SECTION III

Sports performance analysis in professional contexts
PERFORMANCE ANALYSIS, FEEDBACK AND COMMUNICATION IN COACHING

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Summary

Sports performances are complex and dynamic situations that yield a potentially large volume of quantitative and qualitative information. Coaches need to identify and act on the most critical information to help players improve. The role of performance analysis within the coaching process is to produce quantitative information allowing areas requiring attention to be quickly identified. This allows coaches to focus on those areas requiring attention and to select video sequences to discuss with players through interactive use of video analysis systems. Coaches and players can then engage in detailed analysis of video sequences, identifying why and how performance can improve and to make decisions about training to enhance performance. The use of information by coaches and how it is communicated to players has evolved as performance analysis technology has developed in recent years.

Introduction

Coaching is the main application area of performance analysis. Several models of performance analysis within coaching have been proposed over the years, including the feedback models of Lees (2008), Irwin et al. (2005), Franks (1997), Winkler (1988), O’Donoghue (2006) and Mayes et al. (2009). Performance analysis processes used in coaching depend on a number of factors, including the nature of the sport, the level of the athletes and access to technology. This chapter will cover the typical model used with video feedback technology in formal games, as well as a typical model used in technique-intensive sports. With video feedback being provided over the internet, the chapter will also cover the use of internet video streaming within the coaching process and its potential for remote analysis.
Rationale for performance analysis support

Providing feedback is an essential part of the coaching process if athletes are to improve (Maslovat and Franks, 2008). Athletes receive sensory feedback from experiencing the sport, including sight, sound, tactile and proprioceptive information. Augmented feedback (or extrinsic feedback) is additional information provided to help athletes improve. Augmented feedback can be provided by a coach who observes and analyses the performances of athletes. However, there are limitations to the accuracy with which coaches can recall critical events within the performance (Maslovat and Franks, 2008). Franks and Miller (1986) found that international level soccer coaches recalled less than 45 per cent of critical events during a match. Coach education has changed over the period since, with continuous professional development enhancing the quality of coaching. When Laird and Waters (2008) repeated the study of Franks and Miller on UEFA-qualified coaches, the coaches recalled 59 per cent of critical events. While this is an improvement, there is still a large number of critical events that are not being accurately recalled by coaches. A further issue is the possibility of biased observation by coaches or emotions influencing the accuracy of their evaluations (Maslovat and Franks, 2008). Therefore, the augmented feedback provided by coaches should be supported by performance analysis.

The information provided to coaches and players by performance analysis support can be broadly classified as quantitative and qualitative. The quantitative information provided in game sports includes match statistics, which can be presented as tables, charts or special-purpose diagrams of the playing surface, showing the location of events. These statistics can help identify areas of performance that require more detailed attention during analysis. Event frequencies on their own can provide some indication of how a team played. Where event outcomes are also included, areas where performance can improve can be rapidly identified. For example, if the number of points won and lost in a tennis match is displayed for points where different types of serve are used, then any serve type that leads to a relatively low proportion of points won can be targeted for more detailed analysis. Similarly, different types and length of pass made in a team game can be assessed based on the percentages that are successfully received by a teammate. This not only allows areas requiring attention to be recognised, but also allows areas where players and teams are performing well to be identified.

Once the match statistics have been assessed, video analysis packages can be used to interactively view video sequences of events based on criteria of interest. For example, if the statistics have deemed that a player wins fewer points when using a slice serve to advantage service court than when using other serves, then the coach can very quickly view video sequences of points lost when the player used the slice serve to the advantage service court. This qualitative viewing of the events by coaches allows more detailed qualitative analysis to be done, identifying how events were performed and why they may not have been performed as well as other events. This can also allow the coach to identify how players and teams may be able to improve performance in these areas and devise training activities to help enhance performance. Once the coach has viewed candidate video sequences for event types of interest, key clips for discussion with players can be selected. Coaches and players can then view these key sequences, engaging in detailed conversations about performance while viewing relevant video sequences. In this sense, performance analysis support involves analysts analysing what problems exist, with coaches and players doing more in-depth analysis of how and why problems occurred and how to enhance performance. The role of the analyst in tagging the match video, providing match statistics and a means of interactively viewing video sequences is important in helping coaches and players focus on the aspects of play most requiring attention. The discussions between players and coaches and decisions made about preparation have been facilitated by performance analysis support.
Performance analysis within coaching

Information needs

There are some general principles that should be observed when providing performance analysis support to coaches and athletes. First, the system used should be dictated by the information needs of the coaching processes that the system serves. Coaches make decisions based on aspects of performance that are important to the style of play used. Those performance indicators that genuinely represent these aspects of performance should be the highest priorities of the analysis system. Once the information needs of coaches and players are understood, the raw event data required to produce this information can be determined. The system can then be developed to allow the event data to be recorded and performance indicators to be produced in the most efficient way. Regardless of whether manual methods are being used or computer technology is being used, the system should be developed in a user-friendly way to ease the task of data collection and provision of feedback.

Reliability

O’Donoghue and Longville (2004) argued for the importance of reliability in performance analysis support work. This is because important decisions about team and player preparation are made using the information. O’Donoghue and Longville (2004) proposed the use of consistency checking to improve the reliability of data collected using performance analysis systems prior to the processing of performance indicators and selection of related video clips. For example, a point in tennis may be recorded with details of who served, the number of shots played, whether the point ended on a winner or an error and who won the point. If the serving player won the point with a winner or lost the point with an error, then there must have been an odd number of shots played. If, on the other hand, the serving player won the point through an opponent error or lost the point through an opponent winner, then there must have been an even number of shots played. These conditions can be tested by systems highlighting data entry errors that can be corrected relatively quickly after the match. This consistency checking and correction process should not be viewed as ‘cheating’ by the analyst; it should be viewed as part of the method of data collection, which is not completed until the various consistency checking tasks have been completed.

Models of performance analysis support

Models for technique-intensive sports

The importance of technique varies between sports. Lees (2008) classified skills as event skills, major skills and minor skills. Event skills are skills that are themselves the sports performance of interest – for example, the high jump. Major skills are not complete sporting events in their own right but are dominant within the given sporting event. For example, hurdle clearance would be a major skill within the 400 m hurdles. Minor skills are important but do not dominate the sporting performance of interest – for example, kicking a football in a game of soccer. This section is concerned with models of performance analysis support for technique-intensive sports that involve major skills or event skills.

Two similar models are discussed: Lees (2008) described a two-phase approach to the use of qualitative biomechanics in sports performance, while Irwin et al. (2005) describe a process...
where coaches work with biomechanists to improve the performance of athletes. Lees (2008) described a model of two broad phases. In the first phase, detailed observation is undertaken to diagnose faults in technique. The second stage is a remediation stage, where performance is enhanced through instruction.

Irwin et al.’s (2005) conceptual model of technique and performance describes how coaches develop skills in athletes with the aid of biomechanical support. This model recognises sources of biomechanical and coaching knowledge and consists of five phases:

1. development of a mindset of technique (conceptual understanding of technical aspects of the skill)
2. understanding the fundamental components of the technique
3. replication of the spatio-temporal characteristics of the technique
4. developing training drills
5. development of technique.

Both the models of Lees (2008) and Irwin et al. (2005) make use of abstract models of technique that make the processes of fault identification and performance enhancement more manageable. Hierarchical models show how an overall performance outcome, such as long jump distance, is determined from key technical variables which themselves are determined from other technical variables (Hay and Reid, 1988). There are also sequential models that represent a skill as a sequence of phases presented in chronological order (Lees, 2008).

These models have an important role to play because the identification of faults and development of training drills require an accurate technical understanding of the skill. Coaching is informed about biomechanical aspects of technique through the ‘coaching-biomechanics interface’ (Kerwin and Irwin, 2008). This enhances the coach’s knowledge about the underlying principles of movement and how they apply to key aspects of the skill being considered. It gives a better understanding of those aspects of technique that are most associated with successful performance of the skill.

Models of technique can be used in experimentation with athletes. For example, Kerwin and Irwin (2008) described how quantitative biomechanics was used to determine the optimal block setting to give an Olympic sprint athlete a more effective sprint start. Models can also be used in simulation studies to investigate the potential effects on outcome of minor changes in different parts of the technique. Due to the nature of the equipment involved and the data being analysed, these uses of biomechanical models require close cooperation between coaches and biomechanists.

**Franks’ model**

The most widely used model of the coaching process in performance analysis literature is that of Franks et al. (1983). This simple model was presented as a flowchart of activity, with athletes performing and coaches observing with performance analysis support. The coach’s evaluation of performance from observation is qualitative and subjective. The role of performance analysis in the coaching process is to provide additional feedback based on a more systematic and objective analysis. The information produced by performance analysis includes quantitative information. Franks et al.’s model of the coaching process has been widely used in academia and in sports practice, with organisations such as the National Coaching Foundation (NCF) in the UK adopting it. Some variants of the model have elaborated some activities to show different stages of data processing between video recording of a match and providing feedback to players (Franks, 1997).
Magill (2001) classified feedback as being sensory or augmented. Players receive sensory feedback from their own experience of competing in sport. This sensory feedback includes visual, audio, proprioceptive and tactile data. Augmented feedback is additional feedback provided to players in the form of video sequences, images, quantitative results and qualitative findings about performance. Franks (1997) showed some excellent examples of statistical and graphical outputs from performance analysis that have good visual impact and communicate important aspects to players and coaches. As technology has developed over the years, there has been greater scope to provide even more sophisticated graphical information, using systems such as Dartfish (Dartfish, Fribourg, Switzerland), Hawk-Eye (Hawk-Eye Innovations, Basingstoke, UK), Prozone (Prozone Sports Ltd, Leeds, UK), Amisco (Amisco, Nice, France) and Catapult (Catapult Sports, South Melbourne, Victoria, Australia). Performance analysis has a role in the provision of augmented feedback, which is particularly important to help athletes improve (Franks, 1997). This augmented information provides additional perspectives on the performance that the athletes would not have access to from their own experiences of competing in the sport. Augmented feedback includes information about the outcome and process of performing events during competition or training. Consider a given stroke in tennis: outcome indicators are concerned with the effectiveness of the stroke in terms of winners, errors or getting the ball back into the opponent’s court. Process indicators are concerned with the way in which the stroke was played, going into detail of the technique used. Knowledge of results (outcomes) can identify broad areas that require attention, with knowledge of performance helping detailed decisions about why problems have occurred and how they may be addressed.

Any information used must be capable of being evaluated by the coach and players. It is essential to have some understanding of what high, low and average values are. There are several ways in which this can be done. Franks (1997) showed how data from recent performances could be used to develop baseline measures for a performer or team. This baseline information could then be used when evaluating performances in a tournament situation. Hughes and Bartlett (2002) introduced the term ‘performance indicators’ within performance analysis of sport. They proposed three alternative ways of using performance indicators: (a) to compare performance with that of an opponent, (b) to compare with values for a peer group of performers, or (c) in isolation. The first two of these are means of evaluating performances. Comparison with peer group performances has been developed further through the use of norms for matches against different qualities of opposition (O’Donoghue, 2006; O’Donoghue et al., 2008; O’Donoghue and Cullinane, 2011).

**Winkler’s model**

There are a number of models of performance analysis process that have been used in coaching, with individual models being influenced by the type of sport and resources available. One of the earliest models for feedback and control in professional soccer was presented by Winkler (1988). This model represented observational analysis activity within the coaching process, a cycle of activity involving systematic observation of matches and training, evaluation of the data gathered and providing feedback to the squad. An important point made by Winkler was that there should be clear aims and purpose to any observation done. This is an aspect of performance analysis that has been consistent in further models that have been developed. According to Winkler, systematic game analysis is only possible if:

- the aims of observation are clearly defined
- observation methods include the use of technical aids (video and computer equipment)
• there is a viable means of analysis of observation
• results are presented in the form of video sequences, figures, graphs and tables
• results are interpreted and stored for later reference.

Performance analysis within the Norwegian FA

The Norwegian national football squads were among the first international soccer squads to introduce performance analysis (match analysis) into the coaching process. The approach was distinguished from other match analysis processes used in soccer since then because the information produced was the information required to analyse the effectiveness of the style of play used by Norwegian squads (Olsen and Larsen, 1997). This is a direct style of play aiming to penetrate the opposing defence and capitalise, especially when the opposing defence is unbalanced. The system used by the Norwegian FA bridged the gap between research and practice, and the match analysis support was developed during a three-phase programme. First, the system was developed for analysing individual matches. The second step introduced match event databases, while the third step provided interactive video feedback. This is commonplace today, with many commercial systems such as Sportcode and Focus providing such features. However, in the mid-1990s, this was highly innovative and allowed Norway to maximise its limited playing population (Olsen and Larsen, 1997). During this period, it is notable that Norway qualified for the 1994 World Cup ahead of two of Europe’s leading soccer nations (Holland and England) and, in the 1998 World Cup, they defeated Brazil during the pool stage and qualified for the second round.

Interactive video feedback systems

The emergence of multimedia computer technology has been exploited by performance analysis of sport. The MAVIS (Match Analysis Video Integrated System) was an early prototype developed in the Borland Delphi programming language (O’Donoghue et al., 1995, 1996). Commercial packages have been developed since and used extensively in coaching in many sports. Packages such as Sportcode (SportsTec, Warriewood, Australia) and Focus X2 (Elite Sports Analysis, Fife, UK) are generic packages that can be tailored to record and analyse details of the specific events in a given sport. These systems integrate the video information with a database of recorded events (O’Donoghue, 2006; Hughes, 2008) so that users can inspect matrices of events and outcomes and set criteria for video sequences to be displayed. There are many different ways video can be used to enhance performance, including instructional and motivational feedback, video profiles of key opponents and videos focussing on a single area of technique (O’Donoghue, 2006).

Research into the effectiveness of feedback produced using interactive video analysis systems cannot be controlled like laboratory experiments. There are many variables outside the control of researchers that impact on sports performance. This has discouraged many researchers from investigating the effectiveness of performance analysis support for athletes. However, there are some studies and experience reports that have provided evidence that performance analysis support can be effective. Brown and Hughes (1995) used athlete diaries to record details of training that might influence performance in squash. Murray et al. (1998) provided further evidence that the provision of feedback to elite and non-elite squash players might be responsible for an improvement in performance observed. Factors such as quality of opposition have an effect on performance. Therefore, studies of performance within knockout tournaments may see performance indicator values decline, simply because the quality of opposition increases as a team progresses through the tournament (Martin et al., 2004).
There are various models of the coaching process and how feedback is provided to players within a cycle of preparation and competition (Winkler, 1988; Franks et al., 1983; Hughes, 2008). These models describe how audio-visual aids and commercial computerised systems are used within the process of analysing a performance and preparing feedback for players. Gaston (2004) reported that such models often failed to recognise the need to fit performance analysis and feedback activities within the players’ schedules of training, competition, recovery, medical support, eating and sleeping. This is especially true in sports where there may be competition on a daily basis during tournaments, such as netball.

Jenkins et al. (2007) used the Focus X2 package to provide instructional and motivational feedback to a university netball squad over a series of eight matches. This study showed some areas where feedback was effective in aiding coach decision making, team preparation and subsequent team performance. There were other areas that remained unchanged and some where performance deteriorated. The study showed how an injury keeping a key player out of the squad for the last four matches could affect performance indicator values. One of the main findings of the work of Jenkins et al. (2007) was that areas requiring attention that had been identified by performance analysis were often not dealt with in training because they were problems that would require a long-term solution. Shorter-term tactical aspects could be addressed more effectively within match-to-match cycles. A further finding was that some aspects of the game needed to be practised regularly, even where performance analysis did not identify problems with them. This is particularly true of fundamental aspects of the game that are encountered regularly by players during competition.

**Internet technology**

There have been major technological advances in recent years (Lieberman et al., 2002) that have not only made the process of performance analysis support more efficient, but have also changed the way in which feedback can be provided. Video sequences can now be provided by internet streaming for players to view at times and locations convenient to them. Systems such as Replay (Replay Analysis Limited, London, UK) and Team Performance Exchange (Team Performance Exchange, Best, Netherlands) allow video sequences to be accessed securely by players prior to training sessions. This allows squads to make better use of training time as feedback and discussion about areas of previous performance can be done on-line in the days before the next squad training session. This technology is especially useful for travelling athletes (such as tennis players on the ATP or WTA tours) or teams of players who live in different areas. Mayes et al. (2009) described how the use of performance analysis video streaming has enhanced the coaching process. A greater volume of video feedback has been provided to players through internet streaming than would have been possible before this type of system was used. Figure 13.1 shows the model used by Mayes et al. (2009).

Research and action (decision making) are often done separately by different groups of individuals: researchers and policy makers. Some research findings may never be used to inform decisions, some research is used indirectly and other research studies may be commissioned by policy makers in order to obtain independent evidence to inform decisions. The term ‘action research’ represents a cycle of action and research within a real-world situation. Action research can be done on a range of scales, from the reflective practice of individual professionals (Schön, 1983) to a very large scale for entire organisational change (Zuber-Skerritt, 1996). The role of performance analysis within a coaching context is essentially one that follows four key stages of action research: observing, reflecting, planning and acting. Figure 13.1 shows a modified version of a model of performance analysis activity within the coaching process (Mayes et al.,
When a match is played, it is observed, with match events being entered into a match analysis system live. Match statistics are produced and performance indicator values are compared to norms for the level of opposition faced in the match (O’Donoghue et al., 2008), allowing areas requiring attention to be identified. Commercial match analysis packages have password-protected internet sites for relevant video sequences to be uploaded and viewed by the squad. This helps the squad discuss and reflect on the performance prior to the next training session. Coaches can plan training sessions to specifically address areas where the squad needs to improve. The action taken in training and subsequent match performance can then be evaluated. This activity is repeated in a cyclical fashion throughout the season in a process of gradually improving the quality of performance. The most important aspect of the model of Mayes et al. (2009) is that it is an athlete-centred model, where the intention is to make every player a better player through a coaching process in which different forms of information flow between coaches and players in both directions.

The underlying paradigm of action research is critical theory, which has been described by Cohen et al. (2007: 26–32). The four stages of description, information, confrontation and reconstruction used in critical reflection (Smyth, 1989) are relevant to the way performance analysts work in practice. The performance analyst working with a squad will analyse squad performance, providing a description of the current situation. Analysis of sports performance data identifies areas of the squad’s performance that can improve. This empowers the squad and challenges the status quo of the squad’s situation within the sport, threatening the interests of dominant squads. The confrontation stage is also relevant to performance analysis in practice as

![Figure 13.1](https://example.com/figure13.1.png)

**Figure 13.1** Performance analysis in a coaching context (Mayes et al., 2009)
Performance analysis, feedback and communication

the squad is determining ways in which it can improve. The reconstruction stage is where decisions are made about squad preparation to specifically improve performance. The effectiveness of decisions made and action taken is evaluated during analysis of training and subsequent competition. Critical theory has a transforming intention and seeks to ensure the catalytic validity of research, meaning that the research can be an agent of change. This is a role of performance analysis as well as the wider coaching process.

Concluding remarks

This chapter has reiterated the rationale for performance analysis support in coaching that has been made by Franks and Miller (1986) and Laird and Waters (2008) previously. There are general principles of performance analysis support in coaching that apply irrespective of the particular coaching process that is used. There are a variety of coaching processes that typically work in a cycle of diagnosing problems and developing solutions. In game sports, where tactical information is paramount, the models have evolved with technological developments in performance analysis. Similarly, in technique-intensive sports, different models have been proposed where qualitative biomechanics is being used (Lees, 2008) and where quantitative biomechanics support is being provided (Irwin et al., 2005; Kerwin and Irwin, 2008).

References


