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Rob Mackenzie & Chris Cushion

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Performance analysis in football: A critical review and implications for future research

ROB MACKENZIE & CHRIS CUSHION

Loughborough University, School of Sport, Health and Exercise Sciences, Loughborough, United Kingdom

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Abstract
This paper critically reviews existing literature relating to performance analysis (PA) in football, arguing that an alternative approach is warranted. The paper considers the applicability of variables analysed along with research findings in the context of their implications for professional practice. This includes a review of methodological approaches commonly adopted throughout PA research, including a consideration of the nature and size of the samples used in relation to generalisability. Definitions and classifications of variables used within performance analysis are discussed in the context of reliability and validity. The contribution of PA findings to the field is reviewed. The review identifies an overemphasis on researching predictive and performance controlling variables. A different approach is proposed that works with and from performance analysis information to develop research investigating athlete and coach learning, thus adding to applied practice. Future research should pay attention to the social and cultural influences that impact PA delivery and athlete learning in applied settings.

Keywords: *performance analysis, football, notational analysis, learning*

Introduction

Performance analysis (PA) is firmly positioned as an integral part of the coaching process (Carling, Williams, & Reilly, 2005; Groom, Cushion, & Nelson, 2011; Hodges & Franks, 2002; Lyle, 2002; Stratton, Reilly, Williams, & Richardson, 2004), and there has been a significant increase in the volume of performance analysis research (Lago, 2009). The application of video and computer technology in sport and the implementation of video review sessions into weekly training programmes (Groom & Cushion, 2004; Guadagnoli, Holcomb, & Davies, 2002), has led to the belief that PA "is now widely accepted among coaches, athletes, and sport scientists as a valuable input into the feedback process" (Drust, 2010, p. 921). Moreover, the development of computer and video aided analysis systems (such as Sportscode©, Focus X2©, ProZone and Sport Universal Process AMISCO Pro© match analysis systems) has enhanced accessibility to resources in order to analyse sporting events objectively (Carling et al., 2005), and as a result, research frequently utilises these data. For example, video analysis software has been used with a multitude of purposes in both individual and team based sports (Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009; Jenkins, Morgan, & O'Donoghue, 2007).

Performance analysis specifically in team sports originated in the United States with American football and basketball analysing competitive performance using coded notes in the 1960's (Carling et al., 2005; Hughes & Franks, 2003). Racquet sports adopted this approach before it was applied more widely to football (Carling et al., 2005). However, the past three decades have seen the growth in the use of PA, the development of PA systems, and PA research specifically for football (Hughes & Franks, 2005). Moreover, professional football around the world pursues PA of some kind (Carling et al., 2005; James, 2006) and professional clubs employ individuals to directly provide PA or access PA data (Carling et al., 2005; Groom & Cushion, 2004). Given these developments and taking into account that football is the most popular sport worldwide (Dvorak, Junge, Graf-Baumann, & Peterson, 2004) the focus of this paper is on the substantial body of PA research undertaken in relation to football. The direction and scope of the this research has primarily focussed on key performance indicators such as possession and passing patterns prior to goals

Correspondence: Chris Cushion, Loughborough University, School of Sport, Health and Exercise Sciences, Loughborough, United Kingdom.
E-mail: C.Cushion@lboro.ac.uk

being scored (e.g. Dawson, Appleby, & Stewart, 2005; Hughes & Franks, 2005; James, Jones, & Mellalieu, 2004) in attempts to predict successful future performance. Other common research endeavours have investigated technical and physical comparisons across different leagues (e.g. Bloomfield, Polman, & O'Donoghue, 2004; Coelho e Silva, Figueiredo, Sobral, & Molina, 2004; Kan et al., 2004) and statistical analyses of goal scoring probabilities (e.g. Armatas, Yiannakos, & Sileloglou, 2007; Ensum, Pollard, & Taylor, 2004; Pollard & Reep, 1997). This research activity has made some contribution to developing and furthering a more systematic understanding of football performance.

However, despite these positive developments a number of issues and questions remain around the progress of the field and the assumptions underpinning the research. Embedded within the coaching process and therefore reflective of it, the questions PA research has posed, like coaching, have been shaped by the methods and assumptions of the positivist paradigm (Brustad, 1997; Cushion, 2007; Smith 1989), a key determinant in shaping the research process. A core concept of the positivist paradigm is reductionism, which is an attempt to understand the functioning of the whole through an analysis of its individual parts (Brustad, 1997). By its nature, this approach views human behaviour as measurable, causally derived and thus predictable and controllable (Smith, 1989). In addition, the positivist paradigm structures the types of questions asked by researchers (Brustad, 1997). This epistemological approach has not only impacted PA research but resulted in the wider coaching process being portrayed as a series of steps to be followed as an unproblematic process, and assumed knowledge as transmitted from coach to athlete, thus downplaying the complex and social aspects involved (Cushion, 2007; Cushion, Armour, & Jones, 2006). In the case of PA particularly, the research has been driven to establish causal relationships between isolated performance variables in an attempt to predict outcomes. For the purpose of this article, the term 'isolated performance variable' refers to an independent variable that is directly associated with match outcome in isolation without acknowledging potentially confounding variables or providing sufficient context to the variable itself. As a result, it could be argued that existing PA research consistently reduces the complexity of performance by presenting it in overly descriptive, systematic and unproblematic ways mirroring much coaching research (Cushion, 2007). Whilst mirroring coaching, these assumptions also appear to impact the application of PA research where the PA process is assumed to be a known, linear, and unproblematic sequence. This is reflected in the literature with the use of performance analysis depicted via flow charts and schemas and often illustrated with a simplistic shift from performance, observation, planning, training and practice (e.g. Carling et al., 2005; Hughes & Franks, 2004; O' Donoghue, 2006).

While this approach has seen a substantial growth in PA research, arguably little attention has been paid to the applicability of performance 'variables' that are now being analysed in the context of complex sporting performances. Indeed, it could be argued that variables have been measured as a result of availability rather than to develop a deeper understanding of performance. As a result, the field appears skewed with areas of PA seemingly neglected by research, such as its use for athlete recruitment and opposition analysis (Groom et al., 2011), the dissemination and use of PA research in applied settings, and crucially the impact PA has on athlete learning and information retention as part of performance feedback. Consequently, despite the emergence of PA, it would appear that there has been little evolution in the research, nor a development of the research areas within the PA research landscape.

Importantly, the test of the utility and value of research to a community is the extent to which its findings are (a) used as recommended practices in the preparation of practitioners, and (b) incorporated by practitioners in everyday practice (Cushion, 2007; Ward & Barrett, 2002). There are examples of PA research influencing football practice/behaviour. For example Charles Hughes in England and Egil Olsen in Norway drew on the work of Reep and Benjamin (1968) and developed their own analysis in formulating direct styles of play (Hughes, 1990; Olsen & Larsen, 1997). However, these seem isolated cases and beyond these there is little or no recent evidence for the systematic application of PA findings in coaching practice, in terms of either methodology or results. This appears somewhat alarming for an applied field and could be accounted for in two ways.

First, perhaps the findings offer little in the way of transferability and second the questions asked by scholars, and the subsequent research undertaken is arguably of little help to practitioners producing a 'theory-practice' gap. This paper explores these two issues by critically reviewing existing PA research in football, particularly the work of notational analysis as a means of data collection. In exploring these, and in going some way to understand some of the issues already discussed, the review considers the applicability of the research findings and methodological issues. This includes a consideration at the level of variables being measured to broader issues of the foundations of the research such as questions of basic versus applied science. The importance of the work lies in developing an overview of where the field 'sits' enabling gaps to be identified, problem areas and

issues to be identified and the understanding of the 'progress of the field' (Silverman & Skonie, 1997, p. 301). That is, where the field has been and, importantly, where it may look to evolve in the future, thus directing or re-directing researchers efforts.

The purpose of the paper is to provide a critical review (see for example Hodges & Franks, 2002) rather than a systematic review of research undertaken. In response to the importance placed on researchers making their philosophical stances known (McNamee, 2005; Nelson & Groom, 2011), any consideration of the literature requires us to be transparent and recognise our assumptions about PA and its research. Indeed, these assumptions need to be set out at the outset as a prelude to the more in-depth analysis that will follow later in the review. We are in agreement with calls that ''the findings from research need to be accepted and adopted by the athletes, coaches and sport-science staff at whom they are targeted'' (Bishop, 2008, p.255) and subsequently support an applied science research agenda for PA.

To ensure the transparency and replicability of the literature search (Holt & Tamminen, 2010) and illustrate the elements of the search strategy, principles of a systematic review were utilised (Egger, Juni, Bartlett, Holenstein, & Sterne, 2003). To ensure the review was encompassing, search terms and criteria were used to search peer reviewed articles (Culver, Gilbert, & Trudel, 2003; Holt & Tamminen, 2010) and included 'notational analysis', 'performance analysis', 'match analysis', 'motion analysis' linked to 'football' or 'soccer'. Specific football variables such as 'crossing' and 'passing' were added and also searched. In addition to electronic databases, specific journals were searched where research related to PA and football has been published (e.g. International Journal of Performance Analysis in Sport, Journal of Sport Sciences). Inclusion/exclusion criteria were applied and any article that had football in the title but did not directly apply to association football, i.e. Gaelic Football (King & O'Donoghue, 2003) or professional rugby league football (Eaves & Evers, 2007), were omitted from the review as was any study that did not involve the direct assessment of performance variables (technical or physical) in relation to football performance. The outcome of this process was a total of 60 articles spanning 24 years (44 technical and 16 physical articles, see Tables VI and VII in Appendix 1).

Applicability of research findings

Investigating isolated variables without context

Sporting performance is multifaceted, complex and largely unpredictable. Football is particularly susceptible to unpredictability and inherent match specificity and as such, signature behaviours will not be consistent where performance indicators are influenced by player-opponent interactions (e.g. Bloomfield, Polman & O'Donoghue, 2005; Harris & Reilly, 1988; McGarry, 2009; Tenga, Holme, Ronglan, & Bahr, 2010). Similarly, Reep and Benjamin (1968) concluded that ''chance does dominate the game and probably most similar ball games'' (p.585). McGarry, Anderson, Wallace, Hughes, and Franks (2002) support this notion as descriptive research attempting to break games down into more manageable segments is suggested to not accurately reflect what goes on in the unaccounted for segments (cf. Hodges, McGarry, & Franks, 1998; McGarry & Franks, 1994; 1996). In addition, retrospective analysis is only relevant to the time in which it was recorded (O'Donoghue, 2001). However, PA research into football seems to have largely ignored these issues and generally remained consistent (McGarry, 2009) in investigating aspects of the game in isolation. These include possession and passing patterns associated with successful and unsuccessful teams (e.g. Jones, James & Mellalieu, 2004; Redwood-Brown, 2008; Scoulding, James & Taylor, 2004), the activity profiles of footballers (e.g. Lago-Peñas, Rey, Lago-Ballesteros, Casais, & Dominguez, 2009; O'Donoghue, 2002), comparisons across major tournaments (e.g. Armatas et al., 2007; Luhtanen, Belinskij, Häyrinen, & Vänttinen, 2001), goals analyses (e.g. Garganta, Maia, & Basto, 1997; Johnson & Murphy, 2010; Lanham, 1993; Redwood-Brown, 2008), and the assessment of differing playing styles (e.g. Bate, 1988; Hughes, 1990; Hughes & Franks, 2005; Pollard & Reep, 1997; Yamanaka, Hughes, & Lott, 1993).

In 25 years this approach to research has changed very little, with simple, descriptive and isolated variables investigated and similar methodologies utilised resulting in contemporary research (e.g. James et al., 2004) appearing to do the same as older studies (e.g. Church & Hughes, 1987) (see Tables VI and VII in Appendix 1). This is despite suggestions that analysing the frequency of occurrences (i.e. notational analysis) may not be the most applicable way to differentiate between effective and less effective performance (Borrie & Jones, 1998; Borrie, Jonsson, & Magnusson, 2002).

In addition, there appears a lack of context to the research carried out. For example, Tenga, Holme (2010) argue the importance of including the opposition in team analysis. Yet of the 44 technical articles reviewed, 36 (81%) do not specifically take the opposition into account (see Table I). Similarly, out of 27 articles that investigated games held at non-neutral venues, 19 articles (70%) did not differentiate between match locations in their results (i.e.

Table I. A summary of research that investigates isolated variables without context.

Context	Yes (=*n*)	Authors	No (=*n*)	Authors	N/A (=*n*) - i.e. at a neutral venue (tournament)	Authors
Research Concerning Technical Variables						
Are the opposition specifically taken into account in the results section?	8	Gerisch & Reichelt (1993); Yamanaka et al. (1997); Tenga & Larsen (2003); Lago (2007); Lago & Martin (2007); Szczepanski (2008); Taylor et al. (2008); Lago (2009)	36	Church & Hughes (1987); Harris & Reilly (1988); Hughes et al. (1988); Olsen (1988); Pollard et al. (1988); Jinshan et al. (1993); Lanham (1993); Luhtanen (1993); Yamanaka et al. (1993); Garganta et al. (1997); Pollard & Reep (1997); Luhtanen et al. (2001); Hughes & Wells (2002); James et al. (2002); Ensum et al. (2004); Hughes & Churchill (2005); James et al. (2004); Jones et al. (2004); Scoulding et al. (2004); Taylor et al. (2004); Hughes & Franks (2005); Konstadinidou & Tsigilis (2005); Taylor et al. (2005); Tucker et al. (2005); Seabra & Dantas (2006); Yiannakos & Armatas (2006); Armatas et al. (2007); Cullinane (2009); De Baranda et al. (2008); Redwood-Brown (2008); Boscá et al. (2009); Tenga et al. (2009); Johnson & Murphy (2010); Lago-Peñas et al. (2010); Tenga, Holme et al. (2010); Tenga, Ronglan et al. (2010)	0	
Is there a differentiation between match locations in the authors' results?	8	Gerisch & Reichelt (1993); Yamanaka et al. (1997); Tucker et al. (2005); Lago & Martin (2007); Taylor et al. (2008); Boscá et al. (2009); Lago (2009); Lago-Peñas et al. (2010)	19	Church & Hughes (1987); Harris & Reilly (1988); Pollard et al. (1988); Lanham (1993); Yamanaka et al. (1993); Garganta et al. (1997); James et al. (2002); Tenga & Larsen (2003); James et al. (2004); Jones et al. (2004); Taylor et al. (2004); Taylor et al. (2005); Cullinane (2009); Redwood-Brown (2008); Szczepanski (2008); Tenga et al. (2009); Johnson & Murphy (2010); Tenga, Holme et al. (2010); Tenga, Ronglan et al. (2010)	17	Hughes et al. (1988); Olsen (1988); Jinshan et al. (1993); Luhtanen (1993); Pollard & Reep (1997); Luhtanen et al. (2001); Hughes & Wells (2002); Ensum et al. (2004); Hughes & Churchill (2005); Scoulding et al. (2004); Hughes & Franks (2005); Konstadinidou & Tsigilis (2005); Seabra & Dantas (2006); Yiannakos & Armatas (2006); Armatas et al. (2007); Lago (2007); De Baranda et al. (2008)

(*continued*)

Table I. (*Continued*).

Context	Yes (=*n*)	Authors	No (=*n*)	Authors	N/A (=*n*) - i.e. at a neutral venue (tournament)	Authors
Is there specific information relating to the assessed variables? (i.e. where on the pitch passes are made or where goals are scored from)	19	Harris & Reilly (1988); Hughes et al. (1988); Olsen (1988); Jinshan et al. (1993); Luhtanen (1993); Yamanaka et al. (1993); Garganta et al. (1997); Yamanaka et al. (1997); James et al. (2002); Ensum et al. (2004); Konstadinidou & Tsigilis (2005); Taylor et al. (2005); Seabra & Dantas (2006); Yiannakos & Armatas (2006); De Baranda et al. (2008); Szczepanski (2008); Taylor et al. (2008); Lago (2009); Tenga et al. (2009)	24	Church & Hughes (1987); Pollard et al. (1988); Gerisch & Reichelt (1993); Lanham (1993); Pollard & Reep (1997); Luhtanen et al. (2001); Tenga & Larsen (2003); Hughes & Churchill (2005); James et al. (2004); Jones et al. (2004); Scoulding et al. (2004); Taylor et al. (2004); Hughes & Franks (2005); Tucker et al. (2005); Armatas et al. (2007); Lago (2007); Lago & Martin (2007); Cullinane (2009); Redwood-Brown (2008); Boscá et al. (2009); Johnson & Murphy (2010); Lago-Peñas et al. (2010); Tenga, Holme et al. (2010); Tenga, Ronglan et al. (2010)	1	Hughes & Wells (2002)
Research Concerning Physical Variables						
Are the opposition taken into account?	3	Erdmann (1993); Rampinini et al. (2007); Kan et al. (2004)	12	Ohashi et al. (1988); Yamanaka et al. (1988); O'Donoghue (2002); O'Donoghue et al. (2005); Di Salvo et al. (2007); Di Salvo et al. (2009); Lago-Peñas et al. (2009); Carling (2010); Carling & Bloomfield (2010); Carling et al. (2010); Clark (2010); Gregson et al. (2010)	1	Asami et al. (1988)
Is there a differentiation between home/away teams or match locations in the authors' results?	2	Kan et al. (2004); Carling & Bloomfield (2010)	13	Ohashi et al. (1988); Yamanaka et al. (1988); Erdmann (1993); O'Donoghue (2002); O'Donoghue et al. (2005); Di Salvo et al. (2007); Rampinini et al. (2007); Di Salvo et al. (2009); Lago-Peñas et al. (2009); Carling (2010); Carling et al. (2010); Clark (2010); Gregson et al. (2010)	1	Asami et al. (1988)
Is there specific information relating to the assessed variables? (i.e. positional breakdown or in possession vs. out of possession etc.?)	11	Yamanaka et al. (1988); Erdmann (1993); O'Donoghue (2002); O'Donoghue et al. (2005); Di Salvo et al. (2007); Di Salvo et al. (2009); Lago-Peñas et al. (2009); Carling (2010); Carling et al. (2010); Clark (2010); Gregson et al. (2010)	4	Ohashi et al. (1988); Kan et al. (2004); Rampinini et al. (2007); Carling & Bloomfield (2010)	1	Asami et al. (1988)

home or away). Specific contextual information also appears lacking in that more than half of the articles (24/43; 55%) did not provide specific information relating to the variables assessed (i.e. where on the pitch passes were made or where goals were scored from (see Table I). Given research has suggested that time spent in the attacking, middle or defensive thirds is influenced by match status and match location (Lago, 2009), as are technical and tactical behaviours (Taylor, Mellalieu, James, & Shearer, 2008; Tucker, Mellalieu, James, & Taylor, 2005), the omission of such information is surprising yet appears common.

Although the evidence suggests a problem relating to a lack of context in the majority of PA research, there are positive examples where context is provided. Lago (2009) for instance, when analysing possession strategies during 27 games in Espanyol's 2005/06 season, accounted for match location, quality of opposition, and match status in his results. Moreover, context relating to the possessions themselves were provided as the time spent in the defensive, middle and attacking thirds was reported in the authors' results. Taylor et al. (2008) provided similar context in their research spanning 40 games during the 2002/03 and 03/04 seasons. An approach mirroring Lago (2009) was adopted in that match location, quality of opposition, and match status were considered but in relation to technical performance rather than possession alone.

Table I demonstrates that issues relating to a lack of context are also apparent in PA research concerning the physical demands of football. Of the 15 applicable articles that were reviewed, 12 (80%) did not acknowledge the opposition that players faced despite its direct influence on the physical demands of a game. In addition, 13/15 articles (87%) did not differentiate between match location in their results irrespective of its influence on performance (Taylor et al., 2008; Lago, 2009). One of the few articles to do this was Kan et al. (2004) who, in their analysis of players' movement, considered the opposition and made reference to match location, albeit with a sample size of only two games. Overall, more context tends to be provided by physical articles than technical articles in relation to specific information about variables being assessed (i.e. out of possession vs in possession, positional breakdowns) as 11/15 articles (73%) considered this in their results. One example of this is Gregson, Drust, Atkinson, and Di Salvo (2010) who investigated match-to-match variability of high-speed activities in the English Premier League (EPL). As part of their research and in order to bring context to their sample, the authors categorised their participants into different positions and also reported variables such as high speed running distance both when in and out of possession. This level of information arguably allows for more meaningful interpretations of data given that more is known about the data's origins.

The potential applicability of findings of research that use simple, descriptive and isolated variables in relation to tactical preparation or training content can be problematic due to the uncontrollable nature and myriad of confounding variables impacting performance (Christensen, 2009). For example, greater or less possession alone does not necessarily equate to performance success (Jones et al., 2004). It could be asked how much research of this type has actually furthered our understanding of performance. Indeed, lack of contextual information impacts across the 25 year range of research (e.g. Pollard, Reep, & Hartley, 1988; Redwood-Brown, 2008). This lack of context that appears to surround the results of PA research is concerning given the variables that could have influenced the outcome (see Table I). These variables and the relevant information that accompanies them, such as, where on the pitch the incidents occurred and their impact on match outcome, often remain unstated and thus their impact un-investigated. For example, Redwood-Brown's (2008) research does not present information such as the location of the passes, the opposition's resulting pattern of play following possession turnover, and consequences to the team who had lost the ball following the turnover. This lack of context accompanying results could be considered a limiting factor in the applicability of the findings. Similar issues relating to applicability and lack of context in descriptive research appear common within current PA literature (see Table I).

The notion of context can be applied more broadly to encompass specific events such as one-off tournaments (see Table II) where retrospective research has been found to be applicable to the event in question, with limited transferability to other competitions (McGarry, 2009). Furthermore, the structure of international tournaments lends itself to non-representative scenarios. Teams of distinct quality differences (that are often not accounted for in the research) play each other in knock-out games and in the group stages more successful teams that have already qualified approach subsequent games differently. Despite these concerns, work has continued to investigate isolated competitions without acknowledging or dealing with these issues. For example in 19/44 (42%) of the technical articles reviewed use samples from one off tournaments (see Table II). What is more, of the 24 articles that investigated competitions with different stages (i.e. group stage followed by knock-out group), only five authors (21%) differentiated between the different stages in their results section; the remainder leaving the exact sources of their data unidentified. Of the technical

Table II. A summary of the sample types used.

Context	Yes (=*n*)	Authors	No (=*n*)	Authors	N/A (=*n*) – i.e. one domestic league sample	Authors
Research Concerning Technical Variables						
Is the research from a one off tournament (s)? (i.e. FIFA World Cup)	19	Hughes et al. (1988); Olsen (1988); Pollard et al. (1988); Jinshan et al. (1993); Luhtanen (1993);Yamanaka et al. (1993); Pollard & Reep (1997); Luhtanen et al. (2001); Hughes & Wells (2002); Ensum et al. (2004); Hughes & Churchill (2005); Scoulding et al. (2004); Hughes & Franks (2005); Konstadinidou & Tsigilis (2005); Seabra & Dantas (2006); Yiannakos & Armatas (2006); Armatas et al. (2007); Lago (2007); De Baranda et al. (2008)	25	Church & Hughes (1987); Harris & Reilly (1988); Gerisch & Reichelt (1993); Lanham (1993); Garganta et al. (1997); Yamanaka et al. (1997); James et al. (2002); Tenga & Larsen (2003); James et al. (2004); Jones et al. (2004); Taylor et al. (2004); Taylor et al. (2005); Tucker et al. (2005); Lago & Martin (2007); Cullinane (2009); Redwood-Brown (2008); Szczepanski (2008); Taylor et al. (2008); Boscá et al. (2009); Lago (2009); Tenga et al. (2009); Johnson & Murphy (2010); Lago-Peñas et al. (2010); Tenga, Holme et al. (2010); Tenga, Ronglan et al. (2010)		
Does the research include data from across seasons/ tournaments?	9	Pollard et al. (1988); Lanham (1993); Garganta et al. (1997); Hughes & Wells (2002); James et al. (2002); Hughes & Franks (2005); Armatas et al. (2007); Taylor et al. (2008); Boscá et al. (2009)	35	Church & Hughes (1987); Harris & Reilly (1988); Hughes et al. (1988); Olsen (1988); Gerisch & Reichelt (1993); Jinshan et al. (1993); Luhtanen (1993); Yamanaka et al. (1993); Pollard & Reep (1997); Yamanaka et al. (1997); Luhtanen et al. (2001); Tenga & Larsen (2003); Ensum et al. (2004); Hughes & Churchill (2005); James et al. (2004); Jones et al. (2004); Scoulding et al. (2004); Taylor et al. (2004); Konstadinidou & Tsigilis (2005); Taylor et al. (2005); Tucker et al. (2005); Seabra & Dantas (2006); Yiannakos & Armatas (2006); Lago (2007); Lago & Martin (2007); Cullinane (2009); De Baranda et al. (2008); Redwood-Brown (2008); Szczepanski (2008); Lago (2009); Tenga et al. (2009); Johnson & Murphy (2010); Lago-Peñas et al. (2010); Tenga, Holme et al. (2010); Tenga, Ronglan et al. (2010)		
Are differentiations made between competitions/ competition stages? (i.e. knock out vs group game, friendly vs. qualifier or EPL vs FA Cup)	5	Pollard et al. (1988); Gerisch & Reichelt (1993); Lanham (1993); Lago (2007); Boscá et al. (2009)	19	Hughes et al. (1988); Olsen (1988); Jinshan et al. (1993); Luhtanen (1993); Garganta et al. (1997); Pollard & Reep (1997); Luhtanen et al. (2001); Hughes & Wells (2002); James et al. (2002); Tenga & Larsen (2003); Ensum et al. (2004); Hughes & Churchill (2005);	20	Church & Hughes (1987); Harris & Reilly (1987); Yamanaka et al. (1993); Yamanaka et al. (1997); James et al. (2004); Jones et al. (2004); Scoulding et al. (2004); Taylor et al. (2004); Taylor et al.

(*continued*)

Table II. (*Continued*).

Context	Yes (=*n*)	Authors	No (=*n*)	Authors	N/A (=*n*) – i.e. one domestic league sample	Authors
				Hughes & Franks (2005); Konstadinidou & Tsigilis (2005); Seabra & Dantas (2006); Yiannakos & Armatas (2006); Armatas et al. (2007); De Baranda et al. (2008); Szczepanski (2008)		(2005); Tucker et al. (2005); Lago & Martin (2007); Cullinane (2009); Redwood-Brown (2008); Taylor et al. (2008); Lago (2009); Tenga et al. (2009); Johnson & Murphy (2010); Lago-Peñas et al. (2010); Tenga, Holme et al. (2010); Tenga, Ronglan et al. (2010)
Research Concerning Physical Variables						
Is the research from a one off tournament (s)? (i.e. FIFA World Cup)	0		16	Asami et al. (1988); Ohashi et al. (1988); Yamanaka et al. (1988); Erdmann (1993); O'Donoghue (2002); Kan et al. (2004); O'Donoghue et al. (2005); Di Salvo et al. (2007); Rampinini et al. (2007); Di Salvo et al. (2009); Lago-Peñas et al. (2009); Carling (2010); Carling & Bloomfield (2010); Carling et al. (2010); Clark (2010); Gregson et al. (2010)		
Does the research include data from across seasons/ competitions?	9	Asami et al. (1988); Yamanaka et al. (1988); Kan et al. (2004); O'Donoghue et al. (2005); Di Salvo et al. (2007); Di Salvo et al. (2009); Carling (2010); Clark (2010); Gregson et al. (2010)	6	Ohashi et al. (1988); Erdmann (1993); Rampinini et al. (2007); Lago-Peñas et al. (2009); Carling & Bloomfield (2010); Carling et al. (2010)	1	O'Donoghue (2002) – not published
Are differentiations made between competitions/ competition stages? (i.e. knock-out vs group game or EPL vs FA Cup or reported in separate seasons)	3	Asami et al. (1988); Yamanaka et al. (1988); Kan et al. (2004)	6	O'Donoghue et al. (2005); Di Salvo et al. (2007); Di Salvo et al. (2009); Carling (2010); Clark (2010); Gregson et al. (2010)	7	Ohashi et al. (1988); Erdmann (1993); O'Donoghue (2002); Rampinini et al. (2007); Lago-Peñas et al. (2009); Carling & Bloomfield (2010); Carling et al. (2010)
Potentially unaccounted for skewed data? (i.e. more home than away games, more EPL games than Champion league games etc. that are directly communicated by the author in the sample)	5	Asami et al. (1988); Di Salvo et al. (2007); Carling (2010); Carling et al. (2010); Clark (2010)	11	Ohashi et al. (1988); Yamanaka et al. (1988); Erdmann (1993); O'Donoghue (2002); Kan et al. (2004); O'Donoghue et al. (2005); Rampinini et al. (2007); Di Salvo et al. (2009); Lago-Peñas et al. (2009); Carling & Bloomfield (2010); Gregson et al. (2010)		

research reviewed only 9/44 articles (20%) used samples that spanned across different seasons or different competitions despite O'Donoghue's (2001) proposal that retrospective analysis is only relevant to the time in which it was recorded. Boscá, Liern, and Martinez (2009), however, is a paper that has attempted to address concerns surrounding the type of sample used (see Table II). The authors provided contextual detail when comparing defensive and offensive efficiency of both Italian and Spanish teams across three different seasons (2000/01, 2001/02 and 2002/03) whilst making separate reference to the teams in the study. Moreover, the differences in offensive and defensive performance over time were acknowledged as the data were reported both season-by-season and across seasons.

In summary, to enhance the quality of future research, researchers engaging in research concerned with attributing performance outcomes to performance variables should be mindful of contextual issues. Specifically, researchers could consider the limitations, with specific reference to generalisability, associated with the competition they are investigating. Moreover, pertinent information such as the period of the season the data were collected, the quality of the opposition faced and match location should arguably be provided in order to bring context to research data and its subsequent conclusions. Similarly, if essential information relating to the variable under investigation, such as the location on the pitch the action(s) occurred in, the type of action, the distance the action accrued and subsequent consequences, are to be incorporated into future reporting of data a more holistic understanding of the influence the variable may have had on the outcome may be achieved.

Methodological issues

Assumptions of the research

No studies in the review were explicit about the paradigmatic assumptions or principles underlying them. There also seems to be a lack of clarity as to the explicit scientific approach underpinning PA research undertaken, i.e. whether the research aligns itself with basic science or applied science principles (Funtowicz & Ravetz, 1993). For example, the purpose of basic science is to discover new knowledge and information often without the primary concern of how the knowledge created might be used (Page, 2002). Much of the PA research reviewed could be viewed in this way. However, it is common for researchers to attempt to draw applied science conclusions from their work, thus inferring that the research is aligned with applied science principles (e.g., Chapman, 2011; Gilbert, Nater, Siwik, & Gallimore, 2010; Strean & Roberts, 1992; Weinberg, 1989). Basic science approaches appear to be adopted to establish causal relationships between isolated performance variables in an attempt to predict outcomes, yet authors are then drawing applied conclusions from their data (e.g. Boscá et al., 2009; Harris & Reilly, 1988; Johnson & Murphy, 2010; Szczepanski, 2008; Yamanaki, Liang, & Hughes, 1997). Therefore, researchers arguably are currently investigating PA from a basic science approach but attempt to make applied claims from the research. This leads to a lack of conceptual clarity about the scientific origins of the work and its desired outcome.

Within these implicit methodological frameworks, the consistent use of notational analysis and the analysis of computer generated data by software such as ProZone® match analysis system (e.g. Di Salvo et al., 2007; Di Salvo et al., 2009; Gregson et al., 2010) or AMISCO Pro® (e.g. Carling & Bloomfield, 2010; Carling, Espié, Le Gall, Bloomfield, & Jullien, 2010) has highlighted two significant and unresolved methodological issues. First, sample sizes from which generalisations are made and second, a lack of transparent definitions from which results have been derived.

Sample sizes

There appears to be little agreement in the existing research about what constitutes a representative sample size from which to generalise (James, 2006). From one off tournaments (e.g. De Baranda, Ortega, & Palao, 2008; Jinshan, Xiakone, Yamanaka, Matsumoto, 1993; Luhtanen, 1993; Luhtanen et al., 2001; Olsen, 1988; Scoulding et al., 2004) general claims about football are made from particular findings (see Table II). Moreover, investigating the same variables over different periods of time often yields different results (O'Donoghue, 2001). Regardless of the context, much of the research has used very small samples. Of the 44 technical articles reviewed, only 10 (22%) investigated samples that consisted of 100 games or more. This is against a context of a season that could consist of 380 games or more. Of the 33 articles that did not investigate 100 matches or more, 22 articles used less than 36 games and 6 articles investigated less than 10 games. In the context of a full season or even an isolated tournament, it could be questioned as to how representative are these samples, and how meaningful are their findings? (Refer to Tables VI and VII in Appendix 1).

For example Lago and Martin (2007) investigated the determinants of ball possession using data from a seemingly impressive 170 matches during the 2003/2004 Spanish Professional Football season.

However, all of the games were played within the first 17 days of the season. Clearly, for such a volume of games to have been analysed in such a short period, the games must have included teams from a multitude of standards (different leagues) although the authors make no reference to this. It is unclear what differences between leagues exist, thus calling into question their common sense finding of ''the worse the opponent, the greater the possession of the ball'' (p. 969). Are 17 days representative of a whole season, irrespective of the apparent face validity of findings? (Le Grange & Beets, 2005). More positive examples, however, include Lanham (1993), Boscá et al. (2009) and Lago-Peñas, Lago-Ballesteros, Dellal, and Gomez (2010) who examined sample sizes of 479, 2280 and 380 games respectively; inferring a greater level of generalisability within their results (refer to Appendix 1 for details).

The issue of generalisable sample sizes also impacts the work considering the physical demands of football performance (e.g. Asami, Togari, & Ohashi, 1988; Carling et al., 2010; Clark, 2010; Di Salvo et al., 2009; Erdmann, 1993; Yamanaka et al., 1988; *inter alia*– see Tables II and III). Of the 16 physical articles reviewed, 9 articles (56%) drew conclusions from research that involved less than 50 different players. Moreover, 11 of the 16 articles (69%) used players from less than 36 games. Table II highlights that this is not an isolated case as it emerged in the review that a third (5/16) of the physical articles used samples that had unaccounted for skewed data (i.e. more home than away games). Specific examples such as Taylor et al. (2008) and Carling (2010) used different sample sizes investigating the influence of situational variables on technical performance and activity profiles when running with the ball respectively (see Tables II and III). Both used samples spanning two seasons; thus assuming the variables remained constant over this extended time period. Moreover, Carling (2010) used a skewed sample of 19 home and 11 away matches from just a single professional club.

It could be suggested that the reliability and generalisability of these research approaches pose questions about the overall contribution of this work. Di Salvo et al. (2009) and Gregson et al. (2010) on the other hand arguably used far more representative samples as they investigated 563 and 485 players respectively across three English Premier League seasons (2003/04 to 2005/06). However, sample sizes such as these are not common (see Table III).

In order to address issues relating to sample size and generalisability, authors engaging in research of this nature could consider reporting the power calculations and processes that have been undertaken in order to ensure that the sample size used is representative of the population in question (see Vincent, 2005). It is suggested that such an approach would provide an opportunity to assess the individual merits of each study and provide a basis to evaluate sample sizes.

As will be discussed in detail in the next section, this research also often fails to publish the definitions for analysis of the data leaving much to interpretation (see Table IV). In addition, there is a lack of consistency with the classifications used, notably in papers investigating the physical demands of football. Having acknowledged issues associated with inconsistent sample sizes, to develop the research more stringent measures should be considered in order to ensure that future work utilises statistically acceptable sample sizes. In short, researchers should be encouraged, where appropriate, to publish power calculations that have been completed to ensure their sample is generalisable.

Definitions/classifications

Evidence from the review reveals that there seems to be a lack of transparency and published operational definitions in scholars' work (James, 2006). Of the 44 technical articles that were reviewed, 35 (79%) did not fully define the variables that they were analysing (see Table IV). Of those 35 only 16 partially defined variables, with 4 making reference to the development of definitions without publishing them. Finally, 14 articles (31%) provided no definitions. Subsequently, it would be difficult to compare these studies or replicate them, despite suggestions that ''it is essential for system operators and the eventual consumers of the information generated by performance analysis to have a shared understanding of the variables used'' (O'Donoghue, 2007, p. 36) (see Table IV).

One specific example to highlight this trend is Szczepanski (2008) who measured the effectiveness of strategies and attempted to quantify players performance, yet provided no definitions to supplement the playing tactics that were investigated, such as ''long forward pass'' (p.56). Furthermore, no explanation for what constituted being pressed or not pressed is provided, thus leaving the variable ''type of possession'' (p.60) as ambiguous with a lack of transparency (i.e. it would be difficult to repeat this study). Similarly, there was no definition to explain the analysed term ''running with the ball'' (p.56) which may lead to a misinterpretation of the results. In another example, Scoulding et al. (2004) investigated passing patterns in the 2002 World Cup and while they did classify information relating to passing (i.e. to feet or to space) there was no definition of a pass provided (see Table IV). This may appear trivial, however, given that the term may include goal kicks, free kicks and throw-ins to feet or space then

Table III. A summary of sample sizes used.

Context	Yes (=*n*)	Authors
Research Concerning Technical Variables		
Games Investigated:		
1	2	Gerisch & Reichelt (1993); Tenga & Larsen (2003)
Less than 10 (2–9)	4	Church & Hughes (1987); Yamanaka et al. (1997); Scoulding et al. (2004); Szczepanski (2008)
10–35	16	Harris & Reilly (1988); Pollard et al. (1988); Pollard & Reep (1997); Luhtanen et al. (2001); James et al. (2002); Hughes & Churchill (2005); James et al. (2004); Jones et al. (2004); Taylor et al. (2004); Konstadinidou & Tsigilis (2005); Taylor et al. (2005); Tucker et al. (2005); Seabra & Dantas (2006); Yiannakos & Armatas (2006); Cullinane (2009); Lago (2009)
36–99	11	Hughes et al. (1988); Olsen (1988); Jinshan et al. (1993); Luhtanen (1993); Yamanaka et al. (1993); Garganta et al. (1997); Ensum et al. (2004); Lago (2007); De Baranda et al. (2008); Taylor et al. (2008); Johnson & Murphy (2010)
100–200	7	Hughes & Franks (2005); Armatas et al. (2007); Lago & Martin (2007); Redwood-Brown (2008); Tenga et al. (2009); Tenga, Holme et al. (2010); Tenga, Ronglan et al. (2010)
200–300	0	
300+	3	Lanham (1993); Boscá et al. (2009); Lago-Peñas et al. (2010)
Not published	1	Hughes & Wells (2002) – 129 penalties
Research Concerning Physical Variables		
Individuals Investigated:		
0–10	2	Ohashi et al. (1988); Carling & Bloomfield (2010)
11–20	3	Asami et al. (1988); Erdmann (1993); Clark (2010)
21–30	2	Carling (2010); Carling et al. (2010)
31–40	1	Kan et al. (2004)
41–50	1	Yamanaka et al. (1988);
51–60	0	
61–70	0	
71–80	0	
81–90	0	
91–100	0	
101–200	1	Lago-Peñas et al. (2009)
201–300	4	Rampinini et al. (2007); O'Donoghue (2002); O'Donoghue et al. (2005); Di Salvo et al. (2007)
301–400	0	
401–500	1	Gregson et al. (2010)
500+	1	Di Salvo et al. (2009)
Games Investigated:		
1	2	Erdmann (1993); Carling & Bloomfield (2010)
Less than 10 (2–9)	3	Ohashi et al. (1988); Yamanaka et al. (1988); Kan et al. (2004)
10–35	7	Asami et al. (1988); O'Donoghue (2002); Di Salvo et al. (2007); Lago-Peñas et al. (2009); Carling (2010); Carling et al. (2010); Clark (2010)
36–99	0	
100–200	1	O'Donoghue et al. (2005)
200–300	0	
300+	2	Di Salvo et al. (2009); Gregson et al. (2010)
Not published	1	Rampinini et al. (2007)

the results may not be as clear or straightforward as assumed. Similar research (e.g. Johnson & Murphy, 2010) also used passing and possession as the primary variable of investigation, again, with no definition of a pass. Whilst not investigating passing in isolation, Cullinane's (2009) research on the technical comparison of positional roles in professional football across 18 games (3 teams x 6 games) gives no operational definitions for the variables analysed nor did Tenga and Larsen (2003) for terms such as ''counter attack'' (p.93) despite it being a key variable.

The issue of classification and definition also occurs in research of activity profiles of professional footballers. Although definitions are often provided (11/16 articles (69%) – see Table IV), problems include classifications that are too simplistic with O'Donoghue, (2002) and O'Donoghue et al. (2005) for example using just two classifications (see Table IV). Across the 16 reviewed articles there were six alternative combinations of categories/thresholds used to measure similar physical activities in football. Competing information providers such as ProZone® and AMISCO Pro® have common detailed

Table IV. A summary of definitions/classifications used.

Context	Yes (=*n*)	Authors	No (=*n*)	Authors
Research Concerning Technical Variables				
Are the variables analysed fully defined?	9	Harris & Reilly (1988); Gerisch & Reichelt (1993); James et al. (2002); Ensum et al. (2004); James et al. (2004); Jones et al. (2004); Lago & Martin (2007); Redwood-Brown (2008); Lago (2009)	35	Church & Hughes (1987); Hughes et al. (1988); Olsen (1988); Pollard et al. (1988); Jinshan et al. (1993); Lanham (1993); Luhtanen (1993); Yamanaka et al. (1993); Garganta et al. (1997); Pollard & Reep (1997); Yamanaka et al. (1997); Luhtanen et al. (2001); Hughes & Wells (2002); Tenga & Larsen (2003); Hughes & Churchill (2005); Scoulding et al. (2004); Taylor et al. (2004); Hughes & Franks (2005); Konstadinidou & Tsigilis (2005); Taylor et al. (2005); Tucker et al. (2005); Seabra & Dantas (2006); Yiannakos & Armatas (2006); Armatas et al. (2007); Lago (2007); Cullinane (2009); De Baranda et al. (2008); Szczepanski (2008); Taylor et al. (2008); Boscá et al. (2009); Tenga et al. (2009); Johnson & Murphy (2010); Lago-Peñas et al. (2010); Tenga, Holme et al. (2010); Tenga, Ronglan et al. (2010)
Are the variables partially defined? (i.e. descriptions of variables are provided but potentially ambiguous & undefined terms are used, i.e. a pass, a centre or fast moving attack)	16	Church & Hughes (1987); Olsen (1988); Pollard et al. (1988); Luhtanen (1993); Garganta et al. (1997); Pollard & Reep (1997); Tenga & Larsen (2003); Scoulding et al. (2004); Hughes & Franks (2005); Konstadinidou & Tsigilis (2005); Seabra & Dantas (2006); De Baranda et al. (2008); Tenga et al. (2009); Johnson & Murphy (2010); Tenga, Holme et al. (2010); Tenga, Ronglan et al. (2010)	28	Harris & Reilly (1988); Hughes et al. (1988); Gerisch & Reichelt (1993); Jinshan et al. (1993); Lanham (1993); Yamanaka et al. (1993); Yamanaka et al. (1997); Luhtanen et al. (2001); Hughes & Wells (2002); James et al. (2002); Ensum et al. (2004); Hughes & Churchill (2005); James et al. (2004); Jones et al. (2004); Taylor et al. (2004); Taylor et al. (2005); Tucker et al. (2005); Yiannakos & Armatas (2006); Armatas et al. (2007); Lago (2007); Lago & Martin (2007); Cullinane (2009); Redwood-Brown (2008); Szczepanski (2008); Taylor et al. (2008); Boscá et al. (2009); Lago (2009); Lago-Peñas et al. (2010)
Reference made to development of definitions but not published?	4	Taylor et al. (2004); Taylor et al. (2005); Tucker et al. (2005); Taylor et al. (2008)	40	Church & Hughes (1987); Harris & Reilly (1988); Hughes et al. (1988); Olsen (1988); Pollard et al. (1988); Gerisch & Reichelt (1993); Jinshan et al. (1993); Lanham (1993); Luhtanen (1993); Yamanaka et al. (1993); Garganta et al. (1997); Pollard & Reep (1997); Yamanaka et al. (1997); Luhtanen et al. (2001); Hughes & Wells (2002); James et al. (2002); Tenga & Larsen (2003); Ensum et al. (2004); Hughes & Churchill (2005); James et al. (2004); Jones et al. (2004); Scoulding et al. (2005); Hughes & Franks (2005); Konstadinidou & Tsigilis (2005); Seabra & Dantas (2006); Yiannakos & Armatas (2006); Armatas et al. (2007); Lago (2007); Lago & Martin (2007); Cullinane (2009); De Baranda et al. (2008); Redwood-Brown (2008); Szczepanski (2008); Boscá et al. (2009); Lago (2009); Tenga et al. (2009); Johnson & Murphy (2010); Lago-Peñas et al. (2010); Tenga, Holme et al. (2010); Tenga, Ronglan et al. (2010)
Insufficient definitions provided?	14	Hughes et al. (1988); Jinshan et al. (1993); Lanham (1993); Yamanaka et al. (1993); Yamanaka et al. (1997); Luhtanen et al. (2001); Hughes & Wells	30	Church & Hughes (1987); Harris & Reilly (1988); Olsen (1988); Pollard et al. (1988); Gerisch & Reichelt (1993); Luhtanen (1993); Garganta et al. (1997); Pollard & Reep (1997); James et al. (2002);

(*continued*)

Table IV. (*Continued*).

Context	Yes (=*n*)	Authors	No (=*n*)	Authors
		(2002); Hughes & Churchill (2005); Yiannakos & Armatas (2006); Lago (2007); Cullinane (2009); Szczepanski (2008); Boscá et al. (2009); Lago-Peñas et al. (2010)		Tenga & Larsen (2003); Ensum et al. (2004); James et al. (2004); Jones et al. (2004); Scoulding et al. (2004); Taylor et al. (2004); Hughes & Franks (2005); Konstadinidou & Tsigilis (2005); Taylor et al. (2005); Tucker et al. (2005); Seabra & Dantas (2006); Lago & Martin (2007); De Baranda et al. (2008); Redwood-Brown (2008); Taylor et al. (2008); Lago (2009); Tenga et al. (2009); Johnson & Murphy (2010); Tenga, Holme et al. (2010); Tenga, Ronglan et al. (2010)
N/A (i.e. goal does not require definition)	1	Armatas et al. (2007)	43	Church & Hughes (1987); Harris & Reilly (1988); Hughes et al. (1988); Olsen (1988); Pollard et al. (1988); Gerisch & Reichelt (1993); Jinshan et al. (1993); Lanham (1993); Luhtanen (1993); Yamanaka et al. (1993); Garganta et al. (1997); Pollard & Reep (1997); Yamanaka et al. (1997); Luhtanen et al. (2001); Hughes & Wells (2002); James et al. (2002); Tenga & Larsen (2003); Ensum et al. (2004); Hughes & Churchill (2005); James et al. (2004); Jones et al. (2004); Scoulding et al. (2004); Taylor et al. (2004); Hughes & Franks (2005); Konstadinidou & Tsigilis (2005); Taylor et al. (2005); Tucker et al. (2005); Seabra & Dantas (2006); Yiannakos & Armatas (2006); Armatas et al. (2007); Lago (2007); Lago & Martin (2007); Cullinane (2009); De Baranda et al. (2008); Redwood-Brown (2008); Szczepanski (2008); Taylor et al. (2008); Boscá et al. (2009); Lago (2009); Tenga et al. (2009); Johnson & Murphy (2010); Lago-Peñas et al. (2010); Tenga, Holme et al. (2010); Tenga, Ronglan et al. (2010)
Research Concerning Physical Variables				
Are the categories analysed fully defined? (i.e. specific criteria/speeds provided for each activity category)	11	Ohashi et al. (1988); Erdmann (1993); Di Salvo et al. (2007); Rampinini et al. (2007); Di Salvo et al. (2009); Lago-Peñas et al. (2009); Carling (2010); Carling & Bloomfield (2010); Carling et al. (2010); Clark (2010); Gregson et al. (2010)	5	Asami et al. (1988); Yamanaka et al. (1988); O'Donoghue (2002); Kan et al. (2004); O'Donoghue et al. (2005)
1 Category used? (excl. overall total distance)	3	Ohashi et al. (1988); Erdmann (1993); Kan et al. (2004)	13	Asami et al. (1988); Yamanaka et al. (1988); O'Donoghue (2002); O'Donoghue et al. (2005); Di Salvo et al. (2007); Rampinini et al. (2007); Di Salvo et al. (2009); Lago-Peñas et al. (2009); Carling (2010); Carling & Bloomfield (2010); Carling et al. (2010); Clark (2010); Gregson et al. (2010)
2 Categories/variables used? (excl. overall total distance)	2	O'Donoghue (2002); O'Donoghue et al. (2005)	14	Asami et al. (1988); Ohashi et al. (1988); Yamanaka et al. (1988); Erdmann (1993); Kan et al. (2004); Di Salvo et al. (2007); Rampinini et al. (2007); Di Salvo et al. (2009); Lago-Peñas et al. (2009); Carling (2010); Carling & Bloomfield (2010); Carling et al. (2010); Clark (2010); Gregson et al. (2010)

(*continued*)

Table IV. (*Continued*).

Context	Yes (=*n*)	Authors	No (=*n*)	Authors
3 Categories/variables used? (excl. overall total distance)	0		16	Asami et al. (1988); Ohashi et al. (1988); Yamanaka et al. (1988); Erdmann (1993); O'Donoghue (2002); Kan et al. (2004); O'Donoghue et al. (2005); Di Salvo et al. (2007); Rampinini et al. (2007); Di Salvo et al. (2009); Lago-Peñas et al. (2009); Carling (2010); Carling & Bloomfield (2010); Carling et al. (2010); Clark (2010); Gregson et al. (2010)
4 Categories/variables used? (excl. overall total distance)	3	Asami et al. (1988); Rampinini et al. (2007); Carling (2010)	13	Ohashi et al. (1988); Yamanaka et al. (1988); Erdmann (1993); O'Donoghue (2002); Kan et al. (2004); O'Donoghue et al. (2005); Di Salvo et al. (2007); Di Salvo et al. (2009); Lago-Peñas et al. (2009); Carling & Bloomfield (2010); Carling et al. (2010); Clark (2010); Gregson et al. (2010)
5 Categories/variables used? (excl. overall total distance)	5	Yamanaka et al. (1988); Di Salvo et al. (2007); Lago-Peñas et al. (2009); Carling & Bloomfield (2010); Carling et al. (2010)	11	Asami et al. (1988); Ohashi et al. (1988); Erdmann (1993); O'Donoghue (2002); Kan et al. (2004); O'Donoghue et al. (2005); Rampinini et al. (2007); Di Salvo et al. (2009); Carling (2010); Clark (2010); Gregson et al. (2010)
6 Categories/variables used? (excl. overall total distance)	2	Di Salvo et al. (2009); Gregson et al. (2010)	14	Asami et al. (1988); Ohashi et al. (1988); Yamanaka et al. (1988); Erdmann (1993); O'Donoghue (2002); Kan et al. (2004); O'Donoghue et al. (2005); Di Salvo et al. (2007); Rampinini et al. (2007); Lago-Peñas et al. (2009); Carling (2010); Carling & Bloomfield (2010); Carling et al. (2010); Clark (2010)
7 Categories/variables used? (excl. overall total distance)	1	Clark (2010);	15	Asami et al. (1988); Ohashi et al. (1988); Yamanaka et al. (1988); Erdmann (1993); O'Donoghue (2002); Kan et al. (2004); O'Donoghue et al. (2005); Di Salvo et al. (2007); Rampinini et al. (2007); Di Salvo et al. (2009); Lago-Peñas et al. (2009); Carling (2010); Carling & Bloomfield (2010); Carling et al. (2010); Gregson et al. (2010)
Are ProZone thresholds adopted?	4	Di Salvo et al. (2007); Rampinini et al. (2007); Di Salvo et al. (2009); Gregson et al. (2010)	12	Asami et al. (1988); Ohashi et al. (1988); Yamanaka et al. (1988); Erdmann (1993); O'Donoghue (2002); Kan et al. (2004); O'Donoghue et al. (2005); Lago-Peñas et al. (2009); Carling (2010); Carling & Bloomfield (2010); Carling et al. (2010); Clark (2010)
Are Amisco thresholds adopted?	4	Lago-Peñas et al. (2009); Carling (2010); Carling & Bloomfield (2010); Carling et al. (2010)	12	Asami et al. (1988); Ohashi et al. (1988); Yamanaka et al. (1988); Erdmann (1993); O'Donoghue (2002); Kan et al. (2004); O'Donoghue et al. (2005); Di Salvo et al. (2007); Rampinini et al. (2007); Di Salvo et al. (2009); Clark (2010); Gregson et al. (2010)
Are independent thresholds adopted?	8	Asami et al. (1988); Ohashi et al. (1988); Yamanaka et al. (1988); Erdmann (1993); O'Donoghue (2002); Kan et al. (2004); O'Donoghue et al. (2005); Clark (2010)	8	Di Salvo et al. (2007); Rampinini et al. (2007); Di Salvo et al. (2009); Lago-Peñas et al. (2009); Carling (2010); Carling & Bloomfield (2010); Carling et al. (2010); Gregson et al. (2010)

Table V. A summary of variables suggested to influence success in football.

Context	Yes (=*n*)	Authors
Research Concerning Technical Variables		
ATTACKING TOTAL	**48**	
- Effective/Organised offensive play	2	Yiannakos & Armatas (2006); Boscá et al. (2009)
- Converting shots to goals	2	Luhtanen (1993); Hughes & Churchill (2005)
- Shots on goal	3	Church & Hughes (1987); Lago (2007); Lago-Peñas et al. (2010)
Shooting with instep	1	Jinshan et al. (1993)
- Shots within 16 m	1	Olsen (1988)
- 1st time shots	1	Olsen (1988)
- Creating high quality chances	1	Ensum et al. (2004)
- Long passing	3	Hughes & Franks (2005); Yiannakos & Armatas (2006); Johnson & Murphy (2010)
- Short passing	1	Konstadinidou & Tsigilis (2005)
- Shooting/Attacking from central areas	2	Hughes et al. (1988); Konstadinidou & Tsigilis (2005)
- Passing	3	Luhtanen et al. (2001); Tenga & Larsen (2003); Redwood-Brown (2008)
- Passes in offensive areas	1	Yamanaka et al. (1997)
- Counter Attacks	3	Yiannakos & Armatas (2006); Tenga, Holme et al. (2010); Tenga, Ronglan et al. (2010)
- Crosses (for & against)	2	Ensum et al. (2004); Lago-Peñas et al. (2010)
- Possession	5	Church & Hughes (1987); Lanham (1993); Hughes & Churchill (2004); Lago & Martin (2007); Lago-Peñas et al. (2010)
- Length of individual possessions (long)	3	Hughes et al. (1988); James et al. (2004); Jones et al. (2004)
- Short passing sequences	3	Olsen (1988); Pollard et al. (1988); Garganta et al. (1997)
- Limited players involved in build up	1	Garganta et al. (1997)
- Players receiving ball in opposing penalty box	2	Yiannakos & Armatas (2006); Szczepanski (2008)
- Runs with ball/one on ones	3	Gerisch & Reichelt (1993); Yamanaka et al. (1997); Luhtanen et al. (2001)
- Effective Set Plays	3	Jinshan et al. (1993); Konstadinidou & Tsigilis (2005); Yiannakos & Armatas (2006)
- Effective penalty taking from an even run up (4, 5 or 6 paces taken) or hit with 100% power & with accuracy	1	Hughes & Wells (2002)
- Creating space	1	Harris & Reilly (1988)
OTHER TOTAL	**8**	
- Venue	5	Tucker et al. (2005); Lago & Martin (2007); Taylor et al. (2008); Lago (2009); Lago-Peñas et al. (2010)
- Opposition	2	Taylor et al. (2008); Lago (2009)
- Work rate	1	Harris & Reilly (1988)
DEFENDING TOTAL	**6**	
- Effective/balanced defensive play	2	Boscá et al. (2009); Tenga, Holme et al. (2010)
- Pressing players in & around box	2	Harris & Reilly (1988); Szczepanski (2008)
- Tackling	1	Luhtanen et al. (2001)
- Regaining possession in own final 1/3	1	Garganta et al. (1997)
N/A	**10**	Yamanaka et al. (1993); Pollard & Reep (1997); James et al. (2002); Taylor et al. (2004); Taylor et al. (2005); Seabra & Dantas (2006); Armatas et al. (2007); Cullinane (2009); De Baranda et al. (2008); Tenga et al. (2009)
No Differences	1	
- Passing	1	Scoulding et al. (2004)

classifications but set different thresholds to represent high intensity activity thus offering different data. For example, from the physical articles reviewed four utilised ProZone thresholds (Di Salvo et al., 2007; Di Salvo et al., 2009; Gregson et al., 2010; Rampinini et al., 2007), four adopted Amisco's thresholds (Carling, 2010; Carling & Bloomfield, 2010; Carling et al., 2010; Lago-Peñas et al., 2009) and eight articles adopted their own thresholds independent of both ProZone and Amisco (Asami et al., 1988; Clark, 2010; Erdmann, 1993; Kan et al., 2004; O'Donoghue, 2002; O'Donoghue et al., 2005; Ohashi, Togari, Isokawa, & Suzuki, 1988; Yamanaka et al., 1988).

Weston, Castagna, Impellizzeri, Rampinini, and Abt (2007) observed that ''substantial differences in the methodologies the authors used to classify HIR (high intensity running) made direct comparisons between the results of the present study and those previously reported within the literature impossible'' (p. 395). Contemporary research does adopt stringent thresholds to represent high intensity activity, but dissimilarities between the thresholds contribute to difficulty when attempting to transfer and compare different data sets. For example, Carling and Bloomfield (2010) and Carling et al. (2010) set five detailed classifications to investigate the work rate of substitutes and the effect of an early dismissal on player work rate. However, Carling (2010) changed to four classifications instead of five when investigating the activity profiles of players when running with the ball, having combined both high intensity running and sprinting despite ''running with the ball showed that actions are most commonly undertaken at high running speeds'' (p. 324), inevitably losing some sensitivity to the upper levels of activity profiles, i.e. high intensity running and sprinting as opposed to them both combined (see Table IV).

In summary, the review demonstrates methodological concerns relating to sample sizes, a lack of operational definitions, and conflicting classifications of activity that appear to lack consideration and specific detail (see Table IV). It is proposed that for future research to be more comparable and replicable, authors should consider including comprehensive operational definitions, which explain the variable(s) under investigation more clearly. In addition, research investigating the physical aspects of football performance especially, should seek to establish comparable thresholds that are utilised to assess physical performance in order to enhance our knowledge and allow meaningful comparison across studies.

Utility of research findings

In discussing the implicit assumptions underpinning PA research there seems to be a lack of conceptual clarity about the nature of the science undertaken. While, the majority of the studies reviewed could be considered 'basic research' in that they discover new knowledge and information about performance, the evidence from the review suggests they often infer applied conclusions from their results. Basic science should not be seen as simplistic, and/or of less value and has significant a role to play. However, developing new knowledge rather than re-examining the same variables would appear to be the most fruitful way to develop the field. Moreover, re-examining basic variables of performance has arguably produced research that has reflected common sense footballing 'truisms' rather than genuinely furthering our understanding of football performance, which is complex and dependent on a number of variables including chance. Attempting to identify 'key' aspects of play seems so far to have had limited success.

For example, from the 44 technical articles reviewed, authors' have proposed 23 different 'key' aspects of attacking play that influence 'success' in football (see Table V). The most frequently cited variable is possession, yet it is only cited by 5/44 authors' (11%). This demonstrates the multifaceted nature of successful football performance and that a combination of all variables contributes to success. Moreover, authors' have attributed success to other extraneous factors such as; match venue (five citations), or the quality of the opposition (two citations) (see Table V). Four aspects of defending play were proposed to influence 'success' in football such as; balanced defensive play (two citations), pressing players in and around the box (two citations), tackling (one citation), and regaining possession in own final third (one citation). To illustrate this Lago-Peñas et al. (2010) found that a team's total shots, shots on goal, crosses, crosses against, ball possession and the venue that they were playing at discriminated between whether a team won, drew or lost. Similarly, Tenga, Ronglan, and Bahr (2010) found that the number of times a team was able to successfully put the ball into the penalty box ''can be used as a proxy scored when comparing the effectiveness of different playing tactics in soccer'' (p. 269). Moreover, it was found in a secondary study using the same data set that teams playing against balanced defences yielded less 'score box' opportunities than those playing against an imbalanced defence (Tenga, Holme et al., 2010) – see Table V. It was also found that ''there were too few goals scored against a balanced defence for a meaningful analysis to be done'' (p.253).

This is not a recent issue (see Table V), as findings such as ''successful teams were more able to convert shots to goals from most aspects of play'' (Hughes & Churchill, 2005, p. 505) or ''the study supports previous research that suggests corners occur frequently and provide an opportunity to score ''(Taylor, Mellalieu, & James, 2004, p.519), demonstrate something of a lack of evolution in the research base, and are a direct reflection of the descriptive methods implemented and the types of variables analysed. This trend has also continued in more recent, statistical based research that has concluded ''putting an attacking player (pressed or not) on the ball in the penalty box should be the aim of any team'' (Szczepanski, 2008, p.61). Overall, as these examples illustrate, the research has produced arguably predictable findings and multiple references to what

would be for coaches' well established and commonly accepted 'principles of play'. Therefore we could question, how much does this research actually further our understanding of performance?

Implications for practice

It would appear that there is a genuine need to broaden research undertaken in the name of PA from both a basic and an applied science perspective in order to impact practice. Nash and Collins (2006) argue that coaches make intuitive decisions based often on tacit knowledge. This knowledge is developed by football coaches, often from extensive playing careers, who may view common sense findings such as these with cynicism and irony, which offer little to inform their practice. Subsequently, the knowledge and understanding generated by basic science needs to align with the requirements and demands of its consumers (Bishop, 2008). Therefore, the relationship between research and practice, and researchers and practitioners needs to be developed. Indeed, PA practice and coaching informed by and informing research is worthy of further discussion.

Hayes (1997), over a decade ago, argued ''show me the results of notational analysis, not the notational analysis results'' (p. 4), suggesting descriptive and correlative approaches to investigating dynamic, interactive and uncontrollable phenomenon such as performance is insufficient. Concerns have also been raised as to whether current notational analysis approaches to investigating performance related variables are the most effective way to differentiate between successful and unsuccessful performance (Borrie & Jones, 1998; Borrie et al., 2002). Patton (2002) is also sceptical of objective approaches such as notational analysis as he suggested that ''numbers do not protect against bias, they merely disguise it. All statistical data are based on someone's definition of what to measure and how to measure it'', as this review has demonstrated an ''objective statistic is really made up of very subjective decisions'' (p. 574).

The evidence from the review suggests that if research is to continue in this vein, the potential for significantly enhancing our knowledge and understanding of football performance appears limited. Therefore, it is suggested that researchers engaging in this type of research consider adopting more rigorous approaches when designing studies (see Figure 1.) Specifically researchers should address:

1. The nature of the competition that is to be investigated
2. Providing statistical justification for the sample size
3. Context to the sample used (i.e. location, period of season, opposition faced etc.).
4. Comprehensive and published operational definitions for the variable(s) under investigation and ensure specific contextual information is included.
5. When researching the physical aspects of football performance, giving consideration to previous research in order to better inform the

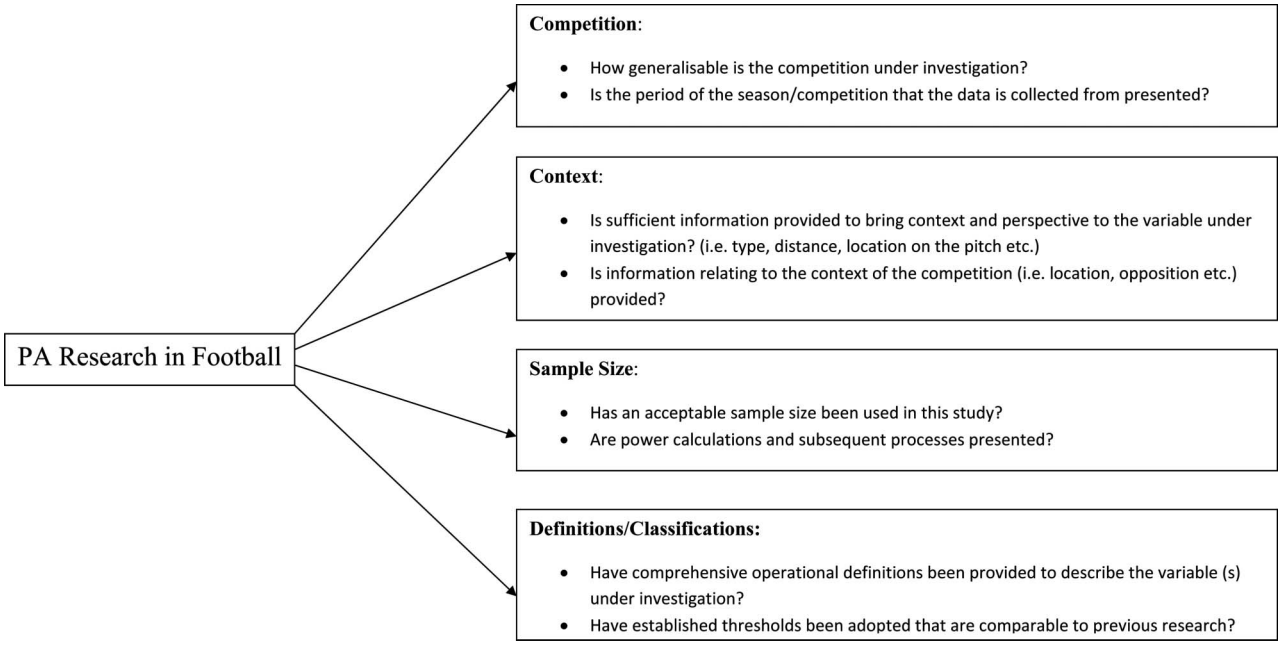

Figure 1. Performance analysis research in football checklist.

thresholds adopted to ensure research that is comparable.

The review has highlighted gaps and issues with existing PA research and identified guidelines to inform future research. There is also an acknowledgement of the paucity of research directed toward applied PA work. We would also suggest a shift in the direction of PA research is warranted. PA as an evaluative feedback tool has arguably received little research attention, as research attempting to describe and predict performance variables have taken precedence. With this in mind, our understanding of the intricacies and dynamics relating to PA as a form of feedback is limited largely due to the lack of research devoted to it. Similarly, there is a surprising paucity of research that has addressed the effectiveness and/or delivery of PA in applied settings leaving much of its purpose and impact unknown (Groom et al., 2011). Subsequently, future research adopting an alternative approach could attempt to bridge the current gaps between the descriptive analysis of performance, the dissemination of analysis information to athletes and its subsequent impact on their learning and performance. If an applied science approach were adopted (Funtowicz & Ravetz, 1993), in that researchers engaged with applied practitioners to establish common issues for research attention, then the potential to positively impact professional practice could be enhanced. Conducting future research in this way would also undoubtedly increase our understanding of the impact that PA has in applied contexts as it addresses the neglected 'analysis – learning-performance' link.

An alternative approach for PA research: Feedback, learning and context

The primary function of video-based performance analysis feedback is to provide information to individuals involved in sporting performances to modify behaviour and improve understanding (Court, 2004; Groom et al., 2011). If an individual is able to retain information effectively and positively affect their future behaviour, performance levels will be impacted. Subsequently, the current research focus on investigating 'predictive' and 'performance-controlling' variables could be broadened. Alternative approaches include both researchers and practitioners attempting to understand what and how coaches and athletes are learning by reviewing performance-analysis information to make sense of their experiences in competition. Therefore, it would appear that the learning processes coaches and players engage in during and post PA exposure are of significant interest and warrant investigation. Despite recent research suggesting that this is an area of importance for practitioners (see Groom & Cushion, 2004, 2005; Groom et al. 2011), little research has investigated PA from a learning perspective.

It is generally accepted that learning in sporting scenarios is largely a result of experience (e.g. Cushion, Armour, & Jones, 2003; Nash, Sproule, & Horton, 2008; O'Bryant, O'Sullivan, & Raudesky, 2000). For athletes playing the game, in training or match play scenarios, is a form of athletic experience, and yet despite often capturing and analysing performance, PA research has not addressed how elite athletic experience may inform performance expertise (Gilbert & Trudel, 1999). Typically, it is argued that PA should inform 'feedback', however Sharp (1992) suggests that feedback may only be advantageous if the individual understands what has been delivered, and is able to interpret the information correctly. Representing learning from PA as the provision of 'feedback' over simplifies the process which is tied to the construction of meaning, and interaction with complex and interchanging environmental and social inter-dependencies (Cushion et al., 2010). Understanding learning in relation to PA requires a consideration of the learners and the world they inhabit and internalise.

Of the few learning models that have been applied to sport, Schön's (1983) Experiential Learning Theory (ELT) has been proposed as a tool to understand and structure experiential learning to develop domain-specific knowledge in the context of professional practice (Gilbert & Trudel, 2001, 2004). Learning occurs through reflection triggered by practical dilemmas that occur and is governed by a role frame, an individual's frame of reference that is formulated on experiences and perceptions. Role frames will impact coach and athlete attitudes and perception towards PA, as well as impact the way athletes respond to PA sessions. This means that a 'one size fits all approach' to PA will be limited as assumptions about performance information and the use of that information will differ. Some research has examined reflection as a by-product of PA video feedback (Groom & Cushion, 2004, 2005), although there has been no explicit investigation into PA video feedback from a learning perspective. Therefore, the typical way in which PA information is disseminated to athletes i.e. video sessions (Groom & Cushion, 2004) appears to warrant further investigation. Similarly, future research could consider the assumptions of coaches and athletes in the use and delivery of PA given the impact it may have on the process. It is suggested that increased dialogue between scientists and coaches is required in order to design research methodologies that are able to advance our understanding whilst also yielding applicable findings. A widening of data collection methodologies (Denzin & Lincoln, 2000) to include

more naturalistic and qualitative methods such as case studies, ethnography, interviews and mixed methods approaches (Nelson & Groom, 2011) may also be beneficial in developing new knowledge and understanding.

In addition, the dissemination of information in football is a situated activity (Christensen, Norgaard Laursen, & Sorensen, 2010) and is influenced by both social and cultural factors. Despite the recognised socio-cultural influences involved in professional practice in sport (e.g. coaching and delivery philosophy, recipient qualities, session design and delivery process – see Groom et al., 2011) and the unique cultural characteristics inherent within football (Cushion & Jones, 2006; Nesti & Littlewood, 2011; Roderick, 2006), PA research appears to have largely ignored these influences. Again, this offers opportunities to develop PA research investigated from the context of the environment in which it is delivered thus understanding how PA impacts learning embedded within a socio-cultural context.

Conclusion

The aim of this paper was to critically review PA research undertaken in football and propose an alternative research perspective to expand the conceptual base as well as our knowledge and understanding of PA. The review has raised methodological concerns in relation to the current positivist and key performance indicator driven research that has focussed on attempting to predict successful future performance, despite the inherent problems associated with investigating a multifaceted and often uncontrollable phenomenon. The evidence suggests that researchers should consider providing stronger rationales for conducting their research, illustrating its value, and its potential to further our understanding of performance and impact professional practice. In addition, the field should consider both more challenging and discerning approaches if it is to continue to progress. At the same time, an alternative perspective is proposed, the beginnings of which can be seen in the work of Groom et al. (2011), in which inherent cultural and social influences are considered along with the learning experience that individuals encounter following exposure to PA in an applied context. Finally, given the paucity of literature acknowledging PA as a social process given its integral role in the coaching process (Carling et al., 2005), considering the notion of PA as a tool for learning may provide researchers with a more critical perspective of the PA field and encourage a broadening of the PA research agenda. It is suggested that such an approach will lead to a greater understanding of the discipline and more meaningful impact upon professional practice.

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Appendix 1

Table VI. Summary of "technical" performance analysis in football journal articles that were reviewed.

Date	Author (s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
2010	Tenga, Ronglan et al.	European Journal of Sport Science	Scoring opportunities & score box possessions in relation to goals scored	163 Norwegian elite soccer games during 2004 season	Yes (although a pass is not defined in isolation but is heavily involved in the authors' definitions)	Game location was factored into their random sample but no reference is made to location of games or quality of opposition in their results.	Multiple logistic regression analyses showed very similar results when comparing the effectiveness of different offensive tactics, regardless of which outcome was used. Counterattacks were more effective than elaborate attacks in producing goals, scoring opportunities and score box possession. Scoring opportunities and score box possessions (shooting opportunities) can be used as a proxy for goals scored when comparing the effectiveness of different playing tactics in soccer.
2010	Tenga, Holme et al.	Journal of Sports Sciences	Playing tactics on achieving score-box possessions	163 Norwegian elite soccer games during 2004 season	Yes (although a pass is not defined in isolation but is heavily involved in the authors' definitions)	Game location was factored into their random sample but not reference is made to location of games or quality of opposition in their results.	Offensive tactics were more effective in producing score-box possessions when playing against an imbalanced defence than against a balanced defence. Multiple logistic regression found that, for the main variable "team possession type", counterattacks were more effective than elaborate attacks when playing against an imbalanced defence but not against a balanced defence.
2010	Johnson & Murphy	Journal of Science & Medicine in Sport	Passing prior to goals scored	All 84 games from 2007/08 Hyundai A-League games (220 goals)	Short or long passing sequences are defined but no definition as to what a pass constitutes is presented	All games grouped together (no location, success of teams, opposition related information)	Longer passing sequences are a more efficient way of scoring goals compared to shorter passing sequences in elite Australian football.
2010	Lago-Peñas et al.	Journal of Sports Science & Medicine	Game-related statistics in relation to result (total shots, shots on goal, effectiveness, assists, crosses, offsides committed and received, corners, ball possession, crosses against, fouls committed and received, corners against, yellow and red cards, and venue	380 games from 2008/09 Spanish Season	Variables are grouped but no definitions are provided	Location was considered, as was the overall result but no information relating to opposition was provided.	The variables that discriminate between winning, drawing and losing teams were the total shots, shots on goal, crosses, crosses against, ball possession and venue.
2009	Boscá et al.	Omega	Offensive and defensive efficiency	All games from 2000/01, 2001/02 and 2002/03 season of Spanish and Italian leagues	A discussion relating to the applicability of the variables used is presented but definitions are not.	Home and away games are considered in the context of the results in relation to league finish.	The Spanish league is more competitive than the Italian league. Defensive efficiency rather than offensive efficiency is most important in the Italian league; the best attack has the best defence. In the Spanish league,

(*continued*)

Table VI. (*Continued*).

Date	Author (s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
							the best league positions were achieved by teams who had offensive efficiency both at home and away from home.
2009	Lago	Journal of Sports Sciences	Possession strategies of one Professional Spanish football team (Espanyol) in relation to match location/ opposition/match status	27 matches from 2005/06 season (17 home and 10 away)	Possession was defined.	Match status, opposition and venue were accounted for as was a background to the team in question.	Possession of the ball was greater when losing than when winning or drawing, and playing against strong opposition was associated with a decrease in time spent in possession. Mean percentage time spent in different zones of the pitch (defensive third, middle third and attacking third) was influenced by match status and match location.
2009	Tenga et al.	International Journal of Performance Analysis in Sport	22 multidimensional categorical variables	200 team possessions from 163 Norwegian Professional League games	Yes (although technical variables within the categories such as "passing", i.e. what a pass is specifically, are not defined)	No information relating to venue or opposition is provided in the analysis although pitch zones are considered in the analysis.	Most of the categorical data recorded in this study are a reliable method to characterise team match performance.
2009	Cullinane	3rd International Workshop of the International Society of Performance Analysis of Sport	Analysis of technical variables in relation to position	18 games from 2007/08 season involving 3 times (Arsenal/Liverpool/ Newcastle)	No	No information was provided as to whether they were playing at home/away or the opposition they faced.	Contributions of performance indicators can be associated with positional roles. Arsenal demonstrated the highest team mean execution scores for all variables except shooting, and consistently higher mean positional scores across performance indicators associated to positional role.
2008	De Baranda et al.	European Journal of Sports Science	Goalkeeping performance variables (such as body part with which last part of attack or shot was made, zone of goalkeeper intervention, defensive technical and physical actions of goalkeeper intervention)	34 goalkeepers from 54 matches in 2002 FIFA World Cup	The variables are listed and described but are not all defined specifically (i.e. counter attack).	No differentiation between group or knock-out games is provided. No links are made to effective goalkeeping or the results of the games that GKs played in/in relation to GK behaviour.	The foot was the body part most often used to finish an attack. Most shots came from central zones. Most goalkeepers' defences came in the penalty area and the defensive actions most frequently used were the save, followed by foot control, and then the clear out.
2008	Redwood-Brown	International Journal of Performance Analysis in Sport	Passing patterns before and after goals scored/conceded	285 goals from 120 EPL games in 2004/05 season	Yes	No information relating to venue, opposition, location of passes on pitch or length of pass	Preceding goals the scoring team played a significantly greater % of passes than the average for the half, while the conceding team played significantly less. After scoring goals, scoring teams played less passes and had less pass success rate.
2008	Szczepanski	International Journal of Performance Analysis in Sport	Technical variables preceding shots at goal	4730 actions from 4 International games for the Polish national team	No	Opposition are named but no information relating to venue or type of fixture (e.g.	Pressed players in and around the penalty area are less dangerous than those with time on the ball. Teams

(*continued*)

Table VI. (*Continued*).

Date	Author (s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
						friendly or tournament qualifier)	should not put their own goalkeepers under pressure and the aim of attacking play should be to get attackers on the ball in the penalty box. Variables that are investigated should be zone specific and be directly linked to goals, or goal scoring opportunities.
2008	Taylor et al.	Journal of Sports Sciences	Influence of match location, opposition & match status on technical performance	40 games of one professional football team during 2002/03 & 2003/04 seasons	Reference is made to the development of definitions in the research process but they are not published	Match status, opposition & venue were accounted for as was a background to the team in question	Log-linear modelling procedures indicated that the incidences of all on-the-ball technical behaviours, with the exception of "set-pieces", were influenced by at least one of the three situation variables, with both independent and interactive effects found. In contrast, logit modelling suggested that there was no general influence of the situation variables on the outcomes of the on-the-ball behaviours.
2007	Armatas et al.	International Journal of Performance Analysis in Sport	Time of goals scored	192 games across 1998, 2002 & 2006 FIFA World Cup Tournaments	N/A	All games included – no differentiation between group/knock-out games or quality of opposition	Statistically significant difference between goals scored in 1st half vs 2nd half at 1998/2002 World Cup (more in 2nd half) but not in 2006. No significant difference in 45/15 min analyses between the 3 World Cups.
2007	Lago	International Journal of Performance Analysis in Sport	Performance (shots on/off target) in relation to stage of competition and result	64 games from 2006 FIFA World Cup in Germany	No	League position in group stage is accounted for in analysis but FIFA World ranking or final position in World Cup competition is not referred to	Performance (shots on/off target) is a relevant variable to explain points attained in group stage, but in the knock-out stages performance is less important as there are no statistically significant differences between winners' and losers' performance.
2007	Lago & Martin	Journal of Sports Sciences	Possession in relation to match status, location, opposition (using Real Madrid as a reference) & identities of the team	170 matches of Spanish 2003/04 season	Possession is defined	Games were taken from first 17 days of season. Location, opposition and match status are included in the results.	Home teams have more possession than away teams, teams have more possession when they are losing matches than when winning or drawing, and the identity of the opponent matters – the worse the opponent, the greater the possession of the ball.
2006	Seabra & Dantas	International Journal of Performance Analysis in Sport	Zone of actions occurrence, Action (shot or pass) shot attempt result & team involved	112 shot attempts from 7 matches of Brazil & Germany in 2002 World Cup	SDO (Space of Defensive Occupation) sectors/zones are defined although technical variables, i.e. such	No differentiation is made between group or knock-out games and no reference is made to the specific	SDO is a reliable instrument capable of spatially characterising actions so as to point out differences in team performance.

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Table VI. (*Continued*).

Date	Author (s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
					as assist & reception were not defined. Successful/ unsuccessful shots were referred to but definitions are ambiguous.	opposition that Brazil/ Germany faced.	
2006	Yiannakos & Armatas	International Journal of Performance Analysis in Sport	Analysis of goals scored in relation to when scored, type of pass preceding the shot, set play, area shot from and type of attack scored from	32 games in Euro 2004 involving 16 different teams	No	All games grouped together = no differentiation between group games or knock out games and opposition team faced is not discussed	More goals scored in 1st half than 2nd half. An organised offence was the attacking style that yielded most goals followed by set plays and counter attacks. Long passes were the most effective pass preceding a goal, corners yielded the most set play goals and most goal attempts materialised in the penalty box.
2005	Hughes & Franks	Journal of Sports Sciences	Passing sequences prior to goals scored	52 matches from 1990 FIFA World Cup & 64 matches from 1994 FIFA World Cup	Passing sequences are described but no definition of a pass is provided.	The goal scoring profiles of successful and unsuccessful teams are published. No differentiation is made between group games, knock-out games or the quality of opposition faced.	More goals were scored from longer passing sequences than from shorter passing sequences. Teams produced significantly more shots per possession for these longer passing sequences, but the strike ratio of goals from shots is better for ''direct play'' than for ''possession play''. An analysis of the shooting data for successful and unsuccessful teams for different lengths of passing sequences in the 1990 FIFA World Cup finals indicated that, for successful teams, longer passing sequences produced more goals per possession than shorter passing sequences. For unsuccessful teams, neither tactic had a clear advantage.
2005	Konstadinidou & Tsigilis	International Journal of Performance Analysis in Sport	Teams' offensive play in relation to zone of scoring attempt, source of scoring attempt, ball possession & type of passes.	749 offensive phases from 20 games of the top four sides in the 1999 Women's World Cup	The variables are listed and described but are not defined.	No differentiation is made between group or knock-out games and no reference is made to the opposition that USA/Brazil/Norway/China faced.	Clear differences between playing styles across the four teams, with Norway being the most direct of the four teams. As champions, USA's scoring attempts were mainly executed from the central zones using combinations of small and medium passes with low possession and set plays.
2005	Taylor et al.	International Journal of Performance Analysis in Sport	13 technical variables (such as passes, shots on goal, tackles made etc.) both individually and as units in relation to zone on pitch	22 games of a British Professional team from the 2003/04 season	Reference is made to the development of definitions in the research process but they are not published.	No reference made to location of the games or the opposition faced but the team's strategy was reported	Overall team strategy showed an attacking bias through the right side of the pitch and a corresponding defensive weakness on the left. Similarities were also observed between the tactical behaviours of

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Table VI. (*Continued*).

Date	Author (s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
							individuals, their respective units and team strategy. Recommendations were made to use this methodology in order to assess individual and unit contributions to team performance in future.
2005	Tucker et al.	International Journal of Performance Analysis in Sport	12 technical variables and area on the pitch (tactical related behaviour) in relation to playing home or away	30 matches of a top 5 side from 2004/05 EPL season	Reference is made to the development of definitions in the research process but they are not published.	15 home and 15 away games analysed. No reference is made to the 8 games that have been omitted from the season in question and who they may have been against. No reference was made to quality of opposition in the 30 games.	Game location effects exist as home advantage was found as the team won more and scored more at homethan away. More successful technical behaviours such as tackles, passes and aerial challenges were made at home. More tactical behaviours such as aerial challenges, corners, crosses, passes, dribbles and shots on goal were made at home than when away.
2004	Ensum et al.	Journal of Sports Sciences (conference communication)	Probabilities of goal scoring from shots on goal	93 goals from 37 matches during 2002 FIFA World Cup	Yes	The authors make specific reference to the performance of semi-finals team.	Much of this study supported the work of Pollard and Reep (1997) However, for the 2002 sample, "distance" was half that of the 1986 sample (-0.113 compared to -0.219). Brazil's players created the best quality chances in the World Cup (their shots had a mean scoring probability of 13.5%, suggesting that they were the most adept at penetrating defences. Also, 8 of their 18 goals were created from crosses (which have been found to improve the chance of scoring).
2004	Hughes & Churchill	Journal of Sports Sciences (conference communication)	Attacking profiles (10 variables)	30 matches from 2001 Copa America (19 = successful, 11 = unsuccessful)	No	Apart from the team being successful/unsuccessful no information relating to opposition or stage of tournament is provided.	Successful teams were more able to convert shots to goals from most aspects of play. They could keep the ball for longer durations and create shots after possessions of over 20 s more frequently than unsuccessful teams.
2004	James et al.	Journal of Sports Sciences (conference communication)	Possession as a function of successful/unsuccessful teams	24 matches (12 of 3 unsuccessful teams/12 of 3 successful teams) from 2001/02 EPL season	A definition of possession is provided.	Reference is made to teams being judged as successful/ unsuccessful on league position but no reference to location of the matches or the opposition that they faced in the 12 matches	Successful and unsuccessful teams differed significantly in the duration of each individual possession. The length of each possession was related to match status as well as the success rate of the teams. Specifically, when drawing and losing games, successful

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Table VI. (*Continued*).

Date	Author (s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
							teams had a significantly higher mean length of possession compared with unsuccessful teams. No significant differences were found when the teams were winning. Additional analyses revealed that both successful and unsuccessful teams had a significantly higher mean length of possession when losing compared to when winning.
2004	Jones et al.	International Journal of Performance Analysis in Sport	Possession in relation to score line	24 matches (12 of 3 unsuccessful teams/12 of 3 successful teams) from 2001/02 EPL season	A definition of possession is provided.	Criteria for successful/ unsuccessful is provided but no reference to location of the matches or the opposition that they faced in the 12 matches	Successful teams had significantly longer possessions than unsuccessful teams irrespective of match status although both successful and unsuccessful teams had longer possessions when they were losing games compared to when winning.
2004	Scoulding et al.	International Journal of Performance Analysis in Sport	Passing	6 games in 2002 FIFA World Cup (3 successful/3 unsuccessful teams)	Information relating to whether it was a pass to feet or to space is provided but no definition of a pass is provided.	Group games were analysed with no reference to opposition or differences between the group games.	No significant differences between passing of successful or unsuccessful teams.
2004	Taylor et al.	International Journal of Performance Analysis in Sport	Frequency of 13 technical variables such as passing, shooting, dribbling, tackling etc. occurring in relation to position	22 games of one British Professional team during the 2002/03 season	Reference is made to the development of definitions in the research process but they are not published.	No reference made to the quality of the team in question.11 home and 11 away games in the sample but no reference is made to as to how this may have influenced the variables (i.e. any home or away differences). Opposition are not considered.	Significant differences in relation to frequencies of technical behaviours between positions although there were also some similarities. Players should be analysed on an individual basis as mean inter-positional averages mask the subtleties of individual performance.
2003	Tenga & Larsen	International Journal of Performance Analysis in Sport	Playing styles (analysis of 23 attacking & 18 defending variables)	1 game (Norway vs Brazil)	The term "attack" is defined and parameters/variables are listed with detail. No definitions for the terms used within the descriptions are provided though (i.e. "attacks moving fast")	No context to the type of game this was is presented (i.e. location, friendly/ tournament)	There were differences amongst Brazil & Norway's attacking play; Norway used more long passes & looked to attack quickly whereas Brazil took more touches on the ball & involved more passes in their attacking play. No differences between the teams' defensive play were reported
2002	Hughes & Wells	International Journal of Performance Analysis in Sport	Penalty taking success	129 penalties from FIFA World Cups & Champions League Finals	No definitions in relation to how they measured variables involved in the taking of a penalty are presented (i.e. the speed of the ball strike or the takers run up)	No information relating to the dates/time span ofthe competitions used are provided. Nodifferentiation between the two competitions is provided in	One in five penalties are saved, one in fifteen are missed and three in four are scored. Most effective penalties are from an even run up consisting of 4, 5 or 6 paces. No shots above waist height were saved, although 18%

(*continued*)

Table VI. (*Continued*).

Date	Author (s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
						the results & only England and Germany are referred to in relation to success levels.	were missed. The main difference between England and Germany's penalty taking ability was that Germany were able to maintain better accuracy when striking the ball at 100% power.
2002	James et al.	International Journal of Performance Analysis in Sport	Playing strategies (passing & ball entries in different areas of the pitch)	21 domestic & European games of a Professional British team during 2001/02 season	Yes (a pass is defined)	Information provided about the team in question's recent history. No reference made to results of the games that were analysed.	Attacking play occurred more frequently down the right hand side of the pitch in domestic compared to Europe. Variability was also observed between ball possession and passing difficulty made by individual players in each pitch area.
2001	Luhtanen et al.	International Journal of Performance Analysis in Sport	% completion of game performance variables such as passes, receiving, runs with the ball etc.	31 games from Euro 2000	No	Teams are named and ranked in relation to variables. No differentiation is made between group and knock-out games.	The variable; passing, was attributed as being the most performance determining variables as France was the best team in the performance activity of passes, receiving, runs with ball and tackles.
1997	Garganta et al.	Science & Football III	Goal scoring patterns	104 goals scored in 44 matches by 5 European teams (Barcelona, Bayern Munich, Milan, Paris SG & Porto)	Description of the features of play that were notated is provided but components such as passing/shot on target are not defined.	No information is provided as to the competition(s) the teams were playing in or the strength of the opposition or the match location.	Paris SG, Bayern Munich and Milan won the highest percentage of ball possessions in their attacking third. Porto had its highest percentage in the defensive third and Barcelona in the middle third.61 to 93% of the actions leading to goals came from movements with no more than 3 passes. In scoring movements, European top level teams often win the ball back in their attacking third, reveal a short attacking reaction time, involve few players touching the ball and perform only a few passes.
1997	Pollard & Reep	The Statistician	Measuring the effectiveness of playing strategies	22 matches from 1986 FIFA World Cup	Possession is defined and outcome measures are described but strategies such as long forward pass are not defined.	No differentiation made between stages of tournament, quality of teams in question (or differences between) or opposition faced.	Through the adoption of the authors' system it is suggested that the variable; yield, can be used to evaluate both the expected outcome of a team possession originating in a given situation, as well as the actual outcome of the possession. The effectiveness of different strategies occurring during the possession can be quantified and compared.
1997	Yamanaka et al.	Science & Football III	Playing patterns	8 games from Asian qualification for 1994	No	Area of passing on pitch was considered and context to	Japan used dribbling tactics more frequently than Saudi Arabia and

(*continued*)

Table VI. (*Continued*).

Date	Author (s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
				FIFA World Cup (5 included Japan)		the fixtures (i.e. venue and score etc.) were provided. It is not acknowledged that most of Japan's opponents' averages come from only 2 games whereas Japan's is derived from 5 games.	Korea, more passes than Saudi Arabia and tried clearing actions more frequently than did Iraq. Japan outnumbered Saudi Arabia, Iran and Korea with reference to passing in offensive areas. Japan passed the ball more frequently than Saudi Arabia and Iran but less frequently than Iraq. Japan need to establish flexible tactics in structuring its offence and defence.
1993	Gerisch & Reichelt	Science & Football II	One on one situations	2 European cup semi-final matches (Bayern Munich vs. Red Star Belgrade) but only one game is referred to	Yes	Individual players are referred to as are one on ones in relation to chances in the game, however no information is provided as to who the one on ones were directly against or the area of the pitch this was done in.	In the first game, both sides won half of the one to one situations they were engaged in (125; 125). Many subjective conclusions are drawn from individual performances during the game such as "the shortcomings of certain Bayern players were complemented by particularly strong performances by a number of Red Star Belgrade players. Midfielder Prosinecki's performance, generally acknowledged as being outstanding in this match, may serve as an example." (p. 172).
1993	Jinshan et al.	Science & Football II	Goals Scored	115 goals from the 52 games of the 1990 FIFA World Cup	No	Areas of the pitch are considered but no information is provided relating to the opposition faced or the stage of the competition.	Using the instep when shooting yielded most goals scored (28.7%) followed by the inside of the foot (24.4%). Most goals were scored from set plays (37 goals; 32.2% of goals). Most goals were scored in the 2nd half (77 goals; 66.9%)
1993	Lanham	Science & Football II	Number of possessions in relation to goals scored	479 games from 1981-1991	No definition of possession is provided	Differences between leagues are presented but averages of possessions prior to goals are taken from a game as a whole rather than specifically before a goal was actually scored. No differentiation is made between home or away games.	Across 479 matches the average number of all lost possessions taken between all teams in total is 181.62 possessions that have been lost and won back before a goal is scored.
1993	Luhtanen	Science & Football II	Offensive actions in final third	47 matches from 1990 FIFA World Cup	Description of the features of play that were notated is provided but components such as ''centres'' are not	No differentiation made between stages of tournament or opposition faced.	Germany were the strongest team in the World Cup as they had the highest number of attacking trials, the lowest number of lost attacks and the

(*continued*)

Table VI. (*Continued*).

Date	Author (s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
					defined.		highest number of scoring trials both with shots and headers.
1993	Yamanaka et al.	Science & Football II	Playing patterns	36 games of European ($n = 12$), British Isles ($n = 12$) and South America ($n = 12$) teams compared to Cameroon ($n = 4$)	No	Although no direct reference is made to information surrounding the games used, efforts were made to create a balanced sample in their method.	Overall teams from the British Isles used goal kicks and long forward passes more than teams in the other groups; they also showed a dominance in the air. European teams played short passes, runs and dribbles in order to reduce the risk of losing possession. South American teams had a higher ratio of shots to crosses with a higher % of crosses coming from the final sixth of the field. Cameroon exhibited similarities to the game patterns of South American teams more so than the European and British Isles' teams. The main differences were attributed to a more defensive emphasis to their game.
1988	Pollard et al.	Science & Football	Playing styles	10 games from 1982 FIFA World Cup & 22 games from the English 1st division during 1984/5 season	Attacking sequences/strategies are described but no definition of a pass is provided.	Specific teams are referred to, but no information as to who they played or the match venue is provided.	Many differences between the two data sets, with long goal clearances having the most marked difference. All World Cup teams were high for short possession play, with France and Brazil using this approach the most, with England and Poland using it the least.
1988	Olsen	Science & Football	Goal scoring strategies	132 goals from 52 games during 1986 FIFA World Cup	Descriptions of variables are provided but information such as a definition of a pass is not provided.	No differentiation made between stages of tournament or opposition faced.	Most goals are scored with one touch on the ball. Very few goals are scored after more than 3 touches of the ball. More than 90% of goals were scored from within a distance of 16 m. Few goals are scored from multi-pass moves; only about 20% of goals are preceded by 5 or more passes.
1988	Hughes et al.	Science & Football	Patterns of play	52 games from 1986 FIFA World Cup	No	Differentiations are made between successful (semi-finalists) and unsuccessful teams (eliminated at end of first round) although no reference is made to opposition faced or potential differences during different stages of the tournament.	Successful teams played significantly more touches of the ball per possession than unsuccessful teams. Unsuccessful teams ran with the ball and dribbled the ball in their own defensive area in different patterns to the successful teams. The latter played up the middle in their own half, the former used the wings more. This pattern was also reflected in the

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Table VI. (*Continued*).

Date	Author (s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
							passing of the ball. The successful teams approached the final sixth of the pitch by playing predominantly in the central areas while the unsuccessful teams played significantly more to the wings. Unsuccessful teams lost possession of the ball significantly more in the final one sixth of the playing area both in attack and defence.
1988	Harris & Reilly	Science & Football	Space, teamwork and attacking success	24 first class soccer matches	Yes	No information relating to quality of opposition, location or information relating to who the "first class" soccer teams were.	Both space and teamwork are important discriminators in relation to attacking success. Results emphasised that team members should concentrate on creating space when attacking and denying it when defending, supporting each other in attack and in defence, and trying to dispossess opponents while they are vulnerable in defence.
1986	Church & Hughes	Communication to First World Congress of Science & Football	Player and team patterns of play	6 Liverpool games from 1985/6 season	Descriptions of variables are provided but information such as a definition of a pass is not provided.	No information relating to quality of opposition, location or stage of the season is provided.	Greater number of passes were attempted when losing than when winning. Possession was lost more often when winning than when losing. Greater number of shots were taken when losing than when winning.

Table VII. Summary of "physical" performance analysis in football journal articles that were reviewed.

Date	Author(s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
2010	Carling	Journal of Sports Science	Physical activity when running with the ball	28 players from 30 French Ligue 1 games across 2 seasons (2007/08 and 2008/09)	Yes – 4 categories using Amisco Pro® thresholds (light speed, low speed, moderate speed, high speed & sprinting)	19 home games and 11 away games used but no differentiation is made in the results between home or away games. No information relating to whether the players are from one team and their opposition repeatedly or various different teams.	Players ran an average of 191 m with the ball of which 34% was covered at speeds of >19.1 km $\cdot$ h^{-1}. Mean distance per possession was 4.2 m. Mean time in possession was 53.4 s, mean duration was 1.1 s and 2 touches were used on average per possession. There were differences across positions for all variables.
2010	Carling & Bloomfield	Journal of Science & Medicine in Sport	Work-rate following a dismissal	7 players from one game in French Ligue 1 season 2007/08	Yes – 5 categories used using Amisco Pro® thresholds (walking and jogging, low intensity running, moderate intensity running, high intensity running and sprinting) as well as overall distance	Data collected from away team. No information relating to ranking of the teams involved is provided, nor is the result of the game.	Players covered a greater total distance than normal particularly in moderate-intensity activities and had shorter recovery times between high-intensity efforts. There was a significant reduction between game halves for total distance covered at both the highest and lowest running intensities.
2010	Carling et al.	Journal of Science & Medicine in Sport	Work-rate of substitutes	11 midfielders and 14 forwards during 18 matches (15 home and 3 away) from one French Ligue 1 club in 2007/08 season	Yes – 5 categories used using Amisco Pro® thresholds (walking and jogging, low intensity running, moderate intensity running, high intensity running and sprinting) as well as overall distance	No information relating to results of the games or the impact that the substitutes had during the games are presented.	No differences in work-rate between first- and second-halves were reported. Non-significant differences existed during the 2nd half. Midfield subs covered greater distances/HI distances than team-mates. Forwards covered less distance than those who started the game.

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Table VII. Summary (*Continued*).

Date	Author(s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
2010	Clark	International Journal of Performance Analysis in Sport	Activity profiles of EPL players	20 outfield players using 1 game per player (EPL, FA cup or Champions League). All games took place at the Emirates Stadium	Yes – 7 categories are used (Standing, walking, backing, jogging, running, shuffling, football)	No information relating to whether they played for Arsenal (home) or the opposition (away team) is provided in the results. No differentiation is made between the different competitions that were observed.	Players spent 9.5% of the first half performing high intensity activity compared to 7.8% of the second half. Positional role had a significant influence on the % of match time spent performing high intensity activity with the 13.1% for wide backs being significantly greater than the 8.1% for centre backs and the 8.0% performed by forwards. High intensity activity performed by players was intermittent with 58% of all bursts of high intensity activity being less than 3 s.
2010	Gregson et al.	International Journal of Sports Medicine	Match to match variability of high speed running activities of EPL footballers	485 outfield players from games during 2003/04 to 2005/05	Yes – ProZone® categories were used (Total high intensity running distance, total sprint distance and the number and type of sprints undertaken. Total high intensity running distance in possession and without possession of the ball)	Opposition and match location were not referred to.	Match-to-match variability was generally high across all variables with a mean CV (Coefficients of Variation) of $16.2 \pm 6.4\%$ reported for HSR (High-Speed Running) and TSD (Total Sprint Distance) covered during a game. This variability was generally higher for central players (midfielders and defenders) and lower for wide midfielders and attackers. Greater variability was also noted when the team were in

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Table VII. Summary (*Continued*).

Date	Author(s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
							possession of the ball (~30%) than when they did not have possession (~23%).
2009	Di Salvo et al.	International Journal of Sports Medicine	High intensity running activity of elite football players in EPL	563 outfield players in EPL from seasons 2003/04 to 2005/06	Yes – ProZone® categories were used (Total high intensity running distance, total sprint distance and the number and type of sprints undertaken. Total high intensity running distance in possession and without possession of the ball)	Team success (of the players in the sample) was taken into account however no differentiation is made between the different seasons and/or the location of the games.	THIR (Total High Intensity Running Distance) was dependent upon playing position with wide midfield and central defenders completing the highest and lowest distance. High intensity activity was also related to team success with teams finishing in the bottom five and middle ten league positions completing significantly more. THIR compared with teams in the top five positions. Both positional differences in high intensity activity and the observed change in activity throughout the game were also influenced by team success.
2009	Lago-Peñas et al.	International Journal of Performance Analysis in Sport	Work-rate/Intensity in relation to position	127 players in 18 Spanish Premier League Games	Yes – 5 categories used using Amisco Pro® thresholds (light speed, low speed, moderate speed, high speed, sprinting)	No reference is made to game location or the quality of the opposition.	No difference in total distance from 1st half to 2nd half at sub and maximal intensities. Medium intensity distance was significantly different.
2007	Di Salvo et al.	International Journal of Sports Medicine	Activity profiles of outfield players	300 outfield players from 20 Spanish Premier League and 10 Champions League games	Yes – 5 categories used using Amisco Pro® thresholds (walking and jogging, low intensity running, moderate	No reference is made to game location or the quality of the opposition. Similarly no differentiation is made	Results showed significant differences between the different playing positions. Midfield players covered a

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Table VII. Summary (*Continued*).

Date	Author(s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
					intensity running, high intensity running and sprinting) as well as overall distance	between the two competitions.	significantly greater total distance than the groups of defenders and forwards did. There were no significant differences between halves in the total distance covered, or in distances covered at submaximal and maximal intensities. However, significantly more distance was covered in the first half compared to the second in medium intensities.
2007	Rampinini et al.	International Journal of Sports Medicine	Physical performance of players in relation to field tests (RSA (Repeated Sprint Ability) etc.)	20 professional players during season & 188 opposing players	Yes – ProZone® categories were used; total covered, high intensity running, very high intensity running, sprinting & top running speed	No reference is made to game location	Significant correlations were found between peak speed reached during the incremental field test and total distance. Significant correlations were also found between RSA mean time and VHIR (Very High Intensity Running) and sprinting distance. RSA and incremental running tests are accurate measures of match-related physical performance in top-level professional soccer players.
2005	O'Donoghue et al.	International Journal of Performance Analysis in Sport	Repeated work activity in EPL	226 different players (15 min match play each) from 124 EPL games ranging from 2000–2005	2 categories used (Work and Rest). Emphasis is placed on observer interpretation.	All games across 5-year period analysed together. No information relating to opposition, venue or amount of times individual players were observed is published	Position had no significant influence on the number of periods of work performed during 15 minutes of soccer. Players performed 49 repeated work bouts with a mean of 3.1 periods of work of 2.9 s in 15 min

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Table VII. Summary (*Continued*).

Date	Author(s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
							of match play.
2004	Kan et al.	Journal of Sports Science (conference communication)	Factors affecting running speed in a game	2 games (Japan vs UAE & Sanfrecce Hiroshima vs Yokohama Marinos)	No definition is provided for possession and little explanation is given as to how they calculated player speeds.	The domestic game was a J-League game however no information is provided as to the type of international fixture assessed (i.e. friendly, qualifier etc.).	The change in average running speed of the outfield players on a team was affected by the change in ball speed. On average the Japanese team were quicker than Sanfrecce Hiroshima. The team that retained possession of the ball the longest recorded the greatest average distance travelled.
2002	O'Donoghue	International Journal of Performance Analysis in Sport	Time-motion analysis of work-rate in EPL	210 players from 35 EPL matches	2 categories used (Work and Rest). Emphasis is placed on observer interpretation	No reference is made to the season the games are taken from. No reference is made to venue or opposition involved in the games.	There was no significant difference between the duration of the average burst performed by defenders, midfielders or forwards. Midfielders had a significantly shorter recovery between bursts than defenders.
1993	Erdmann	Science & Football II	Kinematics	One Polish third division during 1990/91 season (Comindex Damnica vs Baltyk Gdynia)	Process of quantifying speeds and distances is provided	No information relating to home/away team is provided.	Information relating to distances covered and the displacement of team shape is provided, e.g. during the first 5 min of the match a forward player ran 741 m with a mean velocity of 2.5 m $\cdot$ s^{-1}. No generic conclusions are made in relation to performance.
1988	Asami et al.	Science & Football	Movement patterns of referees	6 top class Japanese referees and 7 foreign FIFA referees during 10 Japanese 1st division	4 categories; walking, jogging and running (although no speeds or description of these are	Two groups of referees are acknowledged separately in the results section. No game related information	Variations in distances covered when jogging, walking, running, backward stepping and

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Table VII. Summary (*Continued*).

Date	Author(s)	Journal Published In	Variable(s) Investigated	Sample Size	Operational Definitions Presented?	Context to Sample?	Key Findings
				games and 7 international games.	provided). Backward step is also included.	is provided.	total overall distance were small across different 15 min periods. Backward stepping is more important for referees than for players and players spring more than referees.
1988	Ohashi et al.	Science & Football	Movement speeds and distances covered	4 players during 2 matches from Japan Soccer League	A description of how they calculated the speed and distance is provided.	No reference is made to the season the games are taken from. No reference is made to venue or opposition involved in the games. No information relating to the players' positions is provided.	The triangular surveying methods used in this study are able to precisely measure the movement speeds and distances covered by footballers in a game. Players' distances range from 9303 m to 11,601 m during a game.
1988	Yamanaka et al.	Science & Football	Time and motion analysis during match play	49 players from European-South American Cup/ Japan Emperor Cup/ Japan Inter-college Soccer Championship	5 categories used; Walking, Jogging, Running, Standing and Sprinting (although no speeds given for each category)	Positions are considered in the analysis and differentiation is made between the 3 different sample groups.	All three groups were very similar and the rank order of activities was; walking, jogging, running, standing, sprinting. 83–88% of time is spent walking and jogging, 7–10% is when running or sprinting and 4–10% is standing.