SECTION V

Applied sports performance analysis
Summary

Soccer is one of the most analysed sports and has a relatively long history of performance analysis (Reep and Benjamin, 1968). The ultimate objective of performance analysis in soccer is to enhance player and team performance within the specific context of competition or training. Therefore, the quality of performance analysis may be considered fundamental to the coaching process in soccer.

Research on performance analysis in soccer serves two functions: the descriptive function, in which information about past performance is produced for coaching feedback; and the prescriptive function, where information about future performance is generated for outcome projection and performance optimization. Undoubtedly, the accumulated information from soccer performance analysis has contributed to a substantial increase in our specific knowledge on technical, tactical, physical and psychological aspects of the game over the years. This has led researchers to offer advice to soccer practitioners about different topics of interest, such as detailed understanding of important skills, the positional demands technically, how to play effectively, correct behavioural and mental states in stressful situations and even how these diverse skills can be acquired.

However, applied research in soccer needs to pay further attention to critical issues related to conceptual and methodological shortcomings in order to meet its intents and purposes effectively. In addition to the consideration of opposition relationship, other areas recommended for future research include development of theoretical framework, research on critical behaviours, consideration of situational and playing contexts and inclusion of spatial and temporal dynamics.

Introduction

Soccer is one of the most extensively analysed sports and the use of the ‘Reep system’ (Reep and Benjamin, 1968) of analysis has had a big influence on the development of its performance analysis (McGarry and Franks, 2003).

Most of the research done on performance analysis in soccer is of an applied nature, based on observational research. Its ultimate objective is to enhance player and team performance by providing knowledge which has meaning within the specific context of competition or training. Performance analysis provides the coach and player with information about past performances...
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(descriptive function) and may be useful also in generating data for predictive model development (prescriptive function). The information about skill performance, presented in the form of feedback, is among the critical factors affecting the learning and hence the proficiency of a motor skill (Franks, 2004; McGarry and Franks, 2003).

The second function of facilitating model development moves the role of match performance analysis from descriptive analysis to a prescriptive function. This is because not only can likely outcome be projected through competing playing profiles, but the profiles can also be optimized to promote successful performance. However, the descriptive function of performance analysis in soccer presupposes that the analysed events are not all completely random. Soccer-playing events are assumed to exhibit some inherent organization and explanation (Franks, 1988). Here, the term organization implies stable (or invariant) soccer performance, while explanation implies reliable transfer to future applications based on inductive reasoning. The challenge for performance analysis in soccer becomes, therefore, to identify the stable (or invariant) soccer performance in order to satisfy the necessary condition for its prescriptive function.

Most of the studies on performance analysis in soccer are typically described on the basis of probability (McGarry and Franks, 2003), with the exception of a few studies on perturbations (Hughes and Reed, 2005; Hughes et al., 1998; Hughes et al., 2001) and opposition relationship (Tenga et al., 2010a, 2010b), which incorporated dynamic concepts in their analyses. Some researchers argue that it is difficult if not impossible to have valid data unless sports performance is considered as a complex dynamic process with self-organizing properties (e.g. McGarry et al., 2002; Perl, 2001, 2002). McGarry and Perl (2004) and Hughes (2004) present a good overview of such alternative system descriptions for sports contests. However, so far, these potentially useful analysis approaches are mainly either incomplete or incapable of yielding practical results (Hughes, 2004). Hence, neither the system description based on probability (random processes) nor the one based on dynamical systems so far alone managed to capture all complexities involved in describing a soccer match play. Therefore, further research using various types of system descriptions, separately or together as a hybrid, is warranted.

Research on performance analysis in soccer

The aspects of soccer performance commonly analysed in contemporary research include technical, tactical, physical and psychological aspects. In the past, as for sports performance analysis in general, soccer performance analysis has been limited to notational analysis and biomechanics (O’Donoghue, 2010: 2). The current text will also include research from physiological and psychological investigations, provided that their data were recorded during actual soccer performance in training or competition. Therefore, studies on injury risk and injury mechanism as well as studies on physiological responses and those on the influence of different psychological factors will also be included. In this chapter, applied research on performance analysis in soccer will therefore be organized into five groups according to their contributions.

Analysis of technique

Analysis of technique examines the mechanical aspects of technique and is concerned with the execution of a particular skill in terms of kinetic and kinematic details of the movement involved. This can also be accomplished with the help of qualitative analysis of mechanical properties of a particular soccer skill using video recordings of the player performing the skill. According to O’Donoghue (2010: 2), analysis of technique can include laboratory-based
biomechanical analysis if the technique under investigation is an important skill for performance within the context of a particular sport. Examples of such skills in soccer may include shooting at goal, heading, throwing-in and keeper-related techniques. Kicking technique, with its many variants, is the skill which defines soccer and it is undoubtedly the most analysed technique in soccer (Lees, 2003).

Four stages of a mature kicking motion that have been suggested by Lees (2003) include the retraction of the leg during the backswing; the rotation of both thigh and shank forwards; the thigh deceleration and shank acceleration leading to ball impact; and the follow through. In another study, the trend in the data indicating the effect of different angled approaches to kick a stationary ball suggested that the maximum swing velocity of the kicking leg was achieved with an approach angle of 30 degrees and maximum ball velocity with an approach angle of 40 degrees (Isokawa and Lees, 1988). However, this finding is contested by a more recent study using 3D analysis of kinematics, which reported that approach angle had no effect on ball speed (Kellis et al., 2004).

More recently, detailed analyses of kicking technique including 3D aspects of the skill have been reported as a result of the increasing availability of suitable analysis equipment (Lees, 2009). Lees and Nolan (2002) concluded that slower and more precise action leads to greater consistency in accuracy, while the increases in ball speed were associated with increases in range of motion at the pelvis, hip and knee joints. Ball velocities of 32 and 27 m.s⁻¹ with foot velocities of 22 and 20 m.s⁻¹ were reported for the preferred and non-preferred foot, respectively, in skilled amateur players (Nunome et al., 2006). From these results, it was concluded that the better performance of the preferred foot was due to strength rather than coordination. Elsewhere, a full-body model and a 3D optoelectronic motion capture system was used to analyse selected kinematic variables (Shan and Westerhoff, 2005). This study concluded that the arm contralateral to the kicking leg has a role to play in influencing the efficiency of the kick. Kristensen and Bull (2009) found that the approach velocity influences the ball velocity and that optimal subject-specific velocity of approach does exist in soccer kicking. In another study, players displayed similar kinematic strategies in knee flexion but not ankle extension at the ball contact and follow-through phases of the instep penalty kick when targeting four different corners of the goal (Goktepe et al., 2010). These researchers concluded that the area of the goal targeted affects the kinematics of ankle extension but not knee flexion. Katis and Kellis (2011) reported kinematic differences between straight approach soccer kicks and kicks performed following a cutting manoeuvre action. In specific, these researchers found that a double-cutting manoeuvre reduces ball and foot speed.

The use of fast automatic and reliable data collection systems based on optoelectronic motion analysis is still new to the analysis of kicking and other soccer skills (Lees, 2009). Thus, many more studies on analysis of soccer techniques are to be expected in the near future.

**Technical effectiveness**

Technical effectiveness is concerned with the assessment of the effect of the skills performed by players during match play and it is expressed by using positive-to-negative ratios. Olsen and Larsen (1997) reported the use of frequency profiles of positive and negative applications of different skills for every player’s ball involvement as first attacker and first defender. Their instrument (DOMP) included defensive plus (e.g. winning the ball by reading the game; D), offensive plus (e.g. passing an opponent with the ball; O), offensive minus from losing the ball (e.g. losing the ball during dribbling; M) and offensive minus from passing errors (e.g. square or back pass to the opponent; P). The resulting ratios show good correlation with match result
(r = 0.764) and created scoring opportunity (r = 0.49) and the total number of ball involvements for individual players reflected well the demands of different positional roles according to the style of play in attack (direct play) and in defence (zone-oriented) employed by the Norwegian national team. Hughes and Probert (2006) found no significant difference in either number or quality of different techniques employed by outfield players between successful and unsuccessful teams. Unfortunately, this study used a single scale to represent two different concepts (i.e. quality of skill execution and pressure), something which is simply not correct.

As is evident from the limited number and quality of studies available, despite its potential to be used directly by the squads, it seems apparent that considerable research on technical effectiveness will be beneficial for the enhancement of soccer performance.

**Tactical analysis and evaluation of decision making**

Tactical analysis attempts to identify effective strategy and tactics of play employed by a player, a group of players or a whole team. A strategy refers to a plan agreed in advance in order to make best use of the player’s or team’s strengths, while limiting the effects of any weaknesses. At the same time, the strategy should seek to exploit any known weaknesses of the opposition, while avoiding situations where the opposition can make use of their strengths. On the other hand, tactics relate to a punctual adaptation to new configurations of play and to the circulation of the ball, and therefore tactics are adaptations to opposition. This means tactics relate to the positions taken in reaction to an adversary in a match situation, as well as the adaptation of the team to the conditions of players’ (for details of the different aspects of strategy and tactics, see Gréhaigne et al., 1999).

The strategy that has been agreed prior to the match and tactical decisions made during the match are not directly observable. Instead, the observation of different skills performed by players, the locations on the pitch where they are performed as well as the timing of these actions during a match play can give an indication of the strategy and tactics being applied. The evaluation of decision making through observational means is a natural extension of tactical analysis, often implicitly accomplished within tactical analysis. The decisions made by a player during a match play can only be observed indirectly. This requires an understanding of different options available, their relative chance of success and any risks involved, as well as the situational pressure that a player was under when making a decision. However, despite its potential to influence soccer performance directly, research on decision-making processes during real soccer matches is very scarce. Only a study by Jordet (2005) is available in the literature. Using post-intervention questionnaires and interviews to support the video analyses, Jordet concluded that ecological imagery training can improve visual exploratory ability in elite players, but without clear improvement of players’ performance with the ball.

The original work of Reep and Benjamin (1968) is considered to be a landmark in match performance analysis in soccer (McGarry and Franks, 2003). This research was based on the analysis of data collected from 3213 matches played between 1953 and 1968. These data on goal scoring and the length of passing sequences were analysed statistically and appeared to follow a probability structure. Two main findings from this research were: first, approximately 80 per cent of goals resulted from a sequence of three passes or less and, second, a goal is scored in every ten shots. These findings have been reconfirmed by several different studies (e.g. Bate, 1988; Franks, 1988; Hughes, 1990). In short, Reep and his colleague showed that a successful style of play can be built by maximizing the ‘chance’ elements of the game (Reep and Benjamin, 1968). For example, Bate (1988) concluded that, to increase the number of scoring opportunities, a team should play the ball forward as often as possible, reduce square and back passes to a
minimum, increase the number of long passes forward and forward runs with the ball, and play the ball into forward space as often as possible. Indeed, the adoption of these recommendations by some soccer managers in England has been responsible for what has come to be known as the ‘direct play’ style of attack (Franks and McGarry, 1996). However, McGarry and Franks (2003) maintain that the nature of the good association between successful match performance and the direct style of play is still not well understood.

Research on playing effectiveness concentrates mainly on how goals are scored and comparisons between successful and unsuccessful teams. The question of whether longer or shorter passing sequences are more effective in goal scoring has long been disputed in the soccer community, including among performance analysis researchers (e.g. Bate, 1988; Hughes et al., 1988; Olsen and Larsen, 1997; Reep and Benjamin, 1968). Literature shows mixed findings, with studies supporting either longer passing sequences (e.g. Hughes and Churchill, 2004; Hughes and Snook, 2006; Hughes et al., 1988) or shorter passing sequences (e.g. Bate, 1988; Hughes, 1990; Olsen and Larsen, 1997; Reep and Benjamin, 1968) as a more effective attacking style. Furthermore, the most recent studies demonstrated that more goals were scored from shorter passing sequences, but also that there were more instances of shorter passing sequences than longer ones (Hughes and Franks, 2005; Hughes and Snook, 2006; Tenga et al., 2010a, 2010b). Thus, the difference between these studies appears to be due to the different interpretations of effectiveness and that, if the data are normalized, the longer passing sequences indeed become more effective than shorter ones.

Furthermore, team possessions originating from the final third of the playing field were found to be effective in goal scoring (Bate, 1988; Garganta et al., 1997; Hughes, 1990; Hughes and Snook, 2006; Tenga et al., 2010a, 2010b). Bate (1988), for example, reported 50 to 60 per cent of all possessions leading to shot on goal originated in the attacking third. This finding favoured the approach of direct play as this tactic is expected to decrease the likelihood of a team losing possession in the defending third of the field (Bate, 1988). More recently, compared to the unsuccessful teams, successful teams were reported to score more goals from possessions started in the midfield zone, but not in the attacking third (Tenga and Sigmundstad, 2011). Hook and Hughes (2001) reported similar results, showing that successful teams were more able to start with the ball in their own defensive half and end with a shot at goal compared to unsuccessful teams.

Several studies have reported that possessions with relatively longer duration were related with successful teams (Hook and Hughes, 2001; Hughes and Churchill, 2004; Jones et al., 2004; Tenga and Sigmundstad, 2011). Hughes and Churchill (2004) found that successful teams in Copa America 2001 kept the ball for longer durations and created shots after possessions lasting more than 20 seconds more frequently than unsuccessful teams. Also, significantly longer possessions were performed by successful rather than unsuccessful teams from the 2000 European Championships (Hook and Hughes, 2001). The same was found for teams from the English Premier League (Jones et al., 2004) and from the Norwegian top professional league (Tenga and Sigmundstad, 2011). Hughes et al. (1988) also reported that successful teams used more touches per possession than unsuccessful teams in the 1986 World Cup finals. Moreover, style of play seems to influence possession duration as well. Carling et al. (2005) reported that the majority of goals (53 per cent) in 1998 and 2002 FIFA World Cup finals were scored after possessions lasting between 6 and 15 seconds, while more than 55 per cent of all goals scored in the English Premier league in the 1997–98 season were from possessions of less than five seconds. The authors suggested that international teams are more likely to score goals after long passing sequences and that English Premiership teams tend to employ a more direct attacking strategy.
More qualitative possession characteristics, indicating high and low degrees of offensive directness (counter-attacks and elaborate attacks, respectively), have been used in more recent studies (Tenga and Sigmundstad, 2011; Tenga et al., 2010a, 2010b). Counter-attacks were found to relate to success in goal-scoring. The authors argued that the inclusion of qualitative evaluation improves the ability to describe team possessions in soccer because it enables the analysis of temporal and spatial dimensions of soccer performance, which usually are difficult to measure directly. However, most of the studies on tactical analysis use unidimensional frequency data based on analyses done in isolation from the match context. Since the opposition is responsible for the ‘unexpected’ in a match, requiring constant adaptation to constraints due to the confrontation between two teams (Elias and Dunning, 1966; Gréhaigne et al., 1997), tactical analysis must consider the relationship between the two opposing teams to be a more valid analysis.

Only a few studies on tactical analysis in soccer have considered, directly or indirectly, opposition relationship in their analyses (Table 26.1). Harris and Reilly (1988) showed that defence against attacks with a shot on target, compared to the ones without a shot, tended to involve higher attacker-to-defender ratios and greater average distances between the attacker in possession and the nearest defender throughout the attack.

According to Gréhaigne (1991), the overall attacking configuration with adequate space and time against an opponent’s defence which is out of balance had a positive effect on goal-scoring in 10 out of 33 goals. Elsewhere, it was reported that the defending performances, directly measured through distances and angles between attackers and defenders and the number of players, were related to delaying and diverting attacks, and covering attacking space (Suzuki and

**Table 26.1** Examples of studies on tactical analysis in soccer that directly or indirectly consider opposition interaction in their analyses

<table>
<thead>
<tr>
<th>Reference</th>
<th>Sample size</th>
<th>Opposition relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taylor et al. (2008)</td>
<td>40 matches (20 strong; 20 weak opposition)</td>
<td>Opposition quality;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Match status</td>
</tr>
<tr>
<td>Lago and Martin (2007)</td>
<td>340 observations from 170 matches between league teams of different quality</td>
<td>Opposition quality;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Match status</td>
</tr>
<tr>
<td>Seabra and Dantas (2006)</td>
<td>112 shot situations from 7 matches</td>
<td>Opposition interaction</td>
</tr>
<tr>
<td>Bloomfield et al. (2005)</td>
<td>22 team performances (7 Arsenal; 8 Chelsea; 7 Man. United)</td>
<td>Match status</td>
</tr>
<tr>
<td>Jones et al. (2004)</td>
<td>3544 team possessions from 24 matches (12 successful; 12 unsuccessful teams)</td>
<td>Opposition quality;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Match status</td>
</tr>
<tr>
<td>Suzuki and Nishijima (2004)</td>
<td>439 defending performances from one match</td>
<td>Opposition interaction</td>
</tr>
<tr>
<td>Olsen and Larsen (1997)</td>
<td>28 counter-attacks (25 scoring chances; 3 goals) from 14 matches</td>
<td>Indirect opposition interaction</td>
</tr>
<tr>
<td>Gréhaigne (1991)</td>
<td>36 goals from 14 matches</td>
<td>Opposition interaction</td>
</tr>
<tr>
<td>Harris and Reilly (1988)</td>
<td>180 randomly selected shot and non-shot attacks from 24 matches</td>
<td>Opposition interaction</td>
</tr>
</tbody>
</table>

Notes

- **a** Analysis of team’s performance according to the quality of opposing team (i.e. strong and weak).
- **b** Analysis of team’s performance according to ongoing status of the match (i.e. winning, drawing and losing).
- **c** Simultaneous analysis of offensive and defensive performances (i.e. in relation to each other) within a match-play situation.
- **d** Indirect analysis of offensive performance in relation to defensive performance (i.e. by observing opponent’s degree of control over the ball prior to ball winning).
Nishijima, 2004). Seabra and Dantas (2006) reported a higher proportion of successful shooting attempts for ball receptions and shots originating from zones of low defensive confrontation than high defensive confrontation. Moreover, though indirectly, Olsen and Larsen (1997) showed more scoring opportunities and goals in counter-attacks started when the opponent defence was imbalanced rather than balanced. Similarly, Bloomfield et al. (2005), Jones et al. (2004), Lago and Martin (2007) and Taylor et al. (2008) reported the influence of match status and opposition quality on ball possession and frequency of technical behaviours. In summary, these studies (Table 26.1) report promising effects of considering opposition relationship to better understand tactical performance in soccer. However, only Suzuki and Nishijima (2004) have used a multivariate analysis approach. Some studies did not use any statistical method to compare sets of data (Bloomfield et al., 2005; Gréhaigne, 1991; Olsen and Larsen, 1997), while the remaining studies employed univariate data analyses. In addition, most of these studies have small sample sizes, making the study power too low to obtain significant results.

The more recent studies by Tenga et al. (2010a, 2010b) presented empirical evidence of opposition relationship between offensive and defensive playing tactics in soccer by using analytical study designs. For example, counter-attacks were associated with a higher odds ratio for producing a score box possession than elaborate attacks when playing against an imbalanced defence, but not against a balanced defence (Tenga et al., 2010a). Similarly, counter-attacks were associated with a higher odds ratio for producing a goal than elaborate attacks when playing against an imbalanced defence (Tenga et al., 2010b). Thus, the fact that these two studies produced very similar results, irrespective of the design (cohort-like vs. case-control-like) and outcome variable (score-box possession vs. goal) used, strengthened the evidence.

Work-rate analysis and evaluation of injury risk and mechanism

Physical aspects of soccer performance analysis include time-motion analysis and supplemented data from heart rate and blood lactate measurements taken during soccer training or competition. Time-motion analysis involves evaluation of player movement throughout the entire game in terms of time spent, distance covered and speed of different movement activities during match play (Bangsbo, 1994a). Data from player movement research provide guidelines for efficient and specific fitness training programmes and tactical elements which can enhance a player’s performance and reduce the risk of injury during a match (Bangsbo, 1996).

Time-motion analysis in soccer using hand notation combined with an audio tape recorder was first described by Reilly and Thomas (1976). They were able to specify in detail the work rates of players in different positions, distances covered in a game and the percentage of time in different categories of activity, classified according to intensity, duration (or distance) and frequency. A summary of the research on such work-rate characteristics indicates that outfield players cover 8–13 km during the course of a match, and with as many as 1000 different activities in a game, there is a break in the level or type of activity every six seconds. The overall distance covered by outfield players during a match consists of 24 per cent walking, 36 per cent jogging, 20 per cent cruising sub-maximally (striding), 11 per cent sprinting, 7 per cent moving backwards and 2 per cent moving with possession of the ball (Williams et al., 1999; Reilly, 2003). The vast majority of actions are ‘off the ball’, such as a jump for the ball or a tackle of an opponent (Reilly, 2003).

The game of soccer has experienced a tremendous increase in tempo of play over the years (Table 26.2). Table 26.2 reveals a parallel increase in the number of short sprints (2–3 s, covering about 10–15 m), which suggests that an increase in the tempo of play over the years is the most likely reason behind the huge distances covered during matches in modern soccer.
Using more sophisticated methods (e.g. Bloomfield et al., 2004; Robinson and O’Donoghue 2008), recent studies have applied detailed time-motion techniques allowing details of accelerations, decelerations, turns, swerves and jumps to be recorded. For example, studies on path changes during player movements for the understanding of agility requirements of soccer have been conducted (e.g. Bloomfield et al., 2007a, 2007b; Robinson et al., 2011). In an analysis of the physical demands when running with the ball in professional soccer, Carling (2010) found that players ran a mean total distance of 191 ± 38 m with the ball, of which 34.3 per cent was covered at speeds of >19.1 km.hour⁻¹. Further, mean time in possession, duration and touches per possession were 53.4 ± 8.1 s, 1.1 ± 0.1 s and 2.0 ± 0.2, respectively, with significant differences across playing positions for all variables. Dupont et al. (2010) reported that physical performance, as characterized by total distance covered, high-intensity distance, sprint distance and number of sprints, was not significantly affected by the number of matches per week (one versus two), whereas the injury rate was significantly higher when players played two matches per week as opposed to one match per week (25.6 versus 4.1 injuries per 1000 hours of exposure). Elsewhere, midfield players were reported to cover a significantly greater total distance than defenders and forward players. Also, more distance was covered in the first half compared to the second in medium intensities (11.1 – 19 km.hour⁻¹), but no difference between the two halves was found in either total distance or distances covered at submaximal and maximal intensities (Di Salvo et al., 2007). High-intensity activity was also related to team success, with teams finishing in the bottom five (919 ± 128 m) and middle ten (917 ± 143 m) league positions completing significantly more total high-intensity running distance per outfield player per match compared with teams in the top five (885 ± 113 m) from three seasons of the English Premier League (Di Salvo et al., 2009).

Buchheit et al. (2010) found similar position-dependent results in highly trained young (U13–U18) soccer players, showing midfielders covered the greater total distance and centre-backs covered the lowest. Also, distance for very high-intensity activities (>16.1 km.hour⁻¹) was lower for centre-backs compared with all other positions, while wide midfielders and strikers displayed the highest very high-intensity activities. In elite female soccer, Andersson et al. (2010) reported more high-intensity running and sprinting in international compared with domestic games. Further, female midfielders covered longer distances with high-intensity running in international than in domestic games over the entire game and in the most intense five-minute period of the games, whereas no differences were observed between the game types for defenders. Carling and Dupont (2011) found no reduction in skill-related performances during

<table>
<thead>
<tr>
<th>Year</th>
<th>Distance in km</th>
<th>Year</th>
<th>Number of sprints</th>
</tr>
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<tbody>
<tr>
<td>1954</td>
<td>4.5</td>
<td>1947</td>
<td>70</td>
</tr>
<tr>
<td>1976</td>
<td>8.7</td>
<td>1970</td>
<td>145</td>
</tr>
<tr>
<td>1986</td>
<td>10.1</td>
<td>1985</td>
<td>185</td>
</tr>
<tr>
<td>1988</td>
<td>10.3</td>
<td>1989</td>
<td>195</td>
</tr>
<tr>
<td>1991</td>
<td>10.8 (9–14)*</td>
<td>1991</td>
<td>196*</td>
</tr>
<tr>
<td>2010</td>
<td>11.9†</td>
<td>2010</td>
<td>13†</td>
</tr>
<tr>
<td>2011</td>
<td>10.8 ± 1.0‡</td>
<td>2011</td>
<td>120 ± 39‡</td>
</tr>
</tbody>
</table>

Notes
* Data for the outfield players (HI≥15 km.h⁻¹); † Data for the central midfield players (sprint>24 km.h⁻¹); ‡ Data for the outfield players in 4–3–3 formation (HI≥14.4 km.h⁻¹).
professional soccer match play as a result of a decline in physical performance. The study by Bradley et al. (2011) showed that attackers in 4-3-3 formations covered about 30 per cent more high-intensity running than attackers in 4-4-2 and 4-5-1 formations. Moreover, despite the fact that no differences were found in overall ball possession, the number of passes performed was higher for players in 4-4-2 compared with 4-3-3 and 4-5-1 formations. Thus, this study is the first to demonstrate that physical performance across playing positions is also dependent upon the team formation employed.

Heart-rate data observed during match play generally confirm that the circulatory strain during match play is relatively high, with patterns closely related to the distances covered by the players in a match (Ali and Farally, 1991; Bangsbo, 1994b). The heart rate varied with the work rate and differed between playing positions and between first and second halves. Mean values of 155 beat.min\(^{-1}\) for a centre-back and a full-back player, 170 beat.min\(^{-1}\) for a midfield player, and 168 and 171 beat.min\(^{-1}\) for two forward players have been reported for a team at university level (Van Gool et al., 1983). The same study reported 169 beats.min\(^{-1}\) in the first half and 165 beat.min\(^{-1}\) in the second half. However, these heart-rate values are likely to overestimate the players’ work rate since other factors, such as dehydration, hyperthermia and mental stress, also contribute in elevating the heart rate during a soccer match (Bangsbo and Krustrup, 2009). Measurements of blood lactate concentration were also used to indicate the severity of soccer match play. The mean values of 2–10 mM, with individual values of above 12 mM were reported during soccer matches (Bangsbo and Krustrup, 2009). Ekblom (1986) reported progressively higher lactates in matches from the lower to the top divisions of the Swedish league. According to Bangsbo and Krustrup (2009), blood lactate values can be high even though the muscle lactate concentration is relatively low due to the higher lactate clearance rate in the muscle than in blood.

Other research investigating injury risk (e.g. Andersen et al., 2004c; Hawkins and Fuller, 1998; Rahnama et al., 2002) and injury mechanism (e.g. Andersen et al., 2004a, 2004b) has used observational analysis of match events. Hawkins and Fuller (1998) found that the playing position has no influence on the rate of injury. Assessing the exposure of players to playing actions during English Premier League matches, Rahnama et al. (2002) found that more than one third of the playing actions were judged to have some level of injury potential (assessed subjectively on the likelihood of the actions to produce an injury). Andersen et al. (2004c) provided a more detailed description of high-risk playing actions by using video-based methods that combine soccer-specific and medical information to represent a different approach. No single classic playing situation typical for soccer injuries or incidents could be recognized in this study. However, in most cases, the exposed player seemed to be unaware of the opponent challenging him for ball possession. Further, this study shows that, of the 121 injuries during matches from the top professional league in Norwegian soccer, 43 per cent were identified on video. Among these, serious, moderate and minor injuries were distributed equally. Sixty-nine injuries were not identified on video. Of these, about half were minor and one-fifth serious. Most of the injuries (75–87 per cent) affected the lower extremities. Sprains of the ankle or knee were the most common injury types seen on video, whereas muscle strains to thigh or lower leg accounted for nearly half of the injuries reported but were not identified on video. This implies that there was no stoppage in play, the player did not go down on the pitch but was able to continue and the player was not given treatment until half-time or after the match. These results suggest that a video analysis alone, as previously used in Hawkins and Fuller (1998) and Rahnama et al. (2002), without simultaneous access to medical information from team medical staff, may result in a biased description of how injuries occur in soccer. A similar conclusion was produced by Rahnama and Zareei (2010) in another video analysis-based study. However, this study
reported higher incidence of injuries in the Asian Cup of 2007 than that recorded for the World Cup competitions in 1998, 2002 and 2006 and that goalkeepers sustained more injuries than players in other positional roles. Rahnama and Zareei suggested that the higher incidences of injury in this study might reflect the relatively lower level of skill evident in Asian soccer players compared to players at international level, as well as differences in physical characteristics.

Andersen et al. (2004a, 2004b) attempted to avoid the shortcomings of recall bias in previous research and studied injury mechanism using video recordings of the incidents cross-referenced with reports of acute time-loss injuries from the team medical staff. They reported two mechanisms for ankle injuries thought to be specific to soccer: 1) player-to-player contact, with impact by an opponent on medial aspect of the leg just before or at foot strike, resulting in a laterally directed force, causing the player to land with the ankle in a vulnerable, inverted position; and 2) forced plantar flexion, where the injured player hit the opponent’s foot when attempting to shoot or clear the ball (Andersen et al., 2004a). For the mechanisms for head injuries, elbow-, arm- or hand-to-head contact was the most common mechanism observed. In most of these contacts, the upper arm of the player causing the incident was at or above shoulder level, and the arm use was considered to be active (Andersen et al., 2004b).

**Behavioural and psychological analysis**

The idea that tactics can be inferred from observed patterns of behaviour during competition or training can also be extended to behavioural and psychological aspects of performance (O’Donoghue, 2010: 7). In soccer, observational technique has been used to investigate the effect of importance of the kicks (Jordet et al., 2007; McGarry and Franks, 2000) and public status (Jordet, 2009a, 2009b; Jordet et al., 2009) on the performance of a penalty kick.

In penalty shootouts, the later kicks are argued to be more important than early kicks (McGarry and Franks, 2000). The authors argued further that, if each kick was to be performed independently of the others, all kicks would be of equal importance. However, in reality, each kick is performed in awareness of both the outcome of the previous kicks and the current standings between the teams. Penalty kicks are also perceived to be important due to the fact that their outcome determines whether a team advances or is eliminated from the tournament, or alternatively, they determine a team’s final rank — that is either winning a tournament or being placed third (Jordet et al., 2007). Thus, one reason as for why penalty kicks are experienced as stressful is that the importance of their outcome is assumed to be indicative of stress and anxiety.

Investigating how the order of the shooters would affect the outcome, McGarry and Franks (2000) found that the goal probabilities of each kick from the first to the sixth kick follows an inverted-U, with the least successful kicks early and late. However, this study used a small sample size and the data used may be confounded by the bias of selected line-up order, with coaches picking the best player to take the first kick. In contrast, another study using a larger data set found that goal probability in penalty shootouts follows a negatively linear curve, with higher anxiety progressively resulting in a poorer outcome (Jordet et al., 2007). In addition, Jordet et al. (2007) demonstrated that importance of the kicks was negatively related to the outcomes of the kicks, whereas skill and fatigue were less, or not, related to outcome.

The phenomenon of choking under pressure was also investigated in relation to poor performance in penalty shootouts. Jordet (2009a) examined links between public status and performance in penalty shootouts and found that players with high current status performed worse and seemed to engage more in self-defeating behaviours than players with future status. Further, there were indications that some performance reduction may be stemmed from misdirected
self-regulation of low response time. Similarly, players from countries with higher public status (England and Spain) spent less time preparing their shots and were less successful in penalty shootouts than players from countries with lower public status (Jordet, 2009b). Jordet et al. (2009) demonstrated that the phenomenon of choking under pressure may indeed be a type of self-defeating behaviour. The authors argued that players may attempt to escape unpleasant emotional distress induced by extreme levels of performance pressure by getting the situation over with as soon as possible, leaving their performance to suffer as a result. In another study, individually displayed post-shot behaviours involving celebration with both arms after successful soccer penalty kicks were found to be associated with winning the shootout (Moll et al., 2010). According to Moll and colleagues, this finding showed that the transference of emotions from individuals onto teammates and opponents is an important process in the context of elite sport performance.

The presented findings indicate a promising potential and therefore further work is needed to explore more behavioural and psychological factors directly associated with performance, especially at high levels of play.

**Future work**

Research on performance analysis in soccer over the past years has undoubtedly advanced our understanding of game behaviour. However, the validity of data generated from most studies, especially on the prescriptive function of tactical analysis, can be questioned due to the lack of assessment of opposition relationship in their analyses. Other critical issues related to conceptual and methodological shortcomings of the contemporary research that need attention in future research may include development of theoretical framework, research on critical behaviours, consideration of situational and playing contexts, and inclusion of spatial and temporal dynamics (McGarry, 2009). The more access to the positional data from automated player tracking systems, covering the entire on-field activity of all players throughout the match, will ensure more efficient and reliable research in the future. This will benefit especially the analysis of time-motion, tactics and decision-making processes during match play. In the past, most time-motion investigations suffered from the limited number of players that could be analysed, as well as the reliability with which they could be analysed. In addition, the availability of movement data for all players throughout the entire match will enrich the time-motion analysis by relating players’ movement data to the performance during match play, as well as enable a more holistic tactical analysis.

Research on technical effectiveness and decision-making processes, as well as observational research on penalty shootouts, serves a direct purpose in enhancing player and team performance in soccer. However, to date, the applied research in these areas appears most limited. More research on technical effectiveness, decision-making processes and observational research within behavioural and psychological aspects of soccer match performance is therefore especially recommended.

**Concluding remarks**

The chapter provides evidence that research on performance analysis in soccer has raised our level of knowledge about technique and technical effectiveness, tactics and evaluation of decision making, work-rate and evaluation of injury risk and mechanism, and behavioural and psychological aspects of player and team performance. The substantial knowledge has been produced for coaching feedback (descriptive function) as well as for outcome projection and
performance optimization (prescriptive function). This has led researchers to offer advice to soccer practitioners about different topics of interest, such as detailed understanding of important skills, the positional demands technically, how to play effectively, correct behavioural and mental states in stressful situations and even how these diverse skills can be acquired.

However, applied research in soccer needs to pay further attention to critical issues related to conceptual and methodological shortcomings in order to meet its intentions and purposes effectively. Nevertheless, more efficient and reliable research on soccer performance analysis in general, particularly on the analysis of time-motion, tactics and decision-making processes during match play, is expected in the future. This is due to the easier availability of positional data from more accurate player-tracking technology. Further, there is a need for more research on technical effectiveness, decision-making processes and observational research within behavioural and psychological aspects of player and team performance. To date, these areas remain most limited, yet necessary, for the enhancement of soccer performance.

References


Soccer


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