

Goal scoring in elite male football: A systematic review

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ABSTRACT

The aim of this paper is to review the available literature on goal scoring in elite male football leagues. A systematic search of two electronic databases (SPORTDiscus with Full Text and ISI Web Knowledge All Databases) was conducted and of the 610 studies initially identified, 19 were fully analysed. Studies that fitted all the inclusion criteria were organised according to the research approach adopted (static or dynamic). The majority of these studies were conducted in accordance with the static approach (n=15), where the data were collected without considering dynamic of performance during matches and were analysed using standard statistical methods for data analysis. They focused predominantly on a description of key performance indicators (technical and tactical). Meanwhile, in a few studies the dynamic approach (n=4) was adopted, where performance variables were recorded taking into account the chronological and sequential order in which they occurred. Different advanced analysis techniques for assessing performance evolution over time during the match were used in this second group of studies. The strengths and limitations of both approaches in terms of providing the meaningful information for coaches are discussed in the present study. **Key words:** GAME ANALYSIS, TEAM SPORT, TACTICS, PERFORMANCE INDICATORS, SOCCER.

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INTRODUCTION

The identification of goal-scoring patterns and successful attacking strategies is one of the most pertinent issues in football match analysis. The recognition of key performance indicators related to goal scoring in football in general derives from two main approaches: the static and the dynamic (Pfeiffer and Perl, 2006; Sampaio et al., 2013; Volossovitch, 2013). In accordance with the static perspective, performance and key game events are recorded using notation systems that address final match statistics, with little or no regard to the context of the match at any given moment, while with the dynamic perspective, actions and key events are recorded in connection with the state of the match at each instant in a chronological and sequential order (Prieto et al., 2015).

To the best of our knowledge, very few systematic reviews of football match analysis have been conducted (Mackenzie and Cushion, 2013; Sarmiento et al., 2014) and there is a lack of research focused particularly on goal scoring in adult male domestic football leagues. Therefore, the aims of this study were: 1) to conduct a systematic review of relevant studies on goal scoring in elite male football leagues, classifying them according to the approaches used for collecting and analysing data; 2) to identify the key performance indicators most frequently associated with goal scoring; 3) to characterise the main methodologies used in studies carried out; and 4) to identify potential questions for future research.

MATERIALS AND METHODS

A systematic search of two electronic databases (SPORTDiscus with Full Text and ISI Web Knowledge All Databases) was conducted from February to September 2016. Reference lists of all identified papers were analysed so that no relevant study would be omitted. Combinations of the following keywords were used: “soccer” and “football”, each associated with the terms: “match analysis”, “game analysis”, “performance indicators”, “goals scored”, “tactical behaviour”, “tactical analysis”, “video analysis”, “playing tactics”, and “collective variables”. With this study no application was made for ethics approval because a systematic review is based on published sources.

Inclusion criteria for studies were: (1) conducted by professional adult male football players in domestic leagues; and (2) written in English or Spanish. Studies were excluded if they were: (1) unpublished articles, dissertations, book chapters, or conference abstracts without a corresponding full text paper; (2) conducted by amateur male footballers, minors and females; and (3) data from World Cup and European tournaments. The eligibility of each paper was assessed independently by two researchers (JP and AV); any disagreement regarding the inclusion of articles was resolved in consultation with a third reviewer (AC).

RESULTS

The bibliographical search initially allowed for 610 titles to be identified using reference manager software (Endnote X7, Thomson Reuters, Philadelphia, PA, USA), while duplicates (n=12) were eliminated. The remaining 598 articles were screened for relevance based on their title and abstract, resulting in another 573 studies being eliminated from the database. The full text of the remaining 25 articles was read and another six papers were rejected due to a lack of relevance for the purpose of this study. At the end of the screening procedure, fifteen articles adopting a static approach and only four articles adopting a dynamic approach remained as being eligible for inclusion in the systematic review. The reviewed published studies on goal scoring adopting static and dynamic approaches were collated, then the sample and statistics and/or methods of data collection and analysis used in each study were identified for classification and analysis

purposes (see Table 1).

Table 1. Characteristics of included studies on goal scoring analysis according to the approach used

	Author	Sample (Competition and number of matches)	Variables	Methods
Static approach	1. Redwood-Brown, A. (2008)	England - 120	Pass accuracy	Non-parametric tests (Spearman's correlations; Friedman and Wilcoxon)
	2. Armatas et al. (2009)	Greece - 240	Temporal analysis; Scoring efficiency	Chi square
	3. Lago-Ballesteros and Lago-Peñas (2010)	Spain - 380	Scoring efficiency	Anova; Bonferroni
	4. Tenga et al. (2010a)	Norway - 163	Types of passes; Zones in which possessions started; Playing style	Chi square; Logistic regression
	5. Tenga et al. (2010b)	Norway - 163	Types of passes; Zones in which possessions started; Playing style	Chi square; Logistic regression
	6. Lago-Penas and Lago-Ballesteros (2011)	Spain - 380	Scoring efficiency	Univariate (t-test and Mann-Whitney U) and multivariate (discriminant analysis)
	7. Janković et al. (2011)	Serbia - 228	Pass accuracy; Areas from which goals were scored; Scoring efficiency	Kruskal Wallis; Mann-Whitney-U; Chi-square
	8. Tenga and Sigmundstad (2011)	Norway - 1324	Number of passes; Duration of possession; Zones in which possessions started; Playing style	Kruskal Wallis H; Bonferroni adjusted Mann-Whitney U
	9. Wright et al. (2011)	England	Number of passes; Zones in which possessions started; Areas from which goals were scored; Game situation	Logistic regressions model
	10. Gomez et al., (2012)	Spain - 1900	Types of passes; Zones in which possessions started; Areas from which goals were scored	Factor analysis
	11. Alberti et al.(2013)	England, France, Italy, Spain - 4560	Temporal analysis	Chi square
	12. Collet (2013)	England, Italy, France, Spain, Germany - 5478	Pass accuracy; Playing style	Regression analysis (ordered logit)
	13. Armatas and Pollard (2014)	Greece - 2160	Areas from which goals were scored	Factor analysis with principal components
	14. Kempe et al. (2014)	Germany - 676	Playing style	Anova
	15. Njororai (2014)	England, Spain, Germany, Italy, France - 3454	Temporal analysis	Descriptive statistics
Dynamic approach	16. Nevo and Ritov (2012)	England - 760	First and next goals	Cox models
	17. Fernando et al. (2015)	380	Space-time coordination	Machine learning algorithms
	18. Cintia et al. (2015)	Germany, Spain England, Italy - 1446	Space-time coordination	Network analysis
	19. Pratas et al. (2016)	Portugal - 240	First goal	Cox regression

DISCUSSION

Goal-scoring analysis adopting the static approach

The static approach represents the simplest form of complexity, mainly because it assumes that the structure of studied phenomenon does not change over time (Sampaio et al., 2013). In accordance with this approach, the relevant aspects of sports performance are captured at a given time (as in a photograph), extrapolated and applied to other competitive situations (Volossovitch and Ferreira, 2013).

Studies adopting this approach frequently associate certain team performance patterns with team success or failure. Performance patterns are configured by mean values of variables calculated from the data accumulated by match or championship. In most cases the data are recorded and analysed with little or no reference to match context (Volossovitch and Ferreira, 2013). The static approach to match analysis relates a range of performance indicators to performance outcomes, roughly identifying the components of teams' success without disclosing the process of how this performance has been achieved (Volossovitch, 2013). The main limitation of this approach is the inevitable loss of information, because the data collected account neither for changes in players' performance over time nor the complex interaction between teammates and opponents (Mackenzie and Cushion, 2013; Volossovitch and Ferreira, 2013).

Despite some limitations, the static approach has been that which is most widely used in football match analysis and studies published have identified different performance indicators related to goal scoring. The reasons for this are that notational analysis systems are easy to design, cost-effective in terms of both time and resources, and provide coaches with valuable and objective quantitative information about the mid- and long-term performance of their teams. This information may be of use for the assessment of different teams' strategies and the planning of the training process.

Several studies attempted to identify goal-scoring patterns in football through the temporal analysis of scoring occurrences. It was demonstrated that team performance during certain periods of a match has a greater impact on match outcome (Armatas et al., 2009; Alberti et al., 2013), 15-min interval analysis revealed a significant increase in goals scored as the game progresses (Alberti et al., 2013). The review of studies conducted in accordance with the static approach showed that goal scoring was time-dependent (Armatas et al., 2009), a greater number of goals were scored in the second half of matches and in the last 15-minute periods of each half (Armatas et al., 2009; Alberti et al., 2013; Njororai, 2014). Additionally, Alberti et al. (2013), suggesting that goal-scoring patterns are not related to particular season or country-related style of play with regard to the English Premier League, the French Football League 1, the Italian Series A and the Spanish Football League.

The findings of several studies support the contention that the majority of goals are scored late in each half, probably on account of fatigue, both physical (Bangsboo, 1994; Krustup et al., 2006) and mental (Smith et al., 2016), which accumulates as a match proceeds, leading to a greater number of technical failures (Russell et al., 2011), or due to the adoption of riskier attacking strategies in an attempt to change the current score (Ferguson, 2013; Njororai, 2014). It seems that the final fifteen minutes of the second half frequently represents a critical period in the match. Coaches should take this trend into account by reinforcing their team's defence, especially if the team does not enjoy a score advantage.

Several authors using pass performance indicators to explain goal-scoring patterns reported that the percentage of accurate passes (Redwood-Brown, 2008; Collet, 2013), short passes (Tenga et al., 2010b), and penetrative passes (Tenga et al., 2010a,b; Gomez et al., 2012), as well as possessions with a duration

of over 12 seconds (Tenga and Sigmundstad, 2011) were associated with scoring situations. Regarding the number of passes, the findings of several studies showed that shorter passing sequences involving one to four passes (Wright et al., 2011; Tenga and Sigmundstad, 2011) and long passing sequences involving five or more (Tenga et al., 2010a,b), led to the highest number of goals being scored. These inconsistent findings raise some questions about the use of possession variables for identifying the most effective offensive strategies.

In order to score a goal a team needs to have possession of the ball, but in some cases percentage of possession may not be a valid indicator of how good a team played (Lago-Peñas and Dellal, 2010). What really matters is scoring goals; possession can never be as important as scoring goals, even though it increases the likelihood of scoring. Possession alone is not the key for success (winning a match). It seems that there is decisive possession, which leads to a goal-scoring opportunity, rather than the mere prolonged possession (Lago-Peñas et al., 2010). In order to differentiate more effective match strategies from those which are less so, it is necessary to contextualise the information regarding ball possession during the match. This means taking into consideration the quality of the opposition (weaker or stronger, or of the same level), scoreline evolution and playing time (how much time remains until the end of the match). The style of team attacking play may also influence time of possession. Direct play and possession play are the two most common attacking styles of playing football (Kempe et al., 2014). A direct attack (also known as a counter-attack or long-ball game) is characterized by the launching of a high-speed attack following ball recovery before the opposing team can regain its composure. Teams often use this style when they consider themselves as being inferior to their opponents, especially when playing away.

Possession football, also known as 'tiki-taka', is advocated by many teams and personalities (from Johan Cruyff to Louis Van Gaal, Arsène Wenger and Pep Guardiola) and is aimed at retaining possession of the ball longer than the opponents by employing many low-risk passes and drawing the opposition out of shape before exploiting any gaps they leave, thus using a gradual pass and move strategy. Teams need technically and tactically well-prepared players in order to use this attacking style.

Using data from five European leagues, Collet (2013) found that in the domestic league, possession time and passing were predictors of goal scoring as well as total points scored. When Champions League teams were removed from the analysis, the effect of possession time on goal scoring did not reach a standard level of statistical significance. For non-elite teams playing in domestic leagues, possession time was not related to the likelihood of scoring. In terms of evaluation of effectiveness, ball efficiency was more closely related to success than ball retention. Accurate shooting and accurate passing were strongly linked to goals scored and wins and therefore these indicators are essential for match control.

Tenga et al. (2010a) analysed 163 of the 182 (90%) matches played in the Norwegian Men's Professional Football League in the 2004 season. Their findings showed that counterattacks were more effective than elaborate attacks for scoring goals, when teams played against an unbalanced defence. It was also found that the assessment of opponent interaction is critical for evaluating the effectiveness of offensive playing tactics as regards the probability of scoring goals, and this assessment improves the validity of team match-performance analysis in football.

Recently, Kempe et al. (2014) analysed a total of 676 official matches played in: the Bundesliga in 2009/2010; the Bundesliga in 2010/2011; and the FIFA World Cup in 2010. The authors suggested some new informative tactical measures: the Index of Offensive Behaviour, based on a number of passing parameters (passes per action, passing direction, and target player passes) and parameters of passing success (passing success

rate and passing success rate in a forward direction), and the Index of Game Control, based on parameters of ball possession, the gaining possession and the quality of possession (mean passes per attack, game speed, mean time of attack, the gaining possession, distance covered per attack, relative ball possession rate). Teams which opt for employing “possession play” present a positive Index of Offensive Behaviour. These teams were more successful than teams which employed “direct play” which presented a negative Index of Offensive Behaviour. One of the most interesting findings of this study is that the teams which recorded the highest Index of Game Control were the most successful, regardless of their style of play. These findings suggest that variables which characterise ball possession and contribute to greater match control might have a great impact on match outcome.

One of the most robust findings in the research literature is the high level of offensive effectiveness of successful teams, which always demonstrate a higher percentage of shot efficiency (Lago-Ballesteros and Lago-Peñas, 2010; Lago-Peñas and Lago-Ballesteros, 2011; Collet, 2013). This allows one to conclude that an offensive playing style is not the determining factor for success, since top teams are usually able to play employing either style. The effectiveness of attacking actions and good teamwork has an overwhelming influence on a team’s scoring ability.

With regard to the field zones in which possession of the ball was regained, the findings suggest a significant positive association with the number of goals scored after regaining possession in the midfield third (Tenga et al., 2010a,b; Tenga and Sigmundstad, 2011) and defensive third (Wright et al., 2011; Gomez et al., 2012). It seems that teams playing in different domestic leagues put defensive pressure on their opponents in order to promote ball recovery in specific zones of the field. On the one hand, the strategy for regaining possession of the ball in mid-defensive zones enables a team’s defensive organisation to be preserved, but on the other hand, starting moves from longer distances from the opponents’ goal requires skilled players who are able to get the ball near the target goal.

One of the greatest challenges in football is to anticipate pitch occupation by opponents, and frequently this information is more relevant for understanding the opponents’ tactical intentions than the frequencies of different players’ actions. One of the methods used to calculate a player’s and teams’ dominant region is a Voronoi diagram. A region is considered as dominant when a player can reach it before any other player does (Lopes et al., 2015). The objective measurement of a player’s region using Voronoi diagrams may be helpful in the analysis of player distribution on the pitch in specific game situations. This evaluation allows for the anticipation and reading of the tactical behaviour of opponents and the timely application of measures to counter this behaviour.

A common trend, which was found in different domestic leagues, is that majority of goals (about 81-83%) were scored from the 18-yard (Janković et al., 2011; Wright et al., 2011; Armatas and Pollard, 2014). This is not surprising because the penalty area is adjacent to the goal and the likelihood of scoring from a position in this area is much higher when compared with positions further from the target goal.

Besides the highest percentage ($\geq 65\%$) of goals being scored from open play, the importance of the preparation and planning of players’ action in set plays (approximately 30%) was highlighted in several studies (Wright et al., 2011). Previous studies suggested that set plays account for a large percentage (27% to 32%) of scoring opportunities per match (Armatas and Yiannakos, 2010; Taylor et al., 2005; Wright et al., 2011). A substantial body of research has suggested that set plays account for approximately 30% to 35% of all goals, irrespective of the type of competition involved (Armatas et al., 2007; Yiannakos and Armatas, 2006; Wright et al., 2011). According to Wright et al., (2011), in the English Premier League the free-kick

conversion rate was 1:12 (the conversion rate for corners was 1:11 and for throw-ins 1:12.6).

These findings highlight the importance of practicing set plays. Despite the relatively low occurrence of set plays in comparison with open-play opportunities, the potential productivity of set plays is quite high. Even in elite football, set plays still play a key role and frequently have a decisive impact on match outcome. Thus, set plays can be regarded as a powerful strategy for any team, regardless of a team's position in the league.

In sum, the analysis of key-indicators associated with goal scoring in football demonstrated the evident importance of: number of shots on goal, passing accuracy and recovering possession in zones nearest to the opponents' goal. The relevance of this information in studies using the static approach raises some pertinent questions. Can this summarised data, collected out of match context and without considering the specific characteristics of teams' tactical behaviour, provide meaningful information for future competitive contexts? It is assumed that changes in scoreline and match outcome are dependent on the dynamic interactions between the actions of players of both teams. Thus, in order to provide a better understanding of the factors that influence the capability of teams for scoring more complex approaches are required, which include the information about offensive and defensive interactions and take into account the relationship between different match events in time.

Goal-scoring analysis using the dynamic approach

Observational data collected and analysed in accordance with the dynamic approach provide information which takes into account time evolution during the match (Volossovitch and Ferreira, 2013). These data aim to describe not only 'what events' occur, and 'when' and 'where', but also 'how' match outcome is achieved in the match process. The dynamic approach allows for the identification of specific patterns of players' interactions which emerge during the match (Passos et al., 2013). The dynamic approach includes the time dimension in the analysis of team performance during the match: players' actions are recorded and related to the match process at each instant, in a chronological and sequential order (Volossovitch and Ferreira, 2013).

Studies on goal scoring conducted in accordance with to the dynamic approach can be classified into two groups: 1) studies based on the dynamic analysis of space-time coordination between players and teams; and 2) the analysis of scoring dynamics.

Dynamic analysis of space-time coordination between players and teams

The technological advances of recent decades have allowed for the collection of positional data about players and the ball during the match, which are now widely used in tactical analysis in football (Bialkowski et al., 2014; Memmert et al., 2016).

Research based on position data is aimed at describing the dynamic patterns of interactive player behaviour during the match and forecasting teams' performance. Recently, two main tools have been used in match analysis to examine dynamic interactions among players in goal-scoring situations: network analysis (Cintia et al., 2015); and machine learning algorithms (Fernando et al., 2015).

The results of network analysis showed that teams with a higher level of passing activity tend to score more goals and the number of passes can be used as a predictor of match outcome (Cintia et al., 2015). Network analysis is growing in importance in sport performance research. Network methods are used to assess group relationships in a football team through the analysis of passing behaviour in combination with spatial information. These methods provide relevant information about team tactical behaviour, and have been

enhanced by the development of a wide range of mathematical tools for analysing networks. For example, it is a straightforward process to work out the most important nodes in the network using a measure known as centrality. In football, goalkeepers and forwards present the lowest level of centrality, while defenders and midfielders have the highest level. However, there are numerous different ways of measuring centrality and determining clusters, and it is not always clear why one method should be preferred over another. Therefore, it is necessary to systematically evaluate and compare these different methods to determine their utility and value in match analysis.

Tactical decision-making in elite football has also been investigated using machine learning algorithms based on game position data (Fernando et al. 2015; Knauf et al., 2016). Machine learning algorithms allow for the identification and comparison of teams' "goal-scoring styles" and the description of team formations in different game situations (Fernando et al., 2015; Grunz et al., 2012; Kempe et al., 2015).

Over the last ten years, the use of positional data has increased in match analysis (Duarte et al., 2012a,b; Folgado et al., 2014). The application of collective variables, such as geometrical centre, surface area, stretch index, team length and team width, among others, has enabled us to capture the spatial and temporal properties of players' displacement and accurately describe the interactive behaviour of a set of players in scoring situations (Frencken and Lemmink, 2008; Frencken et al., 2011). Dynamic tools, such as Voronoi diagrams, used to measure individual and team dominant regions and team spatial configurations, and Approximate entropy, used to identify movement patterns and inter-player coordination, provide new opportunities for describing teams' spatial behavior and characterising players' spatial profiles for different game contexts, particularly in goal scoring situations. Despite considerable technological advances, the use of these dynamic tools in the analysis of real play remains scarce.

The majority of studies on coordination dynamics in football have analysed players' behaviour in small-sided games (Sampaio et al., 2014; Goncalves et al., 2016), and only a few studies have examined the 11x11 game (Fradua et al., 2013; Goncalves et al., 2014).

From a tactical perspective there are some pertinent questions related to goal-scoring analysis which should be addressed in future research. Firstly, it would be interesting to clarify what team formation leads most frequently to success (for example, 1-4-4-2, 1-3-5-2, and so on), and secondly, how teams use such formations (for example, retreating deep or pressing high) to create scoring situations.

Analysis of scoring dynamics

The second group of studies, carried out in accordance with the dynamic approach, includes the prediction of goal scoring based on score evolution analysis during the match (Nevo and Ritov, 2012) and the analysis of factors which influence the probability of scoring (Pratas et al., 2016).

Nevo and Ritov (2012) examined the effect of the first goal on the time the second goal is scored using survival analysis methods and concluded that first goal occurrence could either expedite or impede the next goal being scored, depending on the time at which it was scored. "*Moreover, once a goal is scored, another goal becomes more and more likely whether the goal was scored or conceded*" (Nevo and Ritov, 2012). Also, Dixon and Robinson (1998) argued that expectation of a goal is dependent on current score, and when an early away goal is scored, expectation of further goals is increased (more than the original expectation of goals before the match) with a bias towards the home team having their goal expectation increased. A recent study conducted by Pratas et al., (2016), which used proportional-hazards regression models with time-dependent covariates, allowed for the identification of performance indicators (that is goal difference, shots

on goal, disciplinary sanctions and substitutions) that influence the time at which the first goal is scored in high-level football matches.

The probability of a goal being scored is certainly dependent on the current score and there are variables which increase goal expectation, such as shots on goal (Pratas et al., 2016), an early red card (Bar-Eli et al., 2006) and an early away goal (Dixon and Robinson, 1998). These findings support the suggestion that in order to predict future performance and outcome based on past performances, it is not enough to analyse merely what happened in a match, but it is also important to know when events occurred. Thus, in order to ensure reliable results analysis should include the temporal dimension of game actions.

One of the challenges in match analysis is to progress from the retrospective analysis of performance, based on either discrete performance indicators or positional data collected continuously, to the prediction of future performances and outcomes. Either perspective (continuous or discrete) of analysis may provide relevant information about players' behaviour and the two should be seen as being complementary. The use of different kinds of data will provide a better understanding of the factors that influence the time of goal scoring in football. This information may be useful for predicting (for example, using duration probabilistic models) match scenarios involving a particular opponent and preparing for strategic planning for the following match.

CONCLUSION

Research studies conducting football match analysis have examined goal-scoring patterns from two different perspectives: the static and the dynamic. Football's inherent randomness makes analysis even more impactful and what makes a difference perhaps is not the data itself but rather the capacity to use this data to formulate a theory explaining how a team increases its chances of winning matches. Certain significant performance indicators associated with goal scoring are highlighted in this review and may be important in a given game context but would probably be irrelevant in another, depending on a number of factors related to teams' quality and playing style, the importance of the match, among others. In football analytics the way a team plays dictates which performance indicators are significant. The challenge is to find out how the relevance of different performance indicators changes according to match context.

Further research should continue to explore dynamic methods of analysis with the focus on the time of goal scoring and the evaluation of the relationship between different match events. The standardisation of some tactical metrics (for example, index of game control, passing activity) and collective variables (for instance, surface area, inter-player coordination) might provide more consistent results regarding the goal-scoring process and provide a better understanding about individual and collective behaviours which influence this process. Goal scoring is the main objective of a football match and indeed perhaps it can be said to be its sole purpose and it is the most valid performance indicator determining team success. Thus, all events which take place on the field should be evaluated taking into account the principal objective of the game: to score more goals than one's opponents.

The static approach, based on discrete frequency data may be suitable for the description and comparison of performance profiles associated with team success, but it provides limited information about the game process and performance variability during the match. The dynamic approach, which involves the analysis of the space-time coordination between players and teams in association with goal-scoring opportunities and examines the variety of factors whose interaction may influence scoring dynamics, provides the basis for a better understanding of the game process and provides information on how the game outcome develops over time.

Currently, a huge amount of data is collected during matches, but it is not always clear how these data should be processed with a view to providing coaches, match analysts and players with relevant information. Finding more suitable methods for data analysis is an urgent task but there can be no progress if game analysts are not prepared to formulate pertinent questions and put forward relevant issues which need to be addressed in the field of match analysis.

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