%**	**3.3%**	**1.6%**	**3.3%**	**2.9%**	**0.9%**

Appendix D16: Inter-Observer Reliability – Pitch Area 1 – 18 (Observer 1 vs. Observer 2).

Pitch Area		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Match 1	Observer 1 (O1)	11	3	28	37	8	12	7	25	19	17	13	21	25	17	17	23	17	15
	Observer 2 (O2)	11	3	25	37	10	12	10	26	19	15	12	22	26	19	16	23	21	18
	mod[O1-O2]	*0*	*0*	*3*	*0*	*2*	*0*	*3*	*1*	*0*	*2*	*1*	*1*	*1*	*2*	*1*	*0*	*4*	*3*
Match 2	Observer 1 (O1)	15	10	41	47	7	9	33	40	18	35	24	16	22	19	30	27	17	20
	Observer 2 (O2)	15	10	42	43	7	10	30	41	16	35	24	13	26	21	30	27	16	21
	mod[O1-O2]	*0*	*0*	*1*	*4*	*0*	*1*	*3*	*1*	*2*	*0*	*0*	*3*	*4*	*2*	*0*	*0*	*1*	*1*
Match 3	Observer 1 (O1)	17	8	25	43	7	10	20	38	31	23	19	11	21	17	15	19	18	14
	Observer 2 (O2)	17	8	22	45	7	12	21	35	31	25	19	10	20	17	16	18	18	14
	mod[O1-O2]	*0*	*0*	*3*	*2*	*0*	*2*	*1*	*3*	*0*	*2*	*0*	*1*	*1*	*0*	*1*	*1*	*0*	*0*
Match 4	Observer 1 (O1)	5	6	25	30	7	5	29	32	22	24	14	19	18	21	21	16	20	21
	Observer 2 (O2)	6	8	25	31	7	6	29	30	24	24	15	19	17	21	21	15	21	20
	mod[O1-O2]	*1*	*2*	*0*	*1*	*0*	*1*	*0*	*2*	*2*	*0*	*1*	*0*	*1*	*0*	*0*	*1*	*1*	*1*
Match 5	Observer 1 (O1)	11	10	29	35	10	15	26	39	24	32	25	26	18	17	19	46	34	38
	Observer 2 (O2)	11	10	30	35	10	15	25	36	23	33	25	26	18	20	16	47	34	38
	mod[O1-O2]	*0*	*0*	*1*	*0*	*0*	*0*	*1*	*3*	*1*	*1*	*0*	*0*	*0*	*3*	*3*	*1*	*0*	*0*
	Σmod[O1-O2]	**1**	**2**	**8**	**7**	**2**	**4**	**8**	**10**	**5**	**5**	**2**	**5**	**7**	**7**	**5**	**3**	**6**	**5**
	Σ[O1+O2]/2	**119**	**76**	**292**	**383**	**80**	**106**	**230**	**342**	**227**	**263**	**190**	**183**	**211**	**189**	**201**	**261**	**216**	**219**
	Overall Error	**0.8%**	**2.6%**	**2.7%**	**1.8%**	**2.5%**	**3.8%**	**3.5%**	**2.9%**	**2.2%**	**1.9%**	**1.1%**	**2.7%**	**3.3%**	**3.7%**	**2.5%**	**1.1%**	**2.8%**	**2.3%**

Appendix D17: Inter-Observer Reliability – Pitch Area 19 – 36 (Observer 1 vs. Observer 2).

Pitch Area		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Match 1	Observer 1 (O1)	17	13	17	24	30	13	22	16	11	32	27	20	15	11	13	13	14	17
	Observer 2 (O2)	17	12	17	24	31	13	22	17	13	31	25	21	14	10	13	13	15	17
	mod[O1-O2]	*0*	*1*	*0*	*0*	*1*	*0*	*0*	*1*	*2*	*1*	*2*	*1*	*1*	*1*	*0*	*0*	*1*	*0*
Match 2	Observer 1 (O1)	23	17	31	23	22	13	24	21	24	21	16	20	17	21	8	15	8	13
	Observer 2 (O2)	23	16	32	24	22	12	25	21	24	20	13	21	15	20	8	13	7	14
	mod[O1-O2]	*0*	*1*	*1*	*1*	*0*	*1*	*1*	*0*	*0*	*1*	*3*	*1*	*2*	*1*	*0*	*2*	*1*	*1*
Match 3	Observer 1 (O1)	19	14	21	15	21	20	39	22	20	25	32	27	14	9	16	15	24	53
	Observer 2 (O2)	18	14	23	17	24	22	38	24	20	25	33	26	14	9	16	15	23	52
	mod[O1-O2]	*1*	*0*	*2*	*2*	*3*	*2*	*1*	*2*	*0*	*0*	*1*	*1*	*0*	*0*	*0*	*0*	*1*	*1*
Match 4	Observer 1 (O1)	22	11	21	21	14	23	28	21	23	26	20	25	16	11	11	10	11	16
	Observer 2 (O2)	22	11	20	20	15	23	26	20	26	24	20	23	17	12	15	10	11	16
	mod[O1-O2]	*0*	*0*	*1*	*1*	*1*	*0*	*2*	*1*	*3*	*2*	*0*	*2*	*1*	*1*	*4*	*0*	*0*	*0*
Match 5	Observer 1 (O1)	19	13	29	52	40	31	13	13	20	30	24	37	11	9	12	9	10	14
	Observer 2 (O2)	17	13	27	52	38	32	15	13	20	32	25	36	12	11	12	9	12	12
	mod[O1-O2]	*2*	*0*	*2*	*0*	*2*	*1*	*2*	*0*	*0*	*2*	*1*	*1*	*1*	*2*	*0*	*0*	*2*	*2*
	Σmod[O1-O2]	**3**	**2**	**6**	**4**	**7**	**4**	**6**	**4**	**5**	**6**	**7**	**6**	**5**	**5**	**4**	**2**	**5**	**4**
	Σ[O1+O2]/2	**197**	**134**	**238**	**272**	**257**	**202**	**252**	**188**	**201**	**266**	**235**	**256**	**145**	**123**	**124**	**122**	**135**	**224**
	Overall Error	**1.5%**	**1.5%**	**2.5%**	**1.5%**	**2.7%**	**2.0%**	**2.4%**	**2.1%**	**2.5%**	**2.3%**	**3.0%**	**2.3%**	**3.4%**	**4.1%**	**3.2%**	**1.6%**	**3.7%**	**1.8%**

Appendix D18: Inter-Observer Reliability – Pitch Area 1 – 18 (Observer 1 vs. Observer 3).

Pitch Area		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Match 1	Observer 1 (O1)	11	3	28	37	8	12	7	25	19	17	13	21	25	17	17	23	17	15
	Observer 3 (O3)	11	4	28	35	9	13	7	25	19	15	13	24	25	16	18	24	21	13
	mod[O1-O3]	*0*	*1*	*0*	*2*	*1*	*1*	*0*	*0*	*0*	*2*	*0*	*3*	*0*	*1*	*1*	*1*	*4*	*2*
Match 2	Observer 1 (O1)	15	10	41	47	7	9	33	40	18	35	24	16	22	19	30	27	17	20
	Observer 3 (O3)	15	10	39	50	7	10	34	37	18	32	21	16	21	20	30	27	17	21
	mod[O1-O3]	*0*	*0*	*2*	*3*	*0*	*1*	*1*	*3*	*0*	*3*	*3*	*0*	*1*	*1*	*0*	*0*	*0*	*1*
Match 3	Observer 1 (O1)	17	8	25	43	7	10	20	38	31	23	19	11	21	17	15	19	18	14
	Observer 3 (O3)	18	8	25	42	8	8	21	37	32	23	17	13	23	17	15	21	17	16
	mod[O1-O3]	*1*	*0*	*0*	*1*	*1*	*2*	*1*	*1*	*1*	*0*	*2*	*2*	*2*	*0*	*0*	*2*	*1*	*2*
Match 4	Observer 1 (O1)	5	6	25	30	7	5	29	32	22	24	14	19	18	21	21	16	20	21
	Observer 3 (O3)	4	5	26	29	7	5	31	33	22	25	13	17	20	21	23	14	22	21
	mod[O1-O3]	*1*	*1*	*1*	*1*	*0*	*0*	*2*	*1*	*0*	*1*	*1*	*2*	*2*	*0*	*2*	*2*	*2*	*0*
Match 5	Observer 1 (O1)	11	10	29	35	10	15	26	39	24	32	25	26	18	17	19	46	34	38
	Observer 3 (O3)	11	10	28	34	11	15	25	37	26	31	25	26	19	17	19	44	34	36
	mod[O1-O3]	*0*	*0*	*1*	*1*	*1*	*0*	*1*	*2*	*2*	*1*	*0*	*0*	*1*	*0*	*0*	*2*	*0*	*2*
	Σmod[O1-O3]	**2**	**2**	**4**	**8**	**3**	**4**	**5**	**7**	**3**	**7**	**6**	**7**	**6**	**2**	**3**	**7**	**7**	**7**
	Σ[O1+O3]/2	**118**	**74**	**294**	**382**	**81**	**102**	**233**	**343**	**231**	**257**	**184**	**189**	**212**	**182**	**207**	**261**	**217**	**215**
	Overall Error	**1.7%**	**2.7%**	**1.4%**	**2.1%**	**3.7%**	**3.9%**	**2.1%**	**2.0%**	**1.3%**	**2.7%**	**3.3%**	**3.7%**	**2.8%**	**1.1%**	**1.4%**	**2.7%**	**3.2%**	**3.3%**

Appendix D19: Inter-Observer Reliability – Pitch Area 19 – 36 (Observer 1 vs. Observer 3).

Pitch Area		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Match 1	Observer 1 (O1)	17	13	17	24	30	13	22	16	11	32	27	20	15	11	13	13	14	17
	Observer 3 (O3)	16	14	15	24	31	15	22	16	8	31	29	21	13	10	13	13	15	16
	mod[O1-O3]	*1*	*1*	*2*	*0*	*1*	*2*	*0*	*0*	*3*	*1*	*2*	*1*	*2*	*1*	*0*	*0*	*1*	*1*
Match 2	Observer 1 (O1)	23	17	31	23	22	13	24	21	24	21	16	20	17	21	8	15	8	13
	Observer 3 (O3)	23	17	31	24	22	13	21	22	24	23	16	20	17	21	7	15	8	14
	mod[O1-O3]	*0*	*0*	*0*	*1*	*0*	*0*	*3*	*1*	*0*	*2*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*1*
Match 3	Observer 1 (O1)	19	14	21	15	21	20	39	22	20	25	32	27	14	9	16	15	24	53
	Observer 3 (O3)	19	16	21	16	23	24	37	22	19	23	31	24	13	12	14	17	22	54
	mod[O1-O3]	*0*	*2*	*0*	*1*	*2*	*4*	*2*	*0*	*1*	*2*	*1*	*3*	*1*	*3*	*2*	*2*	*2*	*1*
Match 4	Observer 1 (O1)	22	11	21	21	14	23	28	21	23	26	20	25	16	11	11	10	11	16
	Observer 3 (O3)	22	11	21	23	15	23	26	19	22	26	20	25	14	11	12	12	11	15
	mod[O1-O3]	*0*	*0*	*0*	*2*	*1*	*0*	*2*	*2*	*1*	*0*	*0*	*0*	*2*	*0*	*1*	*2*	*0*	*1*
Match 5	Observer 1 (O1)	19	13	29	52	40	31	13	13	20	30	24	37	11	9	12	9	10	14
	Observer 3 (O3)	21	15	29	52	40	30	12	13	21	28	24	36	11	9	12	9	10	13
	mod[O1-O3]	*2*	*2*	*0*	*0*	*0*	*1*	*1*	*0*	*1*	*2*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*1*
	Σmod[O1-O3]	**3**	**5**	**2**	**4**	**4**	**7**	**8**	**3**	**6**	**7**	**3**	**5**	**5**	**4**	**4**	**4**	**3**	**5**
	Σ[O1+O3]/2	**201**	**141**	**236**	**274**	**258**	**205**	**244**	**185**	**192**	**265**	**239**	**255**	**141**	**124**	**118**	**128**	**133**	**225**
	Overall Error	**1.5%**	**3.5%**	**0.8%**	**1.5%**	**1.6%**	**3.4%**	**3.3%**	**1.6%**	**3.1%**	**2.6%**	**1.3%**	**2.0%**	**3.5%**	**3.2%**	**3.4%**	**3.1%**	**2.3%**	**2.2%**

Appendix D20: Intra-Observer Reliability – Pitch Area (n = 9).

Pitch Area		Defensive Third			Midfield Third			Attacking Third		
		Left	**Centre**	**Right**	**Left**	**Centre**	**Right**	**Left**	**Centre**	**Right**
Match 1	Observation 1 (O1)	46	101	54	72	81	75	64	69	78
	Observation 2 (O2)	44	104	53	71	79	77	65	70	81
	mod[O1-O2]	*2*	*3*	*1*	*1*	*2*	*2*	*1*	*1*	*3*
Match 2	Observation 1 (O1)	98	141	56	81	111	72	83	68	57
	Observation 2 (O2)	101	142	56	80	111	70	81	70	61
	mod[O1-O2]	*3*	*1*	*0*	*1*	*0*	*2*	*2*	*2*	*4*
Match 3	Observation 1 (O1)	83	122	47	71	70	73	84	76	136
	Observation 2 (O2)	82	122	48	71	70	73	84	73	137
	mod[O1-O2]	*1*	*0*	*1*	*0*	*0*	*0*	*0*	*3*	*1*
Match 4	Observation 1 (O1)	72	101	45	72	79	78	75	71	72
	Observation 2 (O2)	73	99	44	76	77	72	73	74	75
	mod[O1-O2]	*1*	*2*	*1*	*4*	*2*	*6*	*2*	*3*	*3*
Match 5	Observation 1 (O1)	86	120	76	67	146	143	46	71	85
	Observation 2 (O2)	84	122	73	70	147	144	47	70	85
	mod[O1-O2]	*2*	*2*	*3*	*3*	*1*	*1*	*1*	*1*	*0*
	Σmod[O1-O2]	**9**	**8**	**6**	**9**	**5**	**11**	**6**	**10**	**11**
	Σ[O1+O2]/2	**769**	**1174**	**552**	**731**	**971**	**877**	**702**	**712**	**867**
	Overall Error	**1.2%**	**0.7%**	**1.1%**	**1.2%**	**0.5%**	**1.3%**	**0.9%**	**1.4%**	**1.3%**

Appendix D21: Inter-Observer Reliability – Pitch Area (n = 9, Observer 1 vs. Observer 2).

Pitch Area		Defensive Third			Midfield Third			Attacking Third		
		Left	**Centre**	**Right**	**Left**	**Centre**	**Right**	**Left**	**Centre**	**Right**
Match 1	Observer 1 (O1)	46	101	54	72	81	75	64	69	78
	Observer 2 (O2)	50	96	56	74	80	83	63	70	78
	mod[O1-O2]	*4*	*5*	*2*	*2*	*1*	*8*	*1*	*1*	*0*
Match 2	Observer 1 (O1)	98	141	56	81	111	72	83	68	57
	Observer 2 (O2)	96	136	54	86	113	71	81	65	55
	mod[O1-O2]	*2*	*5*	*2*	*5*	*2*	*1*	*2*	*3*	*2*
Match 3	Observer 1 (O1)	83	122	47	71	70	73	84	76	136
	Observer 2 (O2)	81	123	48	69	74	78	85	76	134
	mod[O1-O2]	*2*	*1*	*1*	*2*	*4*	*5*	*1*	*0*	*2*
Match 4	Observer 1 (O1)	72	101	45	72	79	78	76	70	72
	Observer 2 (O2)	73	104	47	71	76	79	75	75	70
	mod[O1-O2]	*1*	*3*	*2*	*1*	*3*	*1*	*1*	*5*	*2*
Match 5	Observer 1 (O1)	86	120	76	67	146	143	46	71	85
	Observer 2 (O2)	82	121	76	68	142	142	51	73	85
	mod[O1-O2]	*4*	*1*	*0*	*1*	*4*	*1*	*5*	*2*	*0*
	Σmod[O1-O2]	**13**	**15**	**7**	**11**	**14**	**16**	**10**	**11**	**6**
	Σ[O1+O2]/2	**767**	**1165**	**559**	**731**	**972**	**894**	**708**	**713**	**850**
	Overall Error	**1.7%**	**1.3%**	**1.3%**	**1.5%**	**1.4%**	**1.8%**	**1.4%**	**1.5%**	**0.7%**

Appendix D22: Inter-Observer Reliability – Pitch Area (n = 9, Observer 1 vs. Observer 3).

Pitch		Defensive Third			Midfield Third			Attacking Third		
Area		**Left**	**Centre**	**Right**	**Left**	**Centre**	**Right**	**Left**	**Centre**	**Right**
Match 1	Observer 1 (O1)	46	101	54	72	81	75	64	69	78
	Observer 3 (O3)	47	97	59	71	81	80	61	65	81
	mod[O1-O3]	*1*	*4*	*5*	*1*	*0*	*5*	*3*	*4*	*3*
Match 2	Observer 1 (O1)	98	141	56	81	111	72	83	68	57
	Observer 3 (O3)	96	139	54	81	112	73	81	69	58
	mod[O1-O3]	*2*	*2*	*2*	*0*	*1*	*1*	*2*	*1*	*1*
Match 3	Observer 1 (O1)	83	122	47	71	70	73	84	76	136
	Observer 3 (O3)	84	122	46	75	73	80	84	73	131
	mod[O1-O3]	*1*	*0*	*1*	*4*	*3*	*7*	*0*	*3*	*5*
Match 4	Observer 1 (O1)	72	101	45	72	79	78	76	70	72
	Observer 3 (O3)	73	102	42	74	81	81	70	72	71
	mod[O1-O3]	*1*	*1*	*3*	*2*	*2*	*3*	*6*	*2*	*1*
Match 5	Observer 1 (O1)	86	120	76	67	146	143	46	71	85
	Observer 3 (O3)	83	119	77	72	144	140	45	70	83
	mod[O1-O3]	*3*	*1*	*1*	*5*	*2*	*3*	*1*	*1*	*2*
	Σmod[O1-O3]	**8**	**8**	**12**	**12**	**8**	**19**	**12**	**11**	**12**
	Σ[O1+O3]/2	**768**	**1164**	**556**	**736**	**978**	**895**	**694**	**703**	**852**
	Overall Error	**1.0%**	**0.7%**	**2.2%**	**1.6%**	**0.8%**	**2.1%**	**1.7%**	**1.6%**	**1.4%**

APPENDIX E

Z-scores For Models of Behaviour Incidence

Absolute z-scores relating to the main effects and interactions of match location [L], opposition quality [Q] and match status [S] within behaviour incidence models based upon 40 matches played by a professional British soccer team during the 2002-2003 and 2003-2004 domestic league seasons.

Model Effect	Level of Match Status	Aerial Challenge	Clearance	Cross	Dribble	Interception	Loss of Control	Pass	Shot	Tackle	Tackled	Free Kick	Throw-In
[L]	-	0.120	1.412	4.511	2.697	\	0.008	1.990	2.556	1.067	0.291	1.965	2.103
[Q]	-	0.187	\	\	0.587	\	\	1.541	\	\	\	\	\
[S]	Winning	5.129	6.767	2.285	0.027	4.290	0.836	0.055	2.172	3.906	0.971	0.696	0.272
	Drawing	5.171	3.824	1.221	3.018	2.218	1.155	7.578	2.990	-4.890	2.564	1.609	2.365
	Losing	0.680	2.003	4.030	3.266	1.436	0.381	0.226	1.316	1.499	1.860	2.610	2.917
[LQ]	-	2.272	\	\	3.535	\	\	3.106	\	\	\	\	\
[LS]	Winning	4.760	2.574	\	2.986	\	2.851	8.999	2.257	5.736	3.778	\	\
	Drawing	0.130	0.361	\	0.201	\	0.562	1.754	0.499	0.715	0.578	\	\
	Losing	4.682	1.897	\	3.310	\	2.238	7.510	1.607	4.841	3.244	\	\
[QS]	Winning	2.661	\	\	\	\	\	2.258	\	\	\	\	\
	Drawing	2.115	\	\	\	\	\	0.835	\	\	\	\	\
	Losing	0.260	\	\	\	\	\	3.327	\	\	\	\	\
[LQS]	Winning	\	\	\	\	\	\	\	\	\	\	\	\
	Drawing	\	\	\	\	\	\	\	\	\	\	\	\
	Losing	\	\	\	\	\	\	\	\	\	\	\	\

\ Effect not present in the model of behaviour incidence.

N.B. All omitted z-scores (i.e. those involving away match location and weak opposition quality) can be derived from others by reversing the direction of related effects. For example, with regard to aerial challenges, the z-score for away = -0.120, similarly the z-score for playing against weak opposition and winning = 2.661.

APPENDIX F

Prediction Equations for Behaviour Incidence

Prediction of Expected Frequencies for Behaviours Performed

Predictions of expected behaviour incidence under differing match situations were based upon an additive log-linear equation. The full model (or saturated model) which contains all possible effects of the selected situational variables was:

$$\ln(F_{ijk}) = \theta + \lambda_i^L + \lambda_j^Q + \lambda_k^S + \lambda_{ij}^{LQ} + \lambda_{ik}^{LS} + \lambda_{jk}^{QS} + \lambda_{ijk}^{LQS}$$

where for each contingency table cell the natural logarithm of the expected frequency, ln(*F*), is the summation of a constant, θ, and parameter estimates, λ, for the main effects and interactions of match location [L], opposition quality [Q] and match status [S]. This general log-linear model was subsequently amended in line with the model of best fit identified for each behaviour by removing redundant terms:

Prediction Equation for Expected Aerial Challenge Incidence

$$\ln(F) = \theta + \lambda^L + \lambda^Q + \lambda^S + \lambda^{LQ} + \lambda^{LS} + \lambda^{QS}$$

Prediction Equation for Expected Clearance Incidence

$$\ln(F) = \theta + \lambda^L + \lambda^S + \lambda^{LS}$$

Prediction Equation for Expected Cross Incidence

$$\ln(F) = \theta + \lambda^L + \lambda^S$$

Prediction Equation the Expected Dribble Incidence

$$\ln(F) = \theta + \lambda_i^L + \lambda^Q + \lambda^S + \lambda^{LQ} + \lambda^{LS}$$

Prediction Equation for Expected Interception Incidence

$$\ln(F) = \theta + \lambda^S$$

Prediction Equation for Expected Loss of Control Incidence

$$\ln(F) = \theta + \lambda^{L} + \lambda^{S} + \lambda^{LS}$$

Prediction Equation for Expected Passes Incidence

$$\ln(F) = \theta + \lambda^{L} + \lambda^{Q} + \lambda^{S} + \lambda^{LQ} + \lambda^{LS} + \lambda^{QS}$$

Prediction Equation for Expected Shot Incidence

$$\ln(F) = \theta + \lambda^{L} + \lambda^{S} + \lambda^{LS}$$

Prediction Equation for Expected Tackle Incidence

$$\ln(F) = \theta + \lambda^{L} + \lambda^{S} + \lambda^{LS}$$

Prediction Equation for Expected Incidence of Times Tackled

$$\ln(F) = \theta + \lambda^{L} + \lambda^{S} + \lambda^{LS}$$

Prediction Equation for Expected Free Kick Incidence

$$\ln(F) = \theta + \lambda^{L} + \lambda^{S}$$

Prediction Equation for Expected Throw-In Incidence

$$\ln(F) = \theta + \lambda^{L} + \lambda^{S}$$

APPENDIX G

Z-scores for Models of Behaviour Outcome

Absolute z-scores relating to the main effects and interactions of match location [L], opposition quality [Q] and match status [S] within behaviour outcome models based upon 40 matches played by a professional British soccer team during the 2002-2003 and 2003-2004 domestic league seasons.

Model Effect	Level of Match Status	Aerial Challenge	Clearance	Cross	Dribble	Pass	Shot	Tackle	Tackled	Throw-In
[O]	-	4.115	14.134	7.569	11.311	20.103	2.128	14.422	2.151	6.012
[L]	-	\	\	\	\	1.916	\	\	\	0.146
[Q]	-	2.553	\	\	\	1.831	\	\	\	1.767
[S]	Winning	\	\	\	\	2.774	3.522	\	\	0.294
	Drawing	\	\	\	\	0.656	1.789	\	\	1.474
	Losing	\	\	\	\	2.135	1.349	\	\	2.034
[LQ]	-	\	\	\	\	\	\	\	\	0.309
[LS]	Winning	\	\	\	\	\	\	\	\	1.229
	Drawing	\	\	\	\	\	\	\	\	2.061
	Losing	\	\	\	\	\	\	\	\	1.173
[QS]	Winning	\	\	\	\	2.811	\	\	\	0.755
	Drawing	\	\	\	\	1.243	\	\	\	1.055
	Losing	\	\	\	\	1.495	\	\	\	2.010
[LQS]	Winning	\	\	\	\	\	\	\	\	2.505
	Drawing	\	\	\	\	\	\	\	\	2.417
	Losing	\	\	\	\	\	\	\	\	0.290

\ Effect not present in the model of behaviour outcome.

N.B. All omitted z-scores (i.e. those involving away match location and weak opposition quality) can be derived from others by reversing the direction of related effects. For example, with regard to throw-ins, the z-score for away = 0.146, similarly the z-score for playing at home against weak opposition and winning = 2.505.

APPENDIX H

Prediction Equations for Behaviour Outcomes

Prediction of Expected Behaviour Outcomes

Predictions of the expected behaviour outcomes (odds of success) under differing match situations were based upon an additive log-linear equation that was formulated from a logit model (see Norusis, 1993). As these equations were based upon a logit model no model constant was present and only terms including the dependent variable (e.g. behaviour outcome) were included (see Norusis, 1993). Consequently, using similar notation to that presented by Knoke and Burke (1980), the full model (or saturated model) which contains all possible effects of the selected situational was:

$$\Phi^{O}_{ijk} = 2\left(\beta^{O} + \beta^{OL}_{i} + \beta^{OQ}_{j} + \beta^{OS}_{k} + \beta^{OLQ}_{ij} + \beta^{OLS}_{ik} + \beta^{OQS}_{jk} + \beta^{OLQS}_{ijk}\right)$$

where the log of the expected odds of success, Φ^{O}, is the summation of parameter estimates, β, for the main effects and interactions of behaviour outcome (O), match location [L], opposition quality [Q] and match status [S]. This full model was subsequently amended in line with the model of best fit identified for each behaviour by removing redundant terms:

Prediction Equation for Expected Aerial Challenge Outcomes

$$\Phi^{O} = 2\left(\beta^{O} + \beta^{OQ}\right)$$

Prediction Equation for Expected Clearance Outcomes

$$\Phi^{O} = 2\left(\beta^{O}\right)$$

Prediction Equation for Expected Cross Outcomes

$$\Phi^{O} = 2\left(\beta^{O}\right)$$

Prediction Equation for Expected Dribble Outcomes

$$\Phi^{O} = 2\left(\beta^{O}\right)$$

Prediction Equation for Expected Pass Outcomes

$$\Phi^{O} = 2\left(\beta^{O} + \beta^{OL} + \beta^{OQ} + \beta^{OS} + \beta^{OQS}\right)$$

Prediction Equation for Expected Shot Outcomes

$$\Phi^{O} = 2\left(\beta^{O} + \beta^{OS}\right)$$

Prediction Equation for Expected Tackle Outcomes

$$\Phi^{O} = 2\left(\beta^{O}\right)$$

Prediction Equation for the Expected Outcomes of Being Tackled

$$\Phi^{O} = 2\left(\beta^{O}\right)$$

Prediction Equation for Expected Throw-In Outcomes

$$\Phi^{O} = 2\left(\beta^{O} + \beta^{OL} + \beta^{OQ} + \beta^{OS} + \beta^{OLQ} + \beta^{OLS} + \beta^{OQS} + \beta^{OLQS}\right)$$

APPENDIX I

Z-scores for Models of Behaviour Occurrence within Nine Soccer Pitch Areas

Absolute z-scores relating to the main effects and interactions of match location [L], opposition quality [Q] and match status [S] for models of behaviour occurrence within nine pitch areas based upon 40 matches played by a professional British soccer team during the 2002-2003 and 2003-2004 domestic league seasons.

Model Effect	Level of Match Status	Defensive Third			Midfield Third			Attacking Third		
		Left	Centre	Right	Left	Centre	Right	Left	Centre	Right
[L]	-	0.838	3.485	0.465	1.696	0.485	0.777	3.056	4.071	5.556
[Q]	-	1.661	0.345	1.030	1.442	1.754	2.915	1.460	0.304	2.290
[S]	Winning	1.413	6.263	2.699	0.458	0.164	1.957	2.696	0.689	1.785
	Drawing	3.611	4.078	5.065	4.542	5.605	4.263	5.464	4.121	2.570
	Losing	2.473	1.566	3.091	4.612	6.144	2.603	3.576	5.456	4.720
[LQ]	-	1.595	2.384	0.564	\	\	0.985	\	3.072	2.498
[LS]	Winning	4.554	4.719	3.060	5.492	6.900	6.897	3.347	3.117	3.536
	Drawing	1.336	0.240	0.627	1.993	1.952	1.066	0.964	0.770	0.974
	Losing	3.272	4.133	3.806	3.504	5.142	5.804	2.254	2.501	2.693
[QS]	Winning	2.832	0.669	0.365	2.434	0.937	1.067	2.157	0.813	2.801
	Drawing	0.724	1.837	2.036	0.982	1.503	1.970	2.048	1.467	0.578
	Losing	3.732	2.536	2.705	3.664	2.693	3.189	4.563	0.794	3.732
[LQS]	Winning	3.356	3.537	2.734	\	\	2.152	\	3.285	\
	Drawing	0.351	0.352	0.923	\	\	0.302	\	1.014	\
	Losing	3.103	2.917	1.698	\	\	2.493	\	2.405	\

\ Effect not present in the model for pitch area behaviour occurrence.

N.B. All omitted z-scores (i.e. those involving away match location and weak opposition quality) can be derived from others by reversing the direction of related effects. For example, with regard to defensive third pitch left, the z-score for away = 0.838, similarly the z-score for playing at home against weak opposition and winning = -3.356.

APPENDIX J

Prediction Equations for Behaviour Occurrence within Nine Soccer Pitch Areas

Prediction of Expected Behaviours Occurrence within Nine Soccer Pitch Areas

Predictions for the expected occurrence of behaviours within defined pitch areas under differing match situations were based upon an additive log-linear equation. The full model (or saturated model), which contains all possible effects of the selected situational variables was:

$$\ln(F_{ijk}) = \theta + \lambda_i^L + \lambda_j^Q + \lambda_k^S + \lambda_{ij}^{LQ} + \lambda_{ik}^{LS} + \lambda_{jk}^{QS} + \lambda_{ijk}^{LQS}$$

where for each contingency table cell the natural logarithm of the expected frequency, ln(*F*), is the summation of a constant, θ, and parameter estimates, λ, for the main effects and interactions of match location [L] opposition quality [Q] and match status [S]. This general log-linear model was subsequently amended in line with the model of best fit identified for each behaviour by removing redundant terms:

Prediction Equation for Expected Behaviour Occurrence within the Defensive Third Pitch Left

$$\ln(F) = \theta + \lambda^L + \lambda^Q + \lambda^S + \lambda^{LQ} + \lambda^{LS} + \lambda^{QS} + \lambda^{LQS}$$

Prediction Equation for Expected Behaviour Occurrence within the Defensive Third Pitch Centre

$$\ln(F) = \theta + \lambda^L + \lambda^Q + \lambda^S + \lambda^{LQ} + \lambda^{LS} + \lambda^{QS} + \lambda^{LQS}$$

Prediction Equation for Expected Behaviour Occurrence within the Defensive Third Pitch Right

$$\ln(F) = \theta + \lambda^L + \lambda^Q + \lambda^S + \lambda^{LQ} + \lambda^{LS} + \lambda^{QS} + \lambda^{LQS}$$

Prediction Equation for Expected Behaviour Occurrence within the Midfield Third Pitch Left

$$\ln(F) = \theta + \lambda^L + \lambda^Q + \lambda^S + \lambda^{LS} + \lambda^{QS}$$

Prediction Equation for Expected Behaviour Occurrence within the Midfield Third Pitch Centre

$$\ln(F) = \theta + \lambda^L + \lambda^Q + \lambda^S + \lambda^{LS} + \lambda^{QS}$$

Prediction Equation for Expected Behaviour Occurrence within the Midfield Third Pitch Right

$$\ln(F) = \theta + \lambda^{L} + \lambda^{Q} + \lambda^{S} + \lambda^{LQ} + \lambda^{LS} + \lambda^{QS} + \lambda^{LQS}$$

Prediction Equation for Expected Behaviour Occurrence within the Attacking Third Pitch Left

$$\ln(F) = \theta + \lambda^{L} + \lambda^{Q} + \lambda^{S} + \lambda^{LS} + \lambda^{QS}$$

Prediction Equation for Expected Behaviour Occurrence within the Attacking Third Pitch Centre

$$\ln(F) = \theta + \lambda^{L} + \lambda^{Q} + \lambda^{S} + \lambda^{LQ} + \lambda^{LS} + \lambda^{QS} + \lambda^{LQS}$$

Prediction Equation for Expected Behaviour Occurrence within the Attacking Third Pitch Right

$$\ln(F) = \theta + \lambda^{L} + \lambda^{Q} + \lambda^{S} + \lambda^{LQ} + \lambda^{LS} + \lambda^{QS}$$