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SYSTEMATIC REVIEW

What Performance Analysts Need to Know About Research Trends in Association Football (2012–2016): A Systematic Review

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Abstract

Background Evolving patterns of match analysis research need to be systematically reviewed regularly since this area of work is burgeoning rapidly and studies can offer new insights to performance analysts if theoretically and coherently organized.

Objective The purpose of this paper was to conduct a systematic review of published articles on match analysis in adult male football, identify and organize common research topics, and synthesize the emerging patterns of work between 2012 and 2016, according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.

Methods The Web of Science database was searched for relevant published studies using the following keywords: 'football' and 'soccer', each one associated with the terms 'match analysis', 'performance analysis', 'notational analysis', 'game analysis', 'tactical analysis' and 'patterns of play'.

Results Of 483 studies initially identified, 77 were fully reviewed and their outcome measures extracted and analyzed. Results showed that research mainly focused on (1) performance at set pieces, i.e. corner kicks, free kicks, penalty kicks; (2) collective system behaviours, captured by established variables such as team centroid (geometrical centre of a set of players) and team dispersion (quantification of how far players are apart), as well as tendencies for team communication (establishing networks based on passing sequences), sequential patterns (predicting future passing sequences), and group outcomes (relationships between match-related statistics and final match scores); and (3) activity profile of players, i.e. playing roles, effects of fatigue, substitutions during matches, and the effects of

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environmental constraints on performance, such as heat and altitude.

Conclusion From the previous review, novel variables were identified that require new measurement techniques. It is evident that the complexity engendered during performance in competitive soccer requires an integrated approach that considers multiple aspects. A challenge for researchers is to align these new measures with the needs of the coaches through a more integrated relationship between coaches and researchers, to produce practical and usable information that improves player performance and coach activity.

Key Points

There has been an increase in research examining performance in set plays (free kicks, corner kicks, penalty kicks) in the last few years that have provided valuable information on variables that influence their effectiveness.

Investigations into match activity profiles have evolved to include the characterization of effort during congested fixture periods, in competition with extra time periods and effective use of substitutions.

Specific collective system measures (e.g. a team's geometric centre and dispersion) and analysis techniques (e.g. network, sequential and temporal-pattern analyses) have provided important information about how teammates and opponents interact during performance so that tactical behaviours can be better understood.

1 Introduction

A systematic review of research articles that were published before 2011 provided a timely overview of the most common research topics, methodologies and evolutionary tendencies of research in Association Football [1]. More recently, studies have discussed current approaches to tactical performance analysis in football [2–4].

In the last 5 years there has also been some progress in terms of books dedicated entirely or partially to football [5–7], with one peer-reviewed journal, *Science and Medicine in Football* (Taylor and Francis Group) emerging as a stand-alone journal after 3 years of publication as a regular supplement of the *Journal of Sport Sciences* (Taylor and Francis Group).

Additionally, match analysis as a methodological approach in sports science has progressively grown, based on proliferation of technological systems (e.g. global positioning system [GPS], Prozone—STATS, OPTA) to collect performance data. Interpretation of the data seeks to generate knowledge about team properties and the patterns that characterize their organization [8], with implications for coaches and sport analysts to design practice strategies and plan training sessions [9].

Progression of match analysis research in Association Football has increased exponentially since 2011, and recent literature since that date can offer new insights to the field if theoretically and systematically organized and interpreted. Systematically reviewing research published in refereed journals contributes in several ways, such as (1) informing researchers about the evolution of knowledge on match analysis; (2) the characterization of new techniques for gathering new information; and (3) offering an evolving theoretical organization of the key topics and concepts researched in performance analysis in football.

The purpose of this article was to conduct a systematic review of published articles on match analysis in adult male football, identify and organize common research topics, and synthesize the emerging patterns of work between 2012 and 2016, predicated on findings from the previous review by Sarmento et al. [1] of studies published up to 2011.

2 Methods

2.1 Search Strategy: Databases, Inclusion Criteria and Process of Selection

A systematic review of the available literature was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. The search strategy followed by Sarmento et al. [1] was adopted in the current study.

The Web of Science electronic database was searched on 6 January 2017 for relevant articles published between 1 January 2012 and 31 December 2016, using the keywords 'football' and 'soccer', each one associated with the terms 'match analysis', 'notational analysis', 'game analysis', 'tactical analysis' and 'patterns of play'.

The inclusion criteria for these articles were (1) including relevant data regarding technical and tactical evaluation or statistical compilation, and time–motion analysis; (2) participants included amateur and/or professional adult male footballers; and (3) the articles were published in English. Studies were excluded if they (1) involved children or adolescents (under 18 years of age); (2) included females; (3) did not include relevant data for

this study; and (4) were conference abstracts. If there was disagreement among authors regarding the inclusion of certain articles, a discussion was held until a consensus was found.

Two independent reviewers (HS, FC) independently screened citations and abstracts to identify articles potentially meeting the inclusion criteria. For those articles, full-text versions were retrieved and independently screened by two reviewers to determine whether they met the inclusion criteria. Disagreements about whether the inclusion criteria were met were resolved through discussion with the other authors, who then analyzed the full text of the papers that induced doubt in the two main reviewers who performed the initial screening process. In two cases, direct communication with the authors of the original articles helped in the final decision-making process. In this way, all final decisions resulted from a process of joint decision making.

2.2 Extraction of Data and Quality of the Studies

To evaluate the quality of the studies, a risk-of-bias quality form was adapted for the specific context of research developed in match analysis, from the original version developed by Law et al. [10], following an evaluation process by five senior researchers with substantial experience (including relevant publications) in soccer performance analysis. Some minor suggestions were introduced in the final critical review form (16 items) according to their evaluation (see Electronic Supplementary Table S1).

Articles were assessed based on purpose (item 1), relevance of background literature (item 2), appropriateness of study design (item 3), sample studied (items 4 and 5), use of informed consent procedure (item 6), outcome measures (item 7 and 8), method description (item 9), significance of results (item 10), analysis (item 11), practical importance (item 12), description of dropouts (item 13), conclusions (item 14), practical implications (item 15), and limitations (item 16). All 16 quality criteria were scored on a binary scale (0/1), wherein two of those criteria (items 6 and 13) presented the option: 'If not applicable, assume 3'. The introduction of this option for items 6 'Was informed consent obtained?' and 13 'Were any dropouts reported?' has been included because, in some studies, the investigators were not required to obtain informed consent (item 6) or report dropouts (item 13). The introduction of the option 'not applicable' allowed an appropriate score for the article, eliminating the negative effect of assuming the value '0' on a binary scale, when in fact that specific item was not applicable to that study. As in previous research [11, 12], to make a fair comparison between studies of different designs, the decision was taken to calculate a percentage score as a final measure of methodological quality. For this, the sum of the score of all items was divided by the number of relevant scored items for that specific research design. All articles were classified as (1) low methodological quality, with a score $\leq 50\%$; (2) good methodological quality, with a score of between 51 and 75%, and (3) excellent methodological quality, with a score $> 75\%$.

A data extraction sheet (adapted from Cochrane Consumers and Communication Review Group's data extraction template; available at http://cccrg.cochrane.org/author-resources) was developed and tested with 10 randomly selected studies. First, one researcher extracted the data from included studies and a second researcher then checked the extracted data. Disagreements were resolved by consensus.

3 Results

3.1 Search, Selection and Inclusion of Publications

The initial search identified 483 titles in the described database. These data were then exported to reference manager software (EndNote X8), and any duplicates (189 references) were eliminated automatically. The remaining 294 articles were then screened according to the title and abstract for relevance, resulting in another 156 studies being eliminated from the database. The full text of the remaining 138 articles was read and another 61 were rejected due to a lack of relevance for the specific purpose of the current study. At the end of the screening procedure, 77 articles received further in-depth reading and analysis for the systematic review (Fig. 1).

The main reason for exclusion was that a published study did not concern match analysis ($n = 23$). Other reasons for exclusion included (1) participants were youth players under 18 years of age ($n = 10$); (2) involvement of female players ($n = 8$); and (3) data were included from other team sports ($n = 20$), including rugby, futsal, handball, Australian Football, basketball, volleyball, field hockey, frisbee, floorball and waterpolo.

Sarmento et al. [1] reviewed 53 articles published up to the end of 2011. Interestingly, in a much shorter period (2012–2016), the data revealed an increase ($n = 77$) in the number of studies published on the selected topic.

3.2 Quality of the Studies

Sarmento et al. [1] justified the quality of the papers included in their revision due to the use of Web of Science as the search database. In contrast, in the current review, we evaluated the quality of the papers included for analysis. The results of the interobserver reliability analysis, calculated using the Kappa index, was 0.97 (95%

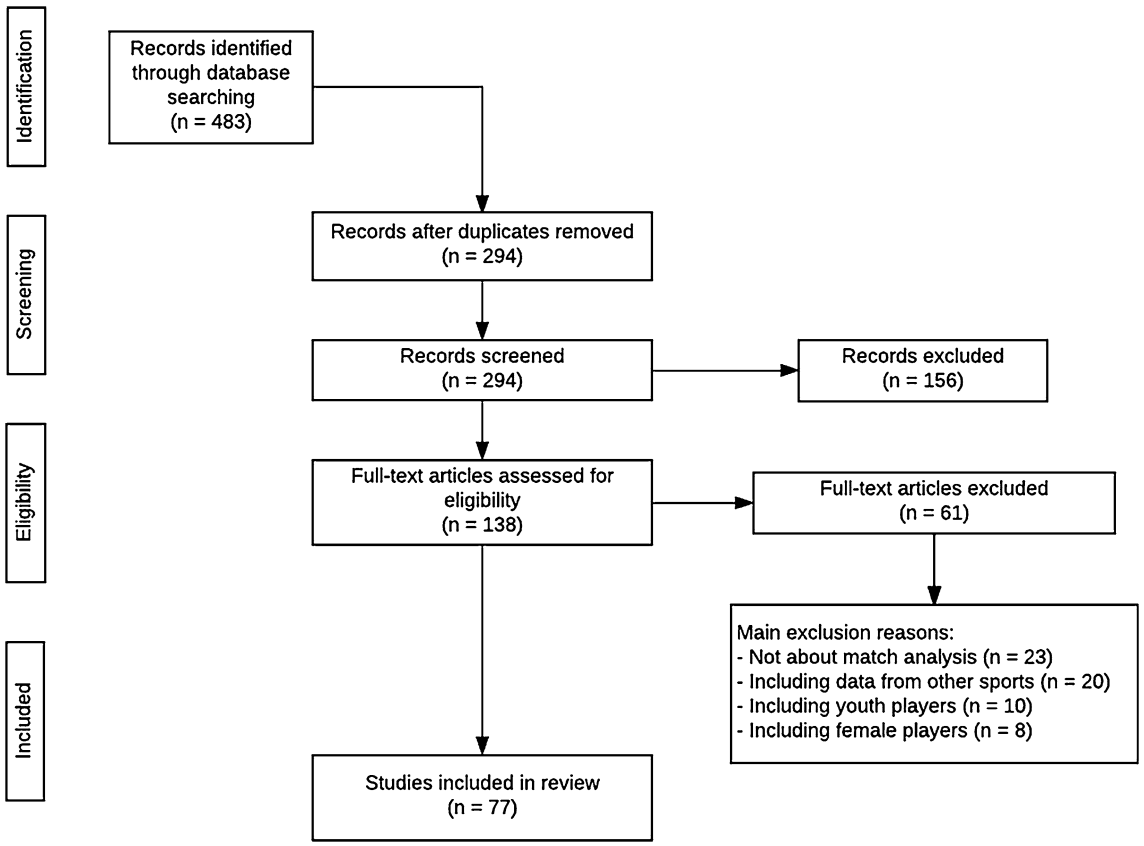

Fig. 1 Preferred reporting items for systematic reviews flow diagram

confidence interval 0.97–0.98), indicating very good agreement between observers. The quality of indicators for the included papers was as follows: (1) the mean methodological quality score for the 77 selected articles was 89.8%; (2) 12 articles achieved the maximum score of 100%; (3) none of the articles scored below 50%; (4) two articles scored between 50 and 75% (good methodological quality); and (5) 75 articles achieved an overall rating of $>75\%$ (excellent methodological quality).

Possible deficiencies identified in the 77 studies were mainly related to two items on the criteria list: (1) for criterion 16 (see Electronic Supplementary Appendix S1), some studies failed to clearly acknowledge the limitations of the study; and (2) some studies lacked information in relation to criterion 5, related to an explicit justification of the study sample size.

3.3 Data Organization

The previous systematic review by Sarmento et al. [1] categorized research according to the type of analyses performed (descriptive analysis, comparative analysis and predictive analysis), and type of variables analyzed. In contrast, the present review grouped studies according to major match analysis research topics (categories) that emerged from the detailed analysis (Fig. 2). This approach was adopted in order to contribute to a theoretical knowledge based on an ecological dynamics framework [7], without losing the bottom-up knowledge that emerges from the systematic analysis of studies review.

Two independent reviewers (HS, FC) independently classified the papers according to the different major research topics. Disagreements were resolved through discussion with the other co-authors until a consensus was found. The aim was not to produce categories that were mutually exclusive since the same analysis can include topics that relate to different categories. Thus, an article included in a specific 'category', could also be classified in another 'category' whenever its content justified it.

3.4 Major Research Topics

The following subsections describe the studies identified in each of the specific research topics. Their findings are outlined and discussed in more detail in Sect. 4.

3.4.1 Set Plays

Set plays, such as free kicks, penalty kicks, corners and throw-ins, can provide match-winning situations. In the

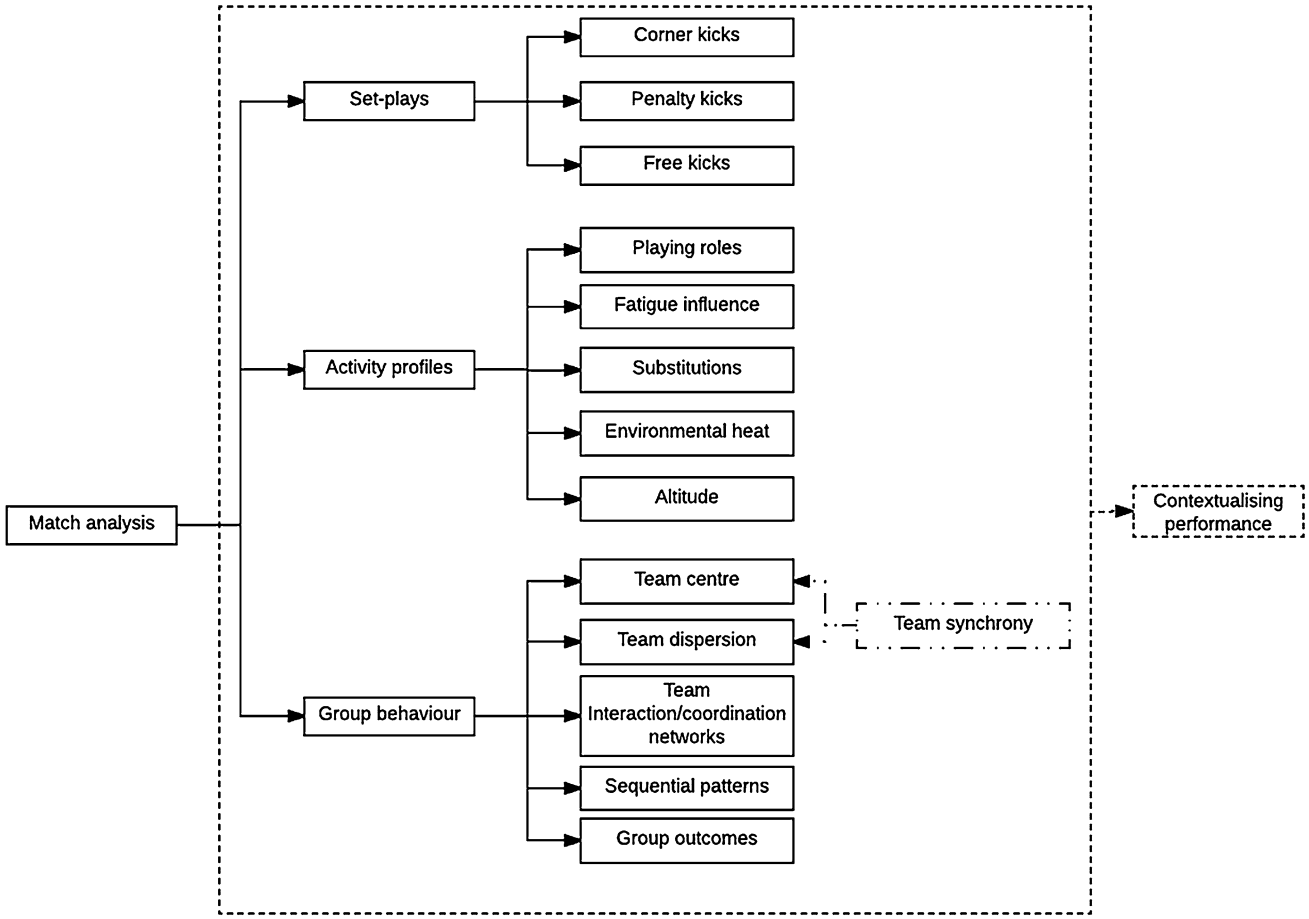

Fig. 2 Scopes of match analysis

last few years, there has been an increase in research examining these match events [13] in different competitions (Table 1). Several studies have estimated that between 30 and 40% of goals are scored from set plays [14]. The importance of this type of situation is highlighted by professional coaches who identified an increased systematization of specific set-play training situations as an evolutionary trend of training/competition [15]. Given its importance to the match, dead-ball specialists work on the training ground to perfect their techniques; however, it is important that defenders also be prepared to face set plays.***

3.4.2 Activity Profile

3.4.2.1 Playing Roles Modern professional soccer imposes more and more demanding requirements on players that relate to their pre-competition preparation [16], specifically to their roles on the field (i.e. goalkeepers, defenders, midfielders and forwards). There is a need to understand how roles performed in soccer can affect performance, as estimated by specific variables (Table 2).

3.4.2.2 Fatigue Influence Match activity and fatigue during football matches has been a topic of increased research in recent years (Table 3). Recent research has shown that physical performance during a match changes throughout the season and is related to players' training status [17]. Previous research has also revealed the evolution of the game over the last few decades, especially the increasing intensity of play [18] that is directly related to physical performance decrements from the first to the second half of elite soccer match play [19]. These trends could result in an inability of players in certain roles to repeatedly cover distances during critical situations, and may also reduce technical capabilities that are related to match outcomes [20].

3.4.2.3 Substitutions Substitutions have enormous impact and importance in modern football contexts because coaches typically attempt to use well-timed substitutions to reduce the effects of fatigue across the team or in an effort to modify tactics. Consequently, some important research (Table 4) has analyzed this specific aspect of the match in the English Premier

Table 1 Studies with predominantly corner kicks, penalty kicks and free kicks analysis

Study	Competition	Number of events analyzed	Results/main findings	Practical applications	Quality score (%)
			Corner kicks		
De Baranda and Lopez-Riquelme [39]	2006 FIFA World Cup	653 Corner kicks	Teams perform (1) more short corners and take more short kicks and outswing corner kicks when winning; (2) more outstep and inswing corner kicks when drawing and losing; (3) more shots that head toward the semicircle placed by the penalty area or do not use the centre when winning. However, teams head their shots toward the first and second goalpost when drawing and losing. When teams that are winning perform the corner kick, the defending teams tend to have fewer players defending the goal line	Allow coaches to design training exercises similar to the actual competition, and adapt the game style with regard to match status	100
Pulling et al. [40]	English Premier League	436 Corner kicks	The most commonly used marking system was one-to-one marking, with zonal marking being used less often. There was no significant association between the marking set-up and the number of attempts at goal conceded when defending corner kicks. Teams who used zonal marking conceded fewer goals and had fewer attempts at goal than teams who applied one-to-one marking. The most common set-up for defenders positioned at the goalposts was having a defender positioned only on the far post	There are no differences in the effectiveness of goal scoring or goal attempts as a function of different defensive strategies (zonal marking vs. one-to-one). There is no advantage in positioning players on the goalpost when defending corner kicks	92.9
Casal et al. [14]	2010 FIFA World Cup, UEFA Euro 2012 and the UEFA Champions League 2010–2011	1139 Corner kicks	Just 2.2% of the corners ended in a goal, but this goal was responsible for the team winning or drawing the match on 76% of occasions. In general, kicks are delivered through the air to the near post, with one or two intervening attackers. The attack is organized statically and the defense is a combination of zone and man-to-man. The following variables were significantly associated with corner kicks resulting in a goal: time, number of intervening attackers and offensive organization	More elaborate corner kicks (sent to the far post, following a short initial kick and the intervention of three or four players in a dynamic set-up) seems to be more effective	92.9

Table 1 continued

Study	Competition	Number of events analyzed	Results/main findings	Practical applications	Quality score (%)
Pulling [41]	English Premier League	328 Corner kicks	There was an association between the area where the ball was delivered to and the number of attempts at goal, and the area the ball was delivered to and the number of defending outcomes. The area where a long corner kick is delivered to will influence how many attempts at goal can be achieved by the attacking team and how many defensive outcomes can be conducted by the defensive team	The area of delivery is more important than the type of delivery for achieving attempts at goal from long corner kicks	85.7
			Penalty kicks		
Farina et al. [42]	World Cup (2010), Copa América (2011) and UEFA Euro (2012) Controlled situation in Club Atletico Peñarol (2010)	There is no reference of the number of penalties analyzed from the 2010 World Cup, 2011 Copa América and UEFA Euro 2012 50 Penalty kicks 52,425 Simulations were analyzed	Saves were found to depend essentially on the beginning of the goalkeeper's motion according to the area. In the central areas of the goal, saves were statistically independent of ball speed and time of reaction. The goal region further away from the centre, where real shots are frequently saved, presented the highest dispersion	Penalty takers should be encouraged to direct the shot to areas near to the posts. Perceptual training related to the skill of anticipating the side (and precise area) of the goal the shot will be directed at may be essential for enhancing goalkeeper performance	57.1
Noel et al. [43]	Controlled situation in a German club FIFA World Cups (1986–2010) and UEFA European Football Championships (1984–2012)	84 Penalty kicks 322 Penalty kicks	The keeper-independent strategy was used much more frequently than the keeper-dependent strategy, but successes did not differ. Penalty takers should use both the strategies to be less predictable	A goalkeeper could try to identify a penalty kick strategy by focusing on the fluency of the early parts of the run-up and the kicker's gaze. A penalty taker who tends to slow down, uses shorter strides and looks frequently at the goalkeeper is likely to use a keeper-dependent strategy. It is advisable for the goalkeeper to wait longer before starting to dive. If a penalty taker runs up steadily, while largely ignoring the goalkeeper, a keeper-independent strategy is more likely. The goalkeeper is then advised to dive early to the kicker's natural side	85.7
Almeida et al. [13]	UEFA Champions and Europa leagues (2010–2011 to 2014–2015)	536 Penalty kicks	The probabilities of penalty kicks being saved significantly increased (1) in the middle of matches (30:01–60:00), and (2) when the shots were directed to the lower zones of the goal, in particular to the lower centre-left zone of the goal (penalty taker's perspective). The odds of missing the penalty substantially increased when the shot was aimed at the high zones of the goal	Penalty takers should be encouraged to direct the shot to the upper corners of the goal and goalkeepers should wait longer in order to dive to the correct side of the ball	100

Table 1 continued

Study	Competition	Number of events analyzed	Results/main findings	Practical applications	Quality score (%)
			Free kicks		
Casal et al. [45]	FIFA World Cup (2010), UEFA Champions League (2010) and UEFA European Championships (2010)	783 Free kicks	Almost 36 indirect free kicks are needed to score a goal, but 64% of goals from indirect free kicks have a decisive influence on match outcome. Goals were more common when the attack was organized dynamically and three or four players touched the ball before a shot was taken	Coaches should promote training sessions with elaborate kicks (more effective): the ball is played along the ground, touched by three or four players, and form part of a dynamically organized attack	92.9
Link et al. [46]	German Bundesliga (2013/2014, 2014/2015)	1624 Free kicks	Centrality and proximity to the goal increased the variables of players in the wall, rule violations and interruption time, and the ratio of goals scored increased from 5.9% (central far) to 10.9% (central near). There was no statistical advantage for the defensive team when distance to the wall was below 9.15 m or when there was a rule violation. Crosses had a success rate of 20.8%. Crosses from the right side outside the penalty box were 10% more successful than from the left side	It might be more effective to increase the proportion of passes from side free kicks and to try to reach the opposing team's penalty area using short passes and dribbles. Since right-side free kicks tend to be more successful, it might be worthwhile practicing the defense of balls that come in from this side	92.9
			Corner kicks, free kicks and penalty kicks		
Siegle and Lames [44]	16 Matches from the German first league	Mean number of occurrences per match: (1) free kicks, 39.69; (2) corner kicks, 10.0; and (3) penalty kicks, 0.13	There is an average of 108 interruptions per match. Throw-ins and free kicks were most frequent. Goal kicks, corner kicks, substitutions, and kick-offs occurred less often. Drop balls, penalties, and injuries occurred least often	Teams utilize match interruptions to run down the clock. While referees should take care to ensure that teams do not do this, coaches, on the other hand, should be aware of this phenomenon and adapt players' behaviour according to the state of the match	85.7

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Table 2 Studies with predominantly activity profile analysis—playing roles

Study	Sample	Categories of player positions	Analyzed variables	Main results	Practical applications	Quality score (%)
Andrzejewski et al. [16]	31 Players participating in the Union of European Football Association cup competitions during the 2008–2009 season	Defenders, midfielders and forwards	Distances covered at different intensities	The midfielders covered the longest average distance during the match. This was 3 and 7% longer than the distance achieved by the attackers and defenders, respectively	Training individualization: (1) the range of intensity during the training activities should oscillate within the limits of individual physical loads of soccer players; (2) speed load is especially important to forwards, who cover twice the distance in sprint than the midfielders	87.5
Andrzejewski et al. [50]	147 Players who played in 10 matches of the 2008–2009 and 2010–2011 UEFA Europa League seasons	Central defenders, external defenders, central midfield players, external midfield players, forwards	Total number of sprints and total sprint distance covered	Significant differences were found between all players' positional groups, particularly, between the forwards, external midfielders and external defenders, as well as between central defenders and central midfielders. Differences in total numbers of performed sprints were found between the forwards, external midfielders, central defenders and central midfielders	There is a necessity to apply distances between 10 and 20 m and longer than 20 m in soccer speed training. The number of sprinting distances (in a match situation) within these two ranges is twice as large in forwards and external midfielders than in central defenders and central midfielders. It seems unfounded to apply 40 m or even 50 m running distances in soccer speed training	87.5
Di Salvo et al. [51]	26,449 Observations (2006–2007 to 2009–2010) from the Premier league (n = 13,991) and Championship league (n = 12,458). 1241 players from the Premier league and 1494 players from the Championship league	Attackers, central defenders, central midfielders, wide defenders, wide midfielders	Distances covered at different intensities	Players from the Championship league travelled more total match distance than players from the Premiership league. Championship players covered greater distances during jogging, running, high-speed running, and sprinting. Premiership players covered more distance walking	Coaches need to develop training programmes that address the physiological requirements necessary to cover the identified distances (at different intensities) according to the specific competition. The most important characteristics of play in the highest division are based on quality (technical, tactical and mental aspects), and not quantity (physical performance) of measures	87.5
Clemente et al. [48]	443 Players from the FIFA World Cup in 2010	Goalkeepers, central defenders, external defenders, midfielders and forwards	Distances covered at different intensities	Statistically significant differences among tactical positions were found, concluding that each position has its specific demands	The specificity of playing positions should be considered by coaches to organize the workout and to adjust the demands to the characteristics of players	92.9

Table 2 continued

Study	Sample	Categories of player positions	Analyzed variables	Main results	Practical applications	Quality score (%)
Varley and Aughey [47]	29 Elite Australian soccer players	Central defenders, wide defenders, central midfielders, wide midfielder and forwards	High-velocity running, sprinting and maximal acceleration	The number of efforts performed in all categories were position-dependent. Wide defenders performed more maximal accelerations, and central defenders and midfielders performed less sprints compared with all other positions	Positional differences in high-intensity movements should be accounted for when developing specific conditioning drills	85.7
Padulo et al. [49]	10 Male Italian goalkeepers from Italian third and fourth divisions	Goalkeepers	Number of frontal and lateral actions with distance covered and total distance covered during the match	Statistically significant differences among lateral actions, distance covered and total distance covered as a function of the competitive level	Training programmes should be determined by the identified running kinematic variable values in order to cope with the specific match demands. Measurement of kinematic variables provides coaches with the necessary information to plan specific training sessions for goalkeepers in order to induce competitive performance improvements	87.5
Liu et al. [52]	380 Matches from the Spanish first league (2012–2013)	Fullback, central defenders, wide midfielder, central midfielder	21 Performance-related match events and actions	Technical performances differed between players of strong and weak teams from different perspectives across different field positions	The players' technical profiles can be useful for talent development and player selection in the transfer market. Nevertheless, these types of player profiles need to be analyzed according to the specificities of player roles and the characteristics of current (or future) teams	100

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Table 3 Studies with predominantly activity profile analysis—fatigue influence

Study	Sample	Variables/tests	Period analyzed	Main results	Practical applications	Quality score (%)
Silva et al. [17]	13 Professional male soccer players competing in the Portuguese soccer League	Distances covered at different intensities; countermovement jump, 5- and 30-m sprints, change of direction, knee extensor and flexor isokinetic strength, and Yo-Yo intermittent endurance test-level 2	Performance across one sporting season	The footballers covered a greater high-intensity distance running in the last quarter of the season than in the second and third quarters. The peak 5-min was higher in the last quarter than in the beginning of the season (first, second and third quarters). Soccer players covered more high-intensity distance running during the match and in the P5-min toward the end of the season	There exists an association between muscle strength and power and performance decrements in game-related physical parameters. In this sense, football players' training should incorporate specific exercise programmes to improve the athletes' strength and power during the performance of soccer-specific activities	93.8
Dellal et al. [54]	16 Outfield players from the French soccer league	Distances covered at different intensities, technical parameters, injury data	Performance across a congested fixture period	No differences were found across the successive matches in the congested period, and between no congested and the three congested periods for all the physical and technical activities. The injury rate during match play was significantly higher during the congested period, and the injury rate during training time was significantly lower during the congested period when compared	The coach, physiologist and medical staff should pay special attention to the recovery strategies when players participate in matches during congested fixture periods. Using low-intensity activities during training sessions, the rotation of players in games, attention to objective markers of fatigue (e.g. creatine kinase concentration) combined with subjective measures of performance, can be useful strategies at these times in the season	100
Penas et al. [55]	99 Players from the FIFA World Cup (2014)	Distances covered at different intensities. Time spent in low, medium and high activities, maximal running speed. Number of sprints per minute	Influence of extra-time period on performance	Total distance, high-intensity running, top speed and high-intensity activities decline significantly from the first to second half of the match. Low-intensity activities increase in the second half, especially in the extra-time period, in comparison with the first half. All of the physical markers under study showed a decline of 15–20% during the extra-time period in comparison with the first half of playing time	Technical coaching staff should be aware of the decline of physical performance in the second half and extra-time period, and, consequently, influence the team from a tactical and physical focus within a training perspective	100
Russell et al. [56]	5 Professional soccer players from an English Premier League reserve team	Distance covered and the number of sprints, accelerations and decelerations. Countermovement jump performance and creatine kinase concentrations were assessed	Influence of extra-time period on performance	From 105 to 120 min, acceleration and deceleration parameters reduced by $> 10\%$ compared with the opening 15 min. Physical performance markers reduced throughout match play and countermovement jump performance was impaired, while creatine kinase remained elevated, for at least 48 h after the match	Technical staff could use this information to inform team tactics and training sessions by implementing strategies that aim to minimize reductions in physical performance during the game and to enhance recovery in the days after a match, namely: (1) substitutions; (2) aerobic and anaerobic conditioning programmes; and (3) nutritional supplementation protocols	87.5

Table 3 continued

Study	Sample	Variables/tests	Period analyzed	Main results	Practical applications	Quality score (%)
Soroka and Lago-Penas [53]	301 Players from the World Cup Brazil 2014	Distances covered at different intensities	Performance across a congested fixture period	No differences were found across the analyzed matches in the distance covered in sprint, high-intensity running, moderate-intensity running and high-intensity running. There is not a clear tendency of how playing multiple matches modified the physical performance of players	To a certain extent, top players can cope with a busy match schedule without underperforming	86.7
Sparks et al. [57]	10 Players from a South African University's first team	Distances covered at different intensities. Yo-Yo intermittent endurance test, level 2	Performance across periods of 5 min along the match	The high activity groups showed (1) moderate to large declines in distance covered between the first 15 min of the second half; (2) small to moderate declines in high-intensity running during the first 10 min of the second half First-half activity profiles had a significant impact on recovery after the most intense 5-min periods	First-half activity profiles had a significant impact on recovery after the most intense 5-min periods, as well as on second-half performances, which may be attributed to the presence of transient fatigue	75

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League [20], Spanish Professional Soccer League [21] and Union of European Football Associations (UEFA) Champions League [22]. However, little scientific evidence is available and has only recently been introduced in the scientific community [20–22].

3.4.2.4 Altitude and Environmental Heat Stress Influence on Performance With the aim to examine the effect of altitude and environmental heat stress on football performance, some interesting studies (Table 5) have been developed with the national teams that participated in the Fédération Internationale de Football Association (FIFA) 2010 [23] and 2014 World Cups [24].

3.4.3 Variables Capturing Group Behaviours

3.4.3.1 Team Centre The team centre represents the geometric centre of a set of points that represent the current positioning of soccer players on field during competition [25]. This measure has been used to analyze the collective spatial–temporal synchronization between competing teams and to identify instabilities or transitions that might lead to the emergence of critical moments in a competitive match, such as an opportunity to score a goal [26, 27]. A summary of the studies that have examined the dynamics of the collective variable 'team centroid' (geometrical centre of the players, excluding goalkeeper and not considering the position of the ball) can be found in Table 6.

3.4.3.2 Team Dispersion The quantification of how far players are apart (dispersion) may help in understanding the nature of the space that emerges from the interactive dynamics of competitive matches, helping us to identify the natural expansion and contraction of soccer teams in attacking and defensive moments. Dispersion of the team can be estimated by calculating the area covered by all points of the team (surface area), identifying the dispersion of players from the geometrical centre (stretch index), calculating the Euclidean distance between each player and his/her teammates (a team's spread) or analyzing the effective defensive triangulations (effective area of play and defensive play area) [25, 28, 29]. These measures have been used to observe the oscillations of the areas of the team during attacking and defensive moments and to compare their variability throughout competitive matches (Table 7).

3.4.3.3 Team Interaction/Coordination Networks The communication process may occur in different ways, but, in match analysis, these have been used to classify the interactions between teammates when in possession of the ball, during passing sequences [30]. Social network

Table 4 Studies with predominantly activity profile analysis—substitutions

Study	Sample	Variables	Main results	Practical applications	Quality score (%)
Bradley et al. [20]	(1) An independent-measures analysis comparing the match performance characteristics of players completing the entire match ($n = 810$) vs. substitutes ($n = 286$) and the players they replaced ($n = 286$), English Premier League; (2) repeated-measures analysis comparing the same players completing full matches vs. those in which they were introduced as a substitute ($n = 94$)	Distances covered at different intensities Time and type of substitutions	More substitutions occurred at halftime and between the 60- and 85-min marks vs. all first-half periods and the remaining second-half periods. More offensive substitutions involving attackers and wide and central midfielders were made between the 60- and 90-min marks compared with defensive substitutes such as central defenders and fullbacks Substitutes cover greater high-intensity running distance Both research designs indicated that attackers covered more high-intensity running than peers or their own performances when completing the entire match	It seems that, from a work-rate perspective, substitution seems to be effective, but from a technical and outcome perspective this still needs to be established	92.9
Rey et al. [22]	124 Matches (677 substitutions) from UEFA Champions League	Timing and tactics of substitutions	Coaches tended to hold onto substitutions later when the team was ahead, but made substitutions earlier when either tied or behind. The probability of the substitution being offensive in tactical terms increased when a team was behind in a match. When a team was ahead, coaches tended to make more defensive substitutions	Coaches should be aware that changing a losing scenario appears to depend on changing tactics early in the match	100
Gomez et al. [21]	50 Matches from the Spanish professional soccer league	Substitutions minute and number. Yellow card, functional position, ball, shots on target, possession percentage and ball regained	When the teams were losing, they made the substitutions quicker within the match when compared with if they were in a tied or winning position. Home teams made the substitutions quicker compared with the away teams When a team is losing, the substitutions take place earlier, and, when winning a match, a team makes their first substitution later than the away team. The better the quality of the opposing team, the later the substitutions will take place	Data demonstrate how an effective timing of substitution strategy can improve team performance and modify the final match outcome. Additionally, this study provides coaches with new information on substitution patterns that can be easily integrated into their overall coaching strategy	85.7

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Table 5 Studies with predominantly activity profile analysis—altitude and environmental heat stress influence on performance

Study	Sample	Aim	Main results	Practical applications	Quality score (%)
Nassis [23]	64 Matches from the FIFA 2010 World Cup	Examine the effect of altitude on football performance	It is concluded that playing football above 1200 m had negative effects on endurance, but not on technical skills, during World Cup 2010 matches. It seems that teams should follow several days of acclimatization before playing at altitude as low as 1200 m to ameliorate the negative effects of altitude on physical performance	Teams should not fly to altitudes of 1500–1700 m just 1–2 days before a football match, as is common practice, but should acclimatize for several days	85.7
Nassis et al. [24]	64 Matches from the 2014 FIFA World Cup Brazil	Analyze performance data in relation to the environmental conditions to identify potential associations	Top-level players seem to modulate their activity pattern during matches in a hot and humid environment to preserve the global match characteristics	Technical and medical staff should be aware that football players may alter their physical activity pattern when competing in the heat. Footballers may reduce their physical performance, especially the high-intensity distance covered, to preserve their ability in key physical and technical performance indicators	100

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analysis based on graph and digraph theories has been used to classify general properties of the network and specific centrality levels of players (nodes) [31, 32]. Identifying networks on the field may help in understanding the specific relationships that emerge between teammates during attacking sequences and the general properties of collective team performance during passing sequences. A summary of the studies that analyzed the networks of soccer players can be found in Table 8.

3.4.3.4 Sequential Patterns Sequential patterns analyze sequential combinations of interactions that emerge between players during a match or a set of matches [33]. Some studies (Table 9) have analyzed the attacking patterns of teams in different competitions, considering criteria such as duration of an attacking sequence of play, number and role of players involved in the attack, zone of pitch where the actions were performed, type of technical behaviours, and the number and co-location of players of both teams (interaction context) in the space adjacent to the ball on field [34, 35].

3.4.3.5 Group Outcomes Winning, drawing and losing may be constrained by, or constrain, some match-related statistics [36–38]. Based on these assumptions, some studies (Table 10) have been conducted to identify the variance that might exist between some playing actions and the final outcomes of a match.

4 Discussion

The aim of this paper was to systematically review the evolving patterns of match analysis in Association Football to organize research studies, published between 2012 and 2016, in a theoretically coherent way. After in-depth analysis, it was decided that the most appropriate way to discuss the results would be to categorize research topics according to similar themes (set plays, group behaviour and activity profile).

4.1 Set Plays

4.1.1 Corner Kicks

The reviewed studies that analyzed corner kicks were mainly focused on international competitions [14, 39] and the English Premier League [40, 41]. Corner kick effectiveness values of 2.6% [39], 2.2% [14], 4.1% [40] and 2.7% [41] were found, which means that, on average, between 24 and 45 corner kicks were needed to lead to a single goal scored. Casal et al. [14] reported that the likelihood of a shot on goal could be increased with the involvement of three or four attackers, a dynamic attacking move, and delivery of the ball to the far post. Pulling et al. [40] analyzed the importance of defensive strategy and concluded that the one-to-one marking set-up did not concede any attempts at goal from 95.7% of corner kicks,

Table 6 Studies of group behaviour analysis with the use of team centroid values

Study	Sample	Aim	Variables	Results	Practical applications	Quality score (%)
Frencken et al. [27]	1 Match from the Champions League	Analyze instantaneous variability of inter-team distance	Difference between longitudinal and lateral inter-team centroids	Greater longitudinal and lateral inter-team centroids were found in the first half (7.10 and 0.58 m, respectively) than in the second half (6.54 and 1.18 m, respectively). However, greater variability was found in the second half. Strong correlation values between centroids were found in both halves. Threshold values for the selection of critical match periods were established at 0.83 m (variability of longitudinal inter-team distance), 0.84 m (variability of lateral inter-team distance), 1.62 (longitudinal rate of change) and 1.66 (lateral rate of change)	The technique allowed to identify that dynamical analysis of inter-team distances most strongly relates to match outcomes, thus it can be possible to quantify the ability of players of the defending team collectively to respond to explorations of the attacking team to create opportunities to move forward to score	86.7
Siegle and Lames [62]	1 Match from the final of the 2006 FIFA World Cup	Analyze the relative phase between the team's centroid	Team centroid	A tight coupling between both teams in the longitudinal team centroid in the first half (relative phase 0.00). The coupling in the lateral team centroid was even smaller (relative phase 0.00)	Relative-phase analysis can analyze coupling between teams, groups or players. Perturbations of the game may also be captured by using relative-phase analysis	78.6
Clemente et al. [61]	1 Match from the Portuguese first league	Analyze the relationship between the centroids of the teams	*W*centroid	Spearman test revealed strong relationships between lateral-to-lateral *w*centroid of both teams ($r_s = 0.707$). Similar evidences were found in the longitudinal *w*centroid ($r_s = 0.781$)	This measure represents the possibility of being adjustable to the position of the ball given information about the weight of the players around the ball. Moreover, the distance between centroids may characterize the synchronization of the teams during the match	85.7
Gonçalves et al. [91]	1 Simulated match of 50 min	Analyze the variance of players based on the group centroid	Centroid per position (defenders, midfielders and forwards)	Results showed that all players were nearer and more coordinated with their own position-specific centroid. The results showed stronger in-phase attractions in lateral than longitudinal direction	The data can be immediately interpreted in interaction with the physical and physiological responses, thus providing more possibilities to observe the game in a holistic and valid way	81.3
Aguiar et al. [92]	6 Bouts of 2-, 3-, 4- and 5-a-side games	Analyze the player's distance to the centroid	Centroid	The distance between centroids presented a small decrease from 2- to 4-a-side SSG and a moderate to nearly perfect increase to a 5-a-side SSG. Larger formats of play increase the absolute distance to both the team and opposition team centroid	4- and 5-a-side games are the preferred formats to achieve team-related emergent and self-organized behaviour. Smaller formats are more appropriate to increase the unpredictability	80

FIFA Fédération Internationale de Football Association, *Centroid* geometrical centre of the team that does not depend on the ball, *wCentroid* weighted geometrical centre of the team that depends on the position of the ball, *SSG* small-sided game

Table 7 Studies of group behaviour analysis with the use of the team's dispersion

Study	Sample	Aim	Variables	Results	Practical applications	Quality score (%)
Bartlett et al. [26]	10 Matches from elite European soccer	Associate team's dispersion with notational variables	Surface area, Stretch index, Frobenius norm, Centroid	Positive correlations between attacking variables and dispersion variables were found. It was suggested that teams expand together or contract together in synchrony. Strong positive correlations were found between teams in both directions: goal-to-goal and lateral-to-lateral ($r = 0.99$ and 0.76, respectively). Goal-to-goal correlations were significantly stronger for the 64 successful attacks than for 241 unsuccessful attacks. No crossing of the centroids of the two teams along the pitch leading up to any of the 14 goals being scored from open play in 50% of the matches was found	In 11-a-side games, the centroid and associated dispersion measures are not sensitive enough to signify critical events. It can be possible to analyze multi-dimensional coordination of groups of more than two players using self-organizing maps. The team length and width should not be used to analyze 11-a-side games	92.9
Moura et al. [28]	8 Matches from the Brazilian first league	Characterize the Brazilian team's coverage are and spread on the pitch	Frobenius norm, team coverage area	All teams had greater values of the Frobenius norm and coverage area in situations of ball possession compared with when they did not. In defending situations, the greater values of coverage area and Frobenius norm were observed when teams suffered shots on goal in comparison with tackles performed. In attacking situations, greater values of Frobenius norm and team coverage area were observed when teams suffered tackles in comparison with when shots on goal were performed	Using automatic tracking systems would be possible to identify the organization on the pitch and systematize tactical strategies of the teams	85.7
Duarte et al. [59]	1 Match from the English Premier League	Analyze the variations in the patterns of collective behaviour	Surface area, Stretch index, Team length, Team width, Geometrical centre	Team length tended to be larger in the home team. Greater values of width were found in the visiting team during the first two periods. The fourth and fifth periods had greater values of dispersion in the home team, after two goals were scored. Approximate entropy applied in dispersion measures revealed a decrease of complexity with the course of the match. Approximate entropy of the geometrical centre per time period: 0.36 (0–15 min); 0.34 (15–30 min); 0.30 (30–45 min); 0.40 (45–60 min); 0.34 (60–75 min); 0.36 (75–90 min). Larger average values of geometrical centre were found in the first half than in the second half	The five collective measures used in this study can be used to capture the idiosyncratic performance values of each team as competitive performances unfold. Data also revealed that teams tended to be less complex over the time but increasing the magnitudes of variation in their organizational shape	85.7

Table 7 continued

Study	Sample	Aim	Variables	Results	Practical applications	Quality score (%)
Fradua et al. [69]	4 Matches from the Spanish first league	Examine the playing area during official matches	Playing area, Length and width of the team, Distance from defending and attacking goalkeeper	Individual playing area: (1) ranged between 78.97 and 93.87 m^2; (2) has changed based on the location of the ball; (3) decreased as the ball approached the middle of the pitch. A rectangle that included all outfield players became smaller as the ball was played in the middle of the pitch	This study revealed that small-sided games can replicate the tactical aspects of full matches. The pitch sizes are valuable for ensuring training specificity of tactical factors. Build-up play and finishing phase should be played with an individual player area of 90 m^2, and transition play should be designed with an individual area of 80 m^2	93.3
Castellano et al. [68]	6 Matches from one team of the Spanish first league	Identify collective tactical decisions from high-level teams	Surface area, Team length, Team width	Length and width were greater in the offensive phase in matches against weak opposition. Both variables were also greater during the defensive moments against stronger teams. The range values of surface area were 800–2800 m^2 in offensive moments and 1000–2000 m^2 in defensive moments	The use of standardized pattern behaviour in the attack can be influenced by the quality of opposition. Therefore, a more efficient coordination in the defensive phase may be appropriate to reduce the effects of higher opponents' irregularity	85.7
Clemente et al. [25]	3 Matches from the Portuguese first league	Analyze the variance of weighted stretch index, surface area and effective area of play between halves	Weighted stretch index, surface area, effective area of play	Greater dispersion was found during offensive moments in comparison with defensive moments. Weighted stretch index, surface area and effective area of play were smaller in the second half in situations with and without ball possession With and without the ball, longitudinal *w*centroid was greater in the first half. Higher values of lateral-to-lateral *w*centroid were found in the first half. Lateral-to-lateral *w*centroid reveals a change of flank between the first and second halves with ball possession	The use of collective measures allowed to identify that dispersion of the team decreased from the first to the second half of the match. An expansion–contraction relationship between the offensive and defensive moments was also detected by the collective measures	92.9
Frencken et al. [29]	4 Small-sided games (4-a-side format)	Analyze the effect of three small-sided games in the surface area	Surface area, Difference between surface areas	4-a-side played at 24 × 16 m had greater surface area (38 ± 1 m^2) in comparison with 30 × 20 m (34 ± 29 m^2), 30 × 16 m (31 ± 25 m^2) and 28 × 21 m (28 ± 21 m^2). Differences between surface areas (of both teams) were greater at 30 × 20 m and 24 × 16 m pitch	Expert players can extract more pertinent information related to player movements more quickly than novices. Absolute values of inter-team distances are key performance indicators in which the strength of the relation is an indicator of playing level	92.9
Moura et al. [66]	20 Matches from the Brazilian first league	Characterize the surface area and spread time series of soccer teams	Surface area Frobenius norm	Both surface area and Frobenius norm were distributed at low frequencies and the values decreased the median frequencies of the time series from the first to the second half	Surface area and spread time series were distributed at low frequencies and the median frequencies decreased from the first to the second half. Results can provide valuable information about the player organization on the pitch and can be used by coaches to adjust tactical behaviours and design new tasks	85.7

Table 7 continued

Study	Sample	Aim	Variables	Results	Practical applications	Quality score (%)
Clemente et al. [65]	3 Matches from the Portuguese first league	Analyze the variance of weighted stretch index, surface area and effective area of play in the three-possible match status	Weighted stretch index, surface area, effective area of play, *w*centroid	Statistically greater values of weighted stretch index (17.44 ± 3.48 m), surface area (1735.63 ± 511.99 m^2) and effective area of play (967.41 ± 663.49 m^2) were found in a drawn score. No differences were found between losing and winning situations Lateral-to-lateral *w*centroid was statistically greater in losing matches than in drawing or winning. Similar evidences were found in the longitudinal *w*centroid	Losing status reduced the space between teammates, increasing the compactness. In drawn situations, the dispersion of teammates was greater than in losing or winning moments. The measures used in the study can provide valuable information about the collective organization of the teams	85.7
Clemente et al. [70]	3 Matches from the Portuguese first league	Analyze the variance of defensive play area between halves and match status	Defensive play area, number of triangulations per defensive play area	Greater values of defensive play area (defensive backward region, defensive first half of the middle region, defensive second half of the middle region, defensive attacking region) were observed in lost matches and during the first half. No differences were found between drawing and winning status	Defensive play area allowed to characterize the inter-sector process during defensive moments. The triangulations allowed to characterize the space between teammates and how they behave during the defensive process	92.9
Moura et al. [67]	20 Matches from the Brazilian first league	Test the anti-phase and in-phase of team spread	Frobenius norm	An in-phase relationship between opposition team spread was predominantly found Sequences ending in shots on goal represent greater anti-phase	Coaches should be aware that the way their own teams are organized may induce changes in the opponent's organization. Such results may be used as a tactical strategy by coaches to influence the status and dynamics of the game	92.9

Table 8 Studies of group behaviour analysis with the use of network

Study	Sample	Aim	Variables	Results	Practical applications	Quality score (%)
Grund [30]	76 Matches for 23 teams of the English Premier League	Analyze the association between network density and centralization and the number of goals	Network density, network centralization	Greater levels of network density lead to a higher number of goals. Inversely, a more centralized interaction leads to a decreased number of goals. A correlation value of 0.18 was obtained for the association between network intensity and goals. A negative correlation of − 0.10 was obtained between centralization and goals	Using this analysis, it could be possible to measure team performance and network structure at the same time. It can be argued that the realized passing structure represents an underlying pattern of orchestrated team play	85.7
Cotta et al. [31]	3 Matches from the Spanish team during the 2010 FIFA World Cup	Analyze which players tend to cluster together during passing sequences, and the most important players	Clustering coefficient, Centrality	Xavi Hernández (central midfielder) and Xabi Alonso (defensive midfielder) were the dominant players during the quarter-finals. Clustering coefficient was greater between the 10–20′, 40–50′ and 70–80′ periods. In the semi-final, clustering coefficient was greater in the first half. Once again, Xavi Hernández and Xabi Alonso were the dominant players in the team. Clustering levels were greater in the 20–30′, 60–70′ and 80–90′ periods of the final. Xavi Hernéndez and Cesc Fàbregas (central midfielder) (in extra time) were the prominent players	The measures used in the study allowed to capture the combinative nature of the 'tiki-taka' style. The techniques can be promising in the future to find other properties associated with each team	85.7
Gama et al. [74]	6 Matches from Portuguese first league	Analyze the connection tendency between teammates	Relative frequency odds method	Left defender was the dominant player in to receive and in to pass the ball. Participation of players 5, 8 and 25 influenced the ball movement during attacking	The approach allowed to capture intra-team interactions across several games, suggesting that some structures of play are stable in the team independently from the opponent	78.6
Clemente et al. [32]	64 Matches from the 2014 FIFA World Cup	Analyze the variance of in-degree, out-degree, closeness and betweenness centralities between playing position and tactical line-up	In-degree, out-degree, closeness centrality, betweenness centrality	Midfielders and external defenders had the higher values of in-degree, out-degree, closeness and betweenness centrality, especially in 1-4-3-3 and 1-4-2-3-1 tactical line-ups. The greater mean values per each measure were in-degree (12.32), out-degree (13.46), closeness (10.17) and betweenness (14.40)	The use of centrality network measures can be used to classify the prominent players in an opposing team and develop defensive strategies to negate the actions of these players during a competitive match	92.9

Table 8 continued

Study	Sample	Aim	Variables	Results	Practical applications	Quality score (%)
Clemente et al. [71]	64 Matches from the 2014 FIFA World Cup	Analyze the variance of general network measures between levels of the teams and associate the metrics with goals scored	Total links, network density, network diameter, clustering coefficient	Goals scored showed a small positive correlation with total links, network density and clustering coefficient. Shots also had a small positive correlation with total links, network density and clustering coefficient. Network diameter had negative correlations with goals scored and shots. Teams that achieved the highest stages in the competition revealed greater capacity to disperse the ball for all teammates	The study suggested that the farthest relationship between teammates can lead to decreasing the possibility of scoring and shooting. Based on that, coaches may design games to increase the homogeneity of relationships and to improve the possibility to be successful in attacking situations	85.7
Clemente et al. [93]	5 Matches from the Portuguese first league	Characterize the general properties of the network	Network density, network heterogeneity, network centralization	Network density varied between 0.3199 and 0.3795; network heterogeneity varied between 0.4182 and 0.4901; and network centralization varied between 0.2114 and 0.3127	The general measures allowed to identify how players connect with each other and the type of strength of the connections between them	85.7
David and Wilson [94]	1564 Matches from national and international competitions	Test the association between cooperation and winning; verify the contribution of each type of cooperation for the winning; test the effect of competition on the cooperation; test the association between cooperation and shooting at goal	Degree, strength, division of labour	Winning teams had higher frequencies of network interactions. Teams with less division of labour were more successful. Greater: (1) levels of passes were found in international tournaments; (2) levels of network were associated with proficiency in shooting at goal; (3) volume of successful passes was associated with a decrease in the opposition's number of network interactions	This study allowed to show that greater activity in physical tasks may not translate into greater team success, showing that greater physical effort is not associated with winning. Rather, more passing interactions between particular players are likely to create better scoring opportunities to win matches	85.7
Clemente et al. [72]	7 Matches from the 2014 FIFA World Cup	Test a new network software Characterize the network process of the FIFA World Cup	Total links, graph density, degree centrality, degree prestige, betweenness centrality	Midfielders had the greater values of degree prestige (12.83), degree centrality (12.58) and betweenness (13.50). The competition stage did not influence the prominence level of playing positions. Total links and network density did not significantly change between group matches and elimination matches	The Ultimate Performance Analysis Tool (uPATO) software can be used by coaches and staff to quantify the teammate's interactions and produce adjacency matrices to be imported in social network software to generate information about the collective structure of the team	100

Table 8 continued

Study	Sample	Aim	Variables	Results	Practical applications	Quality score (%)
Clemente et al. [75]	36 Matches from the Portuguese first league	Characterize the network process during scored and conceded goals	Clustering coefficient, In-degree centrality, Out-degree centrality, Closeness centrality, Betweenness centrality	Attacking midfielder, and left and right forwards were the players with greater in-degree centrality during attacks that resulted in scored goals. Higher values of out-degree were found in right defenders. The greatest betweenness centrality was found in left and right forwards. The greater clustering coefficients were found in the attacking midfielder and striker. Strikers and left forwards were the prominent playing positions to receive the ball in the conceded goals. The greatest value of clustering coefficient was found in left defenders in the conceded goals	Using network analysis, it was possible to classify the most commonly used interactions of a team to produce goals and how they conceded goals against opponents. Moreover, the passing trajectories allowed to identify that passing to teammates in forward sectors of the field increases the possibility of scoring	92.9

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whereas a zonal marking system did not concede goal attempts from 97.7% of corner kicks. In addition, the percentage of corner kicks resulting in a goal or attempt at goal was higher when the defending team used a one-to-one marking system (31.3%), compared with a zonal marking system (30.2%). The investigators highlighted that, although this finding may suggest that a zonal marking set-up is better for defending corners, the percentage difference between these systems is very small. Variables such as the area (e.g. zones inside the penalty area) where the ball was delivered, the type of delivery (long- and short-corner kicks), and the influence of some situational variables (e.g. teams performed more short corners and took more short kicks and outswinging corner kicks when winning, but outstep and inswinging corner kicks when drawing and losing) [39] in the strategies used to perform the corner kick were also analyzed.

Data from the reviewed studies suggest that coaches should design training sessions that simulate the execution of more elaborate corner kicks that involve a short initial kick, followed by a dynamic interaction involving three or four players, before the ball is crossed to the far post. Regarding defensive strategies at corner kicks, there seem to be few differences in the effects of using zonal marking versus one-to-one marking systems. Additionally, coaches should be aware that the positioning of players on the goalpost(s), when defending corner kicks, does not significantly prevent goals from being scored. Rather this tactic actually increases the frequency of attempts on goal by the opposition. These findings suggest that the players positioned at goalposts could be 'used' to carrying out other defensive functions.

4.1.2 Penalty Kicks

The penalty kick is a peculiar event involving a direct confrontation between two opponents directly functioning in a dyadic system—the penalty taker and goalkeeper [13]. It is one of the most pressured and intense moments in a competitive match. In male professional football, approximately 70% of penalty kicks are scored [42].

The studies reviewed [13, 42–44] could help penalty takers and coaches improve their chances of successful outcomes as they provide information suggesting that (1) the areas of the goal to which the ball is aimed is significantly important for penalty effectiveness [13, 42]; (2) saves depend mainly on the goalkeeper's reaction time but also on the ball speed in the penalty kick [42]; (3) situational factors (e.g. period in the match) may influence the success of penalty kicks [13]; (4) goalkeepers should wait longer in order to dive to the side of the goal to which the ball has been kicked [13]; and (5) penalty takers should use

Table 9 Studies of group behaviour analysis with the use of sequential patterns

Study	Sample	Aim	Variables	Results	Practical applications	Quality score (%)
Camerino et al. [34]	10 Matches from the Spanish first league and UEFA Champions League	Describe the patterns during the attacking processes	Attacks categorized by lateral position, zone, possession and interaction contexts	Regularities of Barcelona during ball possession were revealed. It was suggested that the first patterns include penetrating in the central zone before moving forward and attacking as close as possible to the opposition's goal	T-patterns have enabled to identify and define the playing offensive style of the team providing a notion of most representative interaction, the way of moving toward the opposing team's goal or the preference to pass the ball in the pitch	85.7
Sarmento et al. [33]	36 Matches from FC Barcelona (n = 12), Manchester United (n = 12) and Internazionalle Milano (n = 12)	Describe the patterns during attacking processes	Attacks categorized by zone, possession, technical action and interaction contexts	Different sequential patterns are identified as a result of different philosophies of the match. Specific differences are identified regarding the starting zone, development and finalization of the offensive process	The two analysis techniques helped to understand the tactical patterns of teams, and also identified individual characteristics of the players and the tactical technical and strategic aspects of the game. Based on that, it can be possible to design more appropriate exercises	92.9
Zurloni et al. [35]	19 Matches from the Italian first league	Detect the dynamics of attack actions	Attacks categorized by lateral position, zone, lateral passing, zone passing, recovery and loss, and ball out of play	Patterns were more consistent in winning situations A pattern to exploit the right side moving forward was found. In losing situations, patterns were less regular, maybe to test alternative strategies to gain control of the match	Results suggested that t-pattern analysis can be an effective tool to support research in sport-performance analysis. It was possible to differentiate structures of play in won and lost games	78.6
Cavalera et al. [76]	3 Matches from the Italian first league	Analyze the variance of temporal patterns between halves	Attack situation with the following ending: goal, non-goal and permanent loss	The number of patterns statistically increased from the first to the second half. Structure and distribution between won and lost matches were also different Inversely, with the first half, patterns of attack during the second half frequently ended with a shot	It was possible to identify recurrent behaviours related to effective and non-effective playing actions and to show countermeasures to opposing teams	78.6

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both a keeper-independent strategy and keeper-dependent strategy in order to increase their chances of success [43].

4.1.3 Free Kicks

Despite the importance of set-piece goals in modern football, free kicks have not been extensively studied [45, 46]. The study by Link et al. [46] revealed an average of 34.9 ± 7.6 free kicks per match, while Casal et al. [45] concluded that, on average, each team takes three indirect free kicks aimed at scoring a goal per match. Of these, 21.8% ended in a shot, 9.3% ended in a shot between the posts, and 2.9% ended in a goal. The type of attack and the number of players involved in the process has a direct influence on the outcome. Furthermore, Link et al. [46] analyzed variables such as position

Table 10 Studies of group outcomes

Study	Sample	Categories	Variables	Results	Practical applications	Quality score (%)
Castellano et al. [36]	177 Matches from the FIFA World Cup 2002, 2006 and 2010	Winning, drawing, losing	Goals scored, total shots, shots on target, shots off target, ball possession, number of off-sides committed, fouls received, and corners	Total shots and shots on target (made and received) were the main discriminatory variables between winning, losing and drawing. Ball possession was not a discriminating variable	The game models based on indirect style seem to have more chance of success. The effectiveness of attacking play and ball possession appear to be the key indicators for success, and, for that reason, coaches must consider such information to organize their models of play	92.9
Gomez et al. [78]	1900 Matches played over 5 seasons on the Spanish professional league	Match location, Final outcome	Goals, shots, committed fouls, turnovers, ball recovers, crosses	Home matches lead to higher frequencies of goals, shots, committed fouls, turnovers, ball recovers and crosses. Winning teams had a greater volume of ball recovery at zone 2 and tended to organize the offence through long passing sequences	Home matches contribute to the frequencies of notational variables increasing. Discriminating winning teams from losing teams may also provide information about which variables must be considered by coaches to increase the possibilities for success	85.7
Lago-Ballesteros et al. [79]	12 Matches from the Spanish professional league	Playing tactics, Opposition interactions, Situational variables	Success, duration, starting zone, team possession type, pass number, players in possession, passing options, Opposition, defensive pressure, match location, quality of opposition, Match status	When the team was drawing or winning, the probability of reaching the penalty area decreased dramatically compared with the losing situation. Teams often showed a more defensive strategy when winning than when losing, and vice versa. Direct attacks and counterattacks were more effective than elaborate attacks. Playing against less than six defending players increased the offensive effectiveness. Long possessions were more effective than short possessions	Direct attacks and counterattacks were more effective than elaborate attacks for increasing penalty area penetration (defined as an entry into the opposition penalty area with a high degree of control over the ball or when a set play is given to the attacking team as a result of penetration of the penalty area). A more defensive strategy is adopted by winning teams than by losing teams. Such information can be used by coaches to organize the training tasks and to anticipate situations of winning and losing	92.9

Table 10 continued

Study	Sample	Categories	Variables	Results	Practical applications	Quality score (%)
Collet [95]	6078 Matches from clubs and 299 national teams	Possession Outcome	Completed passes, total passes, shots on goal, outcome	Ball possession was a direct predictor of positive outcomes in domestic competitions in Europe, as well as European club and national team competitions. Teams that possessed the ball more shot more and scored more. Frequent and accurate passing were strongly linked to shots, goals and points	Tactical analysis, based on possession of the ball, should consider variations in quality and the competitive context. Coaches must adapt ball possession strategies to increase the efficiency of the team in different scenarios	100
Russell et al. [82]	One team during the 2010/2011 English championship season (23 home matches)	First vs. second half	Possessions, ball distributions, touches taken per possession, number of challenges	Total possessions and number of ball distributions were lower in the second half vs. the first half of match play. Analysis across 15-min intervals revealed reductions during the last 15 min of match play in the total number of possessions and distributions. The number of touches taken per possession, number of challenges, percentage of challenges won, length of forward distributions and percentage success of distributions were all similar between halves and across 15-min intervals	Transient changes occurred in selected measures of technical performance during match play. Individual possessions and passes performed were smaller in the second half. Coaches must consider such decreases in performance to adjust the training plan and minimize such occurrences	92.9
Almeida et al. [80]	28 Matches from the UEFA Champions League	Home vs. away; Winning, drawing, losing; Better ranked, similar ranked, worse ranked	Ball recovery type and zone	There is a tendency for home and losing teams to defend in more advanced pitch zones. Better-ranked teams were more effective than worse-ranked teams in applying defensive pressure in more advanced field positions	Coaches must be aware that promoting the intention to directly gain the ball from the opponents and pressurizing the opposing team near its goal seems to be more effective for defensive moments	92.9

Table 10 continued

Study	Sample	Categories	Variables	Results	Practical applications	Quality score (%)
Bradley et al. [81]	54 Matches from the English Premier League	Home vs. away, quality of opposition, team ranking, minutes winning/drawing		Playing against weak opposition was associated with an increase in time spent in possession, while playing away decreased the time spent in possession by $\sim$ 3%. Possession was increased when losing, than winning or drawing. The better the ranking of a team, the higher the time spent in possession	Technical, tactical or physical aspects of performance can be adversely influenced by specific situational variables. Coaches and analysts may be aware of these variables and adjust training exercises and strategies to avoid a decrease in performance	92.9
Harrop and Nevill [37]	46 Matches played by a League One soccer team	Winning, drawing, losing	Offensive and defensive match-related statistics	More passes and passes in the opposition half were made when the team lost compared with when they won and drew matches. A lower percentage of successful passes were completed when the team drew	Direct play is a more effective approach for teams without sufficient skill levels to sustain ball possession in a succeeded way. Coaches must also be aware that the location of the match can affect the team's performance and the possibility of success	85.7
Moura et al. [77]	32 Teams playing three matches at the FIFA World Cup 2006	Winning, drawing, losing	Shots, shots on goal, goals performed, fouls committed/suffered, corner kicks, direct free kicks to goal, offside, own goals, yellow cards, expulsions due to second yellow cards, direct expulsions, actual playing time with possession of the ball and percentage of ball possession in relation to the total time played	The variables 'shots', 'shots on goal', 'playing time with ball possession' and 'percentage of ball possession' are important to discriminate the winning teams from the drawing and losing teams	Variables such as shots, shots on goal, playing time with ball possession and percentage of ball possession can be used to adjust training plans to improve the execution level	92.9
Wallace and Norton [18]	Final match of each of the 12 World Cup soccer tournaments between 1966 and 2010	Elements of match structure and speed	Play and stop periods, ball speed, player density and passing rates	The increased intensity of play is paralleled by longer stoppage breaks that allow greater player recovery and subsequently more intense play. Defensive strategies dominate over time, as demonstrated by increased player density and congestion	Rapid self-organization in a dynamical system, underpinned by prediction speed and accuracy, skill and fitness will increase the probability of success	92.9

Table 10 continued

Study	Sample	Categories	Variables	Results	Practical applications	Quality score (%)
Castellano and Casamichana [84]	320 First-division matches and 335 second- division matches	First vs. second Spanish division	Variables related to use of space, physical performance and technical/tactical actions	The most successful teams in the first division of the Spanish football performed differently to the other teams analyzed in terms of the majority of variables studied	Successful and less successful teams can be differentiated by performance indicators. Attention to such indicators could make it possible for coaches to improve team playing patterns so that they become more successful	92.9
Paixao et al. [96]	20 Matches from the UEFA Champions League	Winning, drawing, losing	Length of passing sequences (number of passes and duration)	Teams used preferentially long passing sequences when they were losing or drawing, and short passing sequences when they were winning. Additionally, they tended to differently adapt the length of their passing sequences according to the evolving score line	Enable to characterize opponent's teams and to provide useful information to increase tactical knowledge and to improve the design and organization of practice sessions by simulating competitive scenarios	92.9
Garcia-Rubio et al. [83]	475 Matches from the UEFA Champions League	Home vs. away, Scoring first, Group stage, knockout phase, Quality of opposition	Shots on goal, shots off target, off-sides, corners, fouls committed	When scoring first, homes teams win 62.3 and 55.8% in the group and knockout stages, respectively. Regression analysis has found match location as a predictor in group stage, but not in the knockout stage. Scoring first or match location variables can dissolve the quality of opposition variables due to interactive effects of all variables	Identifying the interactive effects of situational variables (home vs. away, scoring first, group stage, knockout phase and quality of opposition) on the performance indicators can be possible to identify and prepare the team to increase or reduce this effect based on the team's need	92.9
Carling et al. [97]	38 League matches per season played over five consecutive seasons	League rankings, points won, goals scored and conceded, and match outcomes	Ball possession and possession in opposition's half, passes, forward passes, completed passes and forward passes, crosses and completed crosses, goal attempts and goal attempts on target, successful final third entries, free-kicks and 50/50 duels won/lost. Total distance and distance covered at high speeds	Highest number of points obtained by the reference team was observed in the championship winning season In all seasons except 2008/09, there was an increase in the number of points won per match for the second half of the season with the largest augmentation In the 2010/11 season, the reference team scored at least one goal, did not concede a goal, and scored first on a greater number of occasions	Higher player availability for selection linked to the ability to remain injury-free combined with good defensive rather than attacking performance may contribute to an increase in the possibility of success	92.9

Table 10 continued

Study	Sample	Categories	Variables	Results	Practical applications	Quality score (%)
Liu et al. [85]	496 Matches of the UEFA Champions League (2009/10 to 2012/13 sporting seasons)	Three	k-means cluster analysis based on UEFA season club coefficients. High-, intermediate- and low-level teams	Comparisons on the performance profiles of teams of all three levels of strength showed that high-level teams are characterized by stability of performance no matter which opposition they are playing against, with resulting pressure, or where they play. On the other hand, performances of intermediate- and low-level teams are associated with more variation in different situational variables	The observational analysis of opponents must identify the specific circumstances of performance. Moreover, observational analysis of their own teams must be used to identify specific patterns and conditions that coaches should use to enhance performance in training	100
Gonzalez-Rodenas et al. [98]	30 Randomly selected matches from US major league soccer	Playing tactics, Match location, Match status, Match half	Scoring opportunities	Set plays created a higher volume of scoring opportunities than recoveries and restarts. Match location, match status and match half had correlations with scoring opportunities	Soccer coaches should be aware that counterattacking effectiveness, performing penetrative actions and penetrative possessions depend on the opponent situation. Thus, coaches must use tasks to simulate different positions of opponents trying to improve the effectiveness and solutions of the team	92.9
Fernandez-Navarro et al. [86]	97 Matches from the Spanish La liga and the English Premier League	English vs. Spanish first league teams	19 Performance indicators—14 describing aspects of attacking play and five describing aspects to defensive play	Six factors, representing 12 different styles of play (eight attacking and four defensive), had eigenvalues > 1 and explained 87.54% of the total variance. Direct and possession styles of play were the most apparent styles	Profiling of playing styles can be used on opponents to identify their dominant styles. By knowing such profiles, coaches may prepare the most appropriate strategies and tactical behaviours that may disrupt the opponent's organization	85.7

Table 10 continued

Study	Sample	Categories	Variables	Results	Practical applications	Quality score (%)
Hoppe et al. [99]	306 Matches from German Bundesliga	Success across the season	Match running performance	The match running performance alone was not significantly correlated with the final points accumulated. Positive significant correlations were observed for match running performance with ball possession	Running performance in competitive matches alone is not sufficient to estimate successful performance outcomes in German teams. The relationship between running performance and technical/tactical skills with regard to ball possession is most prominent. Coaches must consider the need to organize training sessions based on this relationship	100
Lago-Penas et al. [38]	1826 Matches from the English Premier League, French League 1, Spanish La Liga, Italian serie A and German Bundesliga	Home vs. away; winning, drawing, losing; scoring first; quality of the opposition; intervals of 15 min	The team that scored first, the minute in which the goal was scored and the quality of the opposition	Home teams scored first in 57.8% of matches and went on the obtain 84.85% of points won in these matches. When the away team scored first, they obtained only 76.25% of subsequent points. Three independent variables were significant factors on the final outcome: (1) the quality of the opposition; (2) the minute in which the first goal is scored, and (3) the team scoring first	Scoring the first goal assumes great importance in elite football. However, the effects of scoring first depend on the quality of the opposition. Coaches must prepare the team for different scenarios to increase the capacity to deal with the unpredictability of match status	100
Liu et al. [100]	320 Close matches (goal difference ≤ 2)	Match location	16 Football match events	All the variables showed clear within-team relationships and 11 events showed clear between-team relationships with the probability of winning. Ball possession had a small negative within-team effect but a small positive between-team effect on winning	Generalized mixed linear modelling can be more powerful than identifying key performance indicators. More objective information can be collected and provided to coaches	100

Table 10 continued

Study	Sample	Categories	Variables	Results	Practical applications	Quality score (%)
Winter and Pfeiffer [101]	Twenty-seven of the 31 matches played by the 16 teams of the UEFA Euro 2012	Winning, drawing, losing	Goal scoring index, ball recovery index, successful transition index, ball recovery time, ball loss index, prevented transition index, ball loss time, offence efficiency and time, defense efficiency and time	The tactical metrics presented can be summarized in four factors (match speed, transition play after ball loss, transition play after ball recovery and efficiency in open (offence) play). These factors are suited to discriminate winners, losers and drawers, with 64.81% correct classifications	The four factors can be used by coaches to prepare the teams, organize the strategy and plan exercises to increase the possibility of success	92.9

UEFA Union of European Football Associations, *FIFA* Fédération Internationale de Football Association

(2D-location of the free kick on the field) and zone (free-kick location in the attacking third on the field of play (35 m from goal), according to a specific categorization by the authors of the playing area. This included density (number of free kicks in each 1 m^2 sector on the field), interruption time (time span between the foul that led to the free kick and the moment of ball contact when taking the free kick), distance to defensive wall (shortest distance between the ball and the defensive wall at the moment of ball contact), number of players participating in the wall, rule violation, type of play (shot on goal, cross, pass), and outcome shots (goal scored, header, save made by the goalkeeper, etc.). However, studies of this specific event remain rare and more research is needed to better understand the influence of different variables in the effectiveness of the free kick.

Nevertheless, the reviewed scientific evidence suggests that coaches could design specific training sessions that aim to improve the effectiveness of free kicks. They could facilitate players working on elaborate kicks, with the ball being played along the ground and involving interactions between three or four players (trying to reach the opposing team's penalty area using short passes and dribbles).

4.2 Activity Profile

4.2.1 Playing Roles

The relationship between a player's positional role and performance continues to be frequently studied [16, 47–52]. However, in their analysis, Sarmento et al. [1] concluded that previous investigations had grouped players according to different criteria, which made it difficult to accurately compare results regarding player roles.

In line with previous research findings (see Sarmento et al. [1] for a review), the results confirmed that midfielders covered the greatest average distance, followed by attackers, and then defenders. However, Clemente et al. [48] proposed an alternative way of conducting this analysis (distance that each player covered per minute) involving distance covered in possession of the ball and distance without the ball. This revision helped in understanding the running pace of players (m/min) during the match. Moreover, using such an approach, it was possible to compare players who played less frequently (minutes on field) with those who played more. This relative measure based on time allowed us to make comparisons between all players in the competition, independent of their playing time. The results showed that the greatest distances, in possession of the ball, were achieved by midfielders, followed by forwards. Significant differences were also observed between defenders who played wider (more distance covered in possession of the ball) and central

defenders. Without the ball, midfielders covered the greatest distances during play.

Additionally, Andrzejewski et al. [50] found that the mean total sprint distance covered by professional soccer players in the UEFA Cup (≥ 24 km.h^{-1}) amounted to 237 ± 123 m. The sprint distance covered by forwards was the highest (345 ± 129 m), 9% greater than midfielders (313 ± 119 m), and over 100% greater than the same value for central midfielders (167 ± 87 m). Elite footballers performed an average number of 11.2 ± 5.3 sprints per match, of which 90% were shorter than 5 s duration and only 10% were longer than 5 s. The results also revealed that forwards and wide-playing midfielders performed a far greater number of short duration sprints compared with central midfielders and central defenders. In addition, wide-playing defenders (e.g. wing backs) performed the highest number of long-duration sprints, differing significantly from central midfielders, who performed the fewest sprints.

A common mistake made by coaches preparing players for performance is application of the same workload to all players during training sessions. The reviewed studies identified specific physical load profiles for football players during a match, dependent on their specific playing positions, which can be used to design highly individualized training programmes for specific players.

4.2.2 *Fatigue Influence*

Interest in fatigue in football has mainly focused on the impact of a congested fixture list [53, 54], extra time periods [55, 56] on player performance, and variations in performance across a whole season [17]. Additionally, some researchers [57] investigated the fatigue rates and pacing strategies of players during matches by quantifying high-intensity running in rolling 5-min periods.

Studies of extra time clearly showed a greater decrement in physical performance markers during this period [55, 56]. Penas et al. [55] found that performance decrements affected players in all roles to a similar degree. Additionally, all of the physical markers under study showed a decline of 15–20% during the extra-time period in comparison with the first-half performance, and an increase in low-intensity activities in the second half. Russell et al. [56] verified that between 105 and 120 mins, acceleration and deceleration parameters reduced by $> 10\%$ compared with the opening 15 mins.

Dellal et al. [54] examined three different congested fixture periods (six matches in 21 days) and concluded that physical activities and technical performances were unaffected during these periods. Nevertheless, injury rate during match play was significantly higher during congested periods in the fixture list. This difference between training and match play can be explained by the low-intensity training promoted by coaches, the greater emphasis on recovery training programmes in the modern game, as well as players regulating their activity. The results reported by Soroka and Lago-Penas [53] are in line with data reported by Dellal et al. [54], although their study focused on a smaller congested period (three consecutive matches separated by 4 days).

It is noteworthy that the study by Dellal et al. [54] surpassed the limitations of previous research that investigated sporadic congested fixture schedules and only analyzed physical performance across two or three consecutive matches within a short time frame. They concluded that the overall distance covered was greater in the third period (October–November) of the season, whereas no differences were observed in the other speed thresholds (first period—August; second period—September). No studies have examined whether physical and technical activities decreased or varied according to stages of the season. However, a study by Silva et al. [17] examined match activity and the development of fatigue during competitive soccer matches in different periods across a whole season. They reported an association between muscle strength and power, and performance decrements in match-related physical parameters. Their results highlighted the importance of incorporating specific exercise programmes to improve the athletes' strength and power during performance.

The reviewed studies highlighted different fatigue-related mechanisms related to physical performance decrements throughout the duration of a normal match (i.e. $90 +$ mins), the duration of extra time (i.e. 120 min) in match play, or during a congested fixture period (e.g. when three games may be played in 1 week). The available knowledge seems to be useful for technical and medical staff in their implementation of specific strategies to minimize performance decrements during a match or a congested fixture period. Such strategies would include (1) specific exercise programmes to improve the athletes' aerobic capacity during the performance of soccer-specific activities; (2) nutritional supplementation protocols; (3) low-intensity activities during training sessions and adequate rotation of players in congested fixture periods; (4) use of objective markers of fatigue combined with subjective measures of performance; and (5) adaptation of tactical strategies.

4.2.3 *Substitutions*

As a limited resource for tactical interventions, substitutions are assumed to be important in football, although little scientific evidence is available on this issue [20–22]. Gomez et al. [21] concluded that most of the first and

second substitutions occurred during the final third of the match (between 61 and 90 mins), while the third substitution occurred predominantly during the final quarter of the match (76–90 mins), in the Spanish first division. Conversely, in the English Premier League and UEFA Champions League, a large number of substitutions occurred at halftime and between 60 and 85 mins [20] and 57 and 78 mins [22], respectively.

The most substituted position is the central midfielder, followed by forwards, wide midfielders, fullbacks, and central defenders. Additionally, 'like-for-like' substitutions (the same playing position for player in and player out) were the most common, and the defensive and offensive substitutions showed similar distributions [21]. Substitutions became more attack-minded as the second half progressed [20].

Regarding match performance characteristics, Bradley et al. [20] found that the same players displayed more high-intensity running when they were introduced as substitutes compared with the equivalent period of the second half, but not the first-half period when tracked from the start of the match. The distances covered by high-intensity running were greater for attacking substitutes. These results were interpreted according to perceived tactical options and specific physical demands of playing roles.

The effects of situational variables on timing and tactics of substitutions have also been analyzed [21, 22]. Rey et al. [22] presented a decision-tree analysis that could be used to inform UEFA Champions League coaches by using the following heuristics: if losing a match, make the first substitution prior to the 53rd min, make the second substitution prior to the 71st min and make the third substitution prior to the 80th min; if the scores are tied or the team is ahead, make substitutions at will.

The results of these investigations can provide valuable information so that coaches could optimize player and team performance, but more work needs to be undertaken to investigate the overall impact of substitutes on physical and technical indicators, and their contribution to key moments in matches [20–22].

4.2.4 Altitude and Environmental Heat Stress Influence on Performance

Based on the assumption that exposure to altitude and environmental heat stress has a detrimental impact on exercise performance, some researchers have investigated the effects of these on football players [23, 24]. Nassis [23] conducted a study that examined the effects of altitude on soccer performance during the 2010 World Cup in South Africa. The study verified a 3.1% decrease in the total distance covered by teams during matches played at 1200–1400 m and 1401–1753 m, compared with sea level. Through the analysis of environmental heat stress in the 2014 FIFA World Cup (Brazil), Nassis et al. [24] concluded that there was no difference in playing time (average of both teams), total distance traveled (m/min/player), number of goals scored and number of cards issued by referees, compared with matches played under different environmental stress categories (e.g. the risk of heat stress at 50% relative humidity is 'high' for wet-bulb globe temperature (WBGT) 28–33 °C, 'moderate' for WBGT 24–28 °C and 'low' for WBGT < 24 °C). High-intensity activity was lower under high compared with low environmental stress, and the rate of successfully completed passes was greater in the former compared with the latter.

4.3 Group Behaviour

4.3.1 Team Centre

Different terminologies (centroid, i.e. the geometrical centre of players, excluding the goalkeeper and not considering the position of the ball; *w*centroid, i.e. geometrical centre of the team that attributes weight to the teammates based on their proximity to the ball; team centre, i.e. geometrical centre of players, excluding the goalkeeper and not considering the position of the ball) have been used to describe the team centre, which has been defined as the geometric centre of a team, considering the positioning of all players on the pitch [25, 27, 58]. The present review identified three main approaches for centroid analysis in soccer: (1) centroid of the team, calculating the geometric centre without goalkeepers [27, 59]; (2) weighted centroid, considering the proximity of each player to the ball as the weight to move the centroid [25]; and (3) the centroid, considering the middle point between the two teammates furthest apart [60]. Team centre has been used to assess intra- and inter-team coordination in soccer in a temporal sequence [27].

In most cases, an in-phase relationship between the competing teams' centre values during competitive performance has been investigated [26, 27, 61]. The study of elite European soccer suggested that team centroids moved synchronously both up and across the pitch [26]. Similar results in the variable relative phase were found in the final of the 2006 FIFA World Championship [62]. However, in the case of small-sided games (5 vs. 5), specific moments during performance may constrain the synchrony between teams, which can quickly turn into non-synchronization, and even a crossing of team centres that may relate to specific events in the match [63].

The idea of critical moments in competitive performance (e.g. goals, shots) was examined in competitive matches [26, 27]. The study of elite European soccer teams during official competitive 11-a-side matches [26]

contradicted the evidence reported from observations of performance in small-sided games that some goals occurred at moments of non-synchronization or of crossing between centroids [63]. In a different approach, the investigators of the study of performance in small-sided games investigated the hypothesis that inter-team variability would indicate critical moments in a competitive match [27]. However, the results from that study suggested that inter-team distances (differences between teams' centroids) were minimally related to emergence of critical moments in a match [27]. One possible explanation for this finding is that, during small-sided games, it is easier to remain close to other players and for the geometric midpoints of both teams to overlap.

The relationship between competing teams' centroids may provide information about the synchronization of the teams and identify when non-synchronization of team centroids may lead to critical events in a match. The distance between teams may also be used to design small- or medium-sided games that better simulate specific subphases of the game (e.g. direct attacking, indirect attacking) based on the dimensions of the pitch.

4.3.2 Team Dispersion

The dispersion of a team can be defined by quantification of distances between teammates. Dispersion of the players on the pitch can be constrained by specific strategies and tactics that emerge during the match [25]. Regularly, players are more disposed to explore width and length of the pitch when attacking to exploit free space and to destabilize the opposition defense [64]. Conversely, distances between teammates tend to be smaller when defending, to optimize cover and to contract space [28]. To examine some of these suggestions, some measures have been used, including (1) stretch index; (2) weighted stretch index; (3) Frobenius norm (team's spread); (4) surface area; (5) effective area of play; (6) playing area; (7) team length and width; and (8) defensive play area and triangulations.

Stretch index can be described as the mean dispersion of players from the team centre (non-weighted) [58, 59]. This measure can be quantified as the radius or only by the width or length axes. A similar concept was introduced by changing the weight of the centroid [8]. In a study of high-level European soccer teams, smaller stretch index values were reported for defending teams, compared with attacking teams [26]. Nevertheless, the data did not consistently associate stretch index values with goals scored [26]. Using the same measure in an analysis of a competitive match, the evidence suggested that the variability of approximate entropy values decreased progressively during the match, with the exception of the transition from the last 15 min of the first half to the first 15 min of the second half [59]. It was also reported that the stretch index was greater in home teams in most of the match-time observed [59].

The weighted stretch index was also used to analyze performance variance between halves of the match [25]. It was found that values of dispersion were smaller in the second half. In addition, the same group of researchers reported a greater weighted stretch index during drawn matches and no statistical differences between losing and winning situations [65].

The Frobenius norm was used as a measure of a team's spread in four studies [26, 28, 66, 67]. In a study conducted on Brazilian teams, it was suggested that greater values of spread when defending were associated with the emergence of critical moments, such as shots on goal conceded. When attacking, this variable was greater when a team was closer to the opponent's goal [28]. However, the evidence reported on spread in attacking phases of play was not confirmed in a study of elite European teams [26]. More recently, a predominant in-phase relationship (linear association of both teams' spread over time) was observed between the spread of teams and anti-phase periods at critical moments of play, such as when shots at goal emerged or goals were scored [67].

Surface area has been used as an alternative dispersion measure that uses the convex hull to determine the polygon generated by all players [63]. In most cases, it was found that surface area values were greater when attacking than when defending [25, 68]. It was also found that surface area was greater when a team competed against weaker teams [68] and when the scores were level in a match [65]. In a single-match study, there was a progressive tendency of this measure to reduce in variability during the match [59].

The effective area of play was introduced as an alternative measure to the surface area, providing a notion of effectiveness in the defensive triangulation generated when defenders covered each other [25]. Using this measure, a significantly smaller space was covered in defence compared with attack, and there was a tendency for the effective area of play to be greater when the scores were level compared with when a team was losing or winning in matches [65].

In an alternative approach, playing area was introduced to verify the mean area covered per player and to identify the best value to use in designing small-sided games [69]. Individual playing area varied between 81.38 and 86.78 m^2 in observed competitive matches, with the variability in these values influenced by the location of the ball in specific zones of the pitch. An individual playing area of 90 m^2 in small-sided games was suggested to develop build-up play or attacking play in the finishing phase, whereas 80 m^2 for small-sided games developed transition play [69].

Defensive play area was introduced as a tactical measure that determines the area covered by a group of players when defending [70]. It was found that the triangular positioning relationships generated when midfielders covered each other on the field were greater and, for that reason, the defensive playing area in the midfield area was significantly greater than upfront or at the back [70].

Dispersion measures can be directly used to evaluate the space required for defensive and attacking processes, and to adjust the playing dimensions and format for small- or medium-sided games designed in training. The right measure of dispersion can also be used to identify the width and length of attacking and defensive phases of play in teams. Such information can be used to characterize team performance and to help coaches plan better strategies to exploit opposition weaknesses or to reinforce playing patterns in their own team.

4.3.3 Team Interaction/Coordination Networks

The network process can quantify the centrality level of a player (individual values per player), dependence between players (meso-level of analysis) and the general properties of a graph (that quantify a value of a specific network property of a team). General network properties have been studied in association with team performance variables such as shots, goals and successful outcomes in competition [30, 71, 72]. High passing rates were related to an increase in team performance and greater centralization was associated with a decrease, defined by the number of goals scored in an analysis of 760 matches from the English Premier League [30]. It has been reported that winning teams display statistically greater levels of general network measures, such as density, homogeneity or number of total links, with small-to-moderate associations with goals scored, overall shots taken and shots on goal in 64 matches from the 2014 FIFA World Cup [71].

Differences between centrality levels of players (individual level of analysis) have also been investigated using the social network approach [31, 73]. Similar evidence was found in a specific analysis conducted on the Spanish national team during the same international competition [31]. In a study conducted on one team using the centroid measure, it was reported that the left back tended to be the dominant player during attacking sequences [74].

Variance of centrality measures between playing positions has also been analyzed [32, 72]. Midfielders were classified as the most prominent players after observations of 64 official matches from the 2014 FIFA World Cup, independent of the specific team and tactical format used [32]. The specific analysis conducted on the German team revealed that midfielders had greater levels of intermediation (capacity of a player to link two or more teammates to each other during play on field) and dominance (capacity to be the player who most often participates in team networks) [72].

Full passing sequences have been analyzed in most cases; however, in an alternative study, only the network interactions in passing sequences that resulted in scored or conceded goals were analyzed [75]. The results suggested that attacking midfielders and wing forwards were the most prominent players for receiving the ball and the right back was the dominant player for passing. Analysis of pitch zones revealed that central and wing regions closer to the goal being attacked were mainly influential in network interactions during attacking phases of play that led to goals being scored [75].

Identification of prominent players engaged in specific types of playing interactions may be used by coaches to adjust performance strategies. In understanding defensive behaviours, a coach can identify the most prominent opponent and which players are well linked to him. Based on the information gained, the coach may design a strategy to mark a key player or to prevent teammates from passing the ball to him/her. Moreover, knowledge of interactions between teammates can be used to identify how they cooperate and can be used to classify the main networks in the team.

4.3.4 Sequential Patterns

A temporal pattern can be described as a repeated temporal and sequential combination of the same order of events during a period, which are relatively invariant [33]. This kind of analysis, when focused on the sequence (and temporality) of events, supports the detection of patterns of play that have higher probabilities of occurrence than chance. The basis for any prediction model is that performance is repeatable, to some degree, suggesting that events that have previously occurred will occur again in some predictable manner.

Temporal analysis of attacking play has been adopted in many studies [34, 35, 76]. Performance criteria analyzed have included the lateral position (the pitch is split into three longitudinal areas—right, centre and left), zone (ultra-defensive, defensive, central, offensive and ultra-offensive), possession (ball in play), interaction contexts (specific regions of the pitch in which interactions between players emerge), recovery and loss of ball possession and time that the ball is out of play [34, 35].

In a study of performances of FC Barcelona in the Spanish national league and the UEFA Champions League, match-to-match and half-to-half patterns were reported [34]. Sixty-eight patterns were recognized during 10 matches observed. One of the identified patterns was an attacking structure that begins in the central defensive zone

and progresses to the wings before entering the offensive zone. Another pattern was an attack that begins in the central defensive zone, progresses to the left side, moves back to the centre line and attacks again from the same side of the field [34]. A comparison of attacking patterns of play in a top Italian league team, when winning and losing matches, was analyzed [35]. Overall, 167 patterns emerged in 80% of the 19 matches studied. A greater volume of temporal patterns ($n = 101$) emerged when the team was losing matches, compared to when they were winning ($n = 9$). It seemed that, in winning matches, the team was more likely to continue using the same playing pattern [35]. The variance of temporal patterns between halves was investigated, again in an elite Italian team [76]. A greater number of temporal patterns were found in the second halves compared with first halves. More patterns were found [59] and the length and level of passing sequences and their patterning were greater. Five playing patterns were observed in the first half, and nine in the second. Temporal patterns also revealed at least one shot for each pattern (in the second half), whereas in the first half, no such evidence was observed [76].

The study by Sarmento et al. [33], using sequential analysis, is the only study in this updated review that involved the expert opinions of professional coaches to interpret the data. This close relationship between researchers and professionals can be very fruitful for interpreting data in match analysis.

Identification of temporal patterns of play may provide information about structural behaviours that are independent of opposition play. Such patterns can be used by coaches and analysts to identify strategies to negate opposition strengths or to verify congruence between performance behaviours worked on in training and their execution in competitive games.

4.3.5 Group Outcomes

Relationships between match-related statistics and match final scores have been analyzed by several investigators [36–38]. A study of 177 matches from the FIFA World Cups in 2002, 2006 and 2010 found that the total number of shots and shots on target were the main discriminatory variables to predict winning, losing and drawing matches [36]. Shots were also confirmed as the main discriminating variable for winning teams [77]. Moreover, a study conducted on 1900 Spanish league matches revealed that match winning teams displayed a greater number of ball recoveries and tended to perform longer passing sequences [78]. The patterns of ball recovery are also important to discriminate match-winning teams from those who lost and drew matches [77].

An interesting observation from a study of 12 Spanish league matches revealed that match outcome influenced match-related statistics [79]. Teams who drew and won matches showed a decrease in the probability of reaching the penalty area in possession of the ball, in comparison to when they were losing a match [79]. In terms of defensive playing patterns, it was found that losing teams tend to defend in more advanced pitch zones; however, more successful teams tend to be more efficient in defensive pressure and ball recovery [80].

Identification of specific key indicators or use of modelling methods may provide information for coaches to re-prioritize playing styles and to also help re-design training exercises to include indicators of successful performance.

4.4 Contextualizing Performance

Contextualizing performance has been a concern of researchers in this field of study. Although it is possible to categorize studies according to 'major topics' of research, in reviewed studies investigators analyzed different variables (e.g. work rate, technical behaviours, ball possession) according to contextual variables, including (1) match half [25, 57, 81, 82]; (2) quality of opposition [68]; (3) match location [21, 22, 38, 80, 83]; (4) scoring first [38, 83]; (5) group stage vs. knockout phase [22, 83]; (6), intervals of 5 [57] or 15 min used to record data [38, 82]; (7) timing and tactical nature of substitutions [21, 22]; (8) competitive level [51, 84, 85], and (9) different competitions (different leagues and cups) [86].

Interpretation of player behaviours and match outcomes in specific contexts may help identify specific strategies or training designs that coaches could incorporate to prepare the team for different opposition strategies, circumstances and game scenarios.

4.5 Limitations

A possible limitation of this systematic review is that it only includes studies from the Web of Science that were written in English, thereby potentially overlooking other relevant publications in other languages.

5 Conclusions

Research on match analysis in adult male football players has been the subject of growing interest in the past 5 years. Nonetheless, some limitations remain in the published studies between 2012 and 2017, namely the lack of operational definitions and conflicting classifications of activity or playing positions that make it difficult to compare similar groups of studies. Additionally, some potential

weaknesses may be apparent in more recent published research, such as the small sample sizes used in some studies. Nevertheless, researchers have developed new methods in order to better contextualize the performance of players and teams, which is likely to be essential for planning and application of training loads in modern professional soccer.

A progressive increase in group analysis based on positional data is one of the main new insights compared with the previous systematic review by Sarmento et al. [1]. Positional data can be used to identify patterns of interaction between teammates and to explore the spatiotemporal patterns that emerge from a match [9, 87]. Team synchrony has been analyzed based on an in-phase relationship between teams using the measures of centre and dispersion, suggesting regularities in the dynamics of competing teams and some disturbances that emerge at specific critical points of the matches (e.g. goals, shots, counter attacks) [26, 66]. The new collective measures reviewed in this article could help identify the need for specific training conditions for the collective organization of a team, improving the efficacy of practice task design to augment the cognitions and perception of players regarding specific tactical behaviours [69]. Analysis of interactions between teammates may reveal collective properties that cannot be captured by players' individual movements. For example, synergetic properties of the team can offer theoretical guidance to capture system properties such as dimensional compression, patterns of interpersonal linkage, reciprocal compensation or degeneracy [88]. In summary, the collective measures identified in this review provide different information than that typically gained from traditional notational analyses. Knowledge about the spatiotemporal relationships formed by players during competitive performance may explain some behaviours that notational analysis cannot quantify. The exact positioning of players, occupied space and values of interpersonal distance can be more easily and objectively measured by collective measures, using tracking or GPS systems. Moreover, t-patterns (defined as a particular set of event types recurring in the same order with significantly similar distance values between them) and network measures may be used to classify and rank players based on their importance in a competitive game, identifying specific interactions. Both of these methodologies can complement the use of notational analysis.

These novel measures require new measurement techniques, and the complexity engendered during soccer matches requires an integrated approach that considers multiple aspects of performance [89]. A big challenge for researchers is to align these new measures with the needs of the coaching staff, through a more interactive relationship between all practitioners, to produce practically relevant information that can improve performance through constant adaptations of training design. Reductionist methods and approaches should be avoided and multifactorial analyses must be conducted, integrating notational methods and computational collective measures to amplify knowledge and identify long-term patterns in performance dynamics during competition. The association between outcomes (notational analysis) and processes (spatiotemporal analyses) may also contribute to identify which patterns can be avoided or reinforced to increase possibilities for success. Additionally, future studies should promote real-world insights into optimal methodologies for player preparation through integrating sources of information about training requirements, periodization load, structure of the competition, and player fitness and fatigue. Collecting and measuring a large volume of data (e.g. positional, physiological, psychological, environmental conditions, etc.) in real time, and compressing it into a smaller set of variables, providing objective information for coaches that facilitates, to some extent, the prediction of performance outcomes, seems to be a useful path in this specific area. An augmented perception analysis framework for football (ARCANE) [90] represents an interesting first step that may explain how to achieve this significant goal.

Compliance with Ethical Standards

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