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Original Article

A method for classifying and evaluating the efficiency of offensive playing styles in soccer

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Abstract
Introduction: This study aims to develop a method for characterizingthe offensive playing style of soccer teams, in terms of its ball circulation profile, and respective efficiency, considering the ball circulation outcomes.**Methods:**Ball circulation dynamics were categorized based on a descriptive representation of ball possession parts (start, ball path and end) and encompassing four variables: team; action or event; pitch partition; opponent defensive penetration degree. The resultant set of ball circulation dynamics encompassed all possibilities of ball circulation on the pitch and were categorized considering the degree of success of the ball circulation lead to a penetration in the defensive system. Hence, there were defined two main classes - incomplete and complete penetration dynamics. Incomplete penetration dynamics are those that do not reach the last defensive line of the opponent defensive system. Complete penetration dynamics are those in which the offense successfully penetrates the ball until the last defensive line or overcomes the last defensive line. Complete penetration dynamics were divided in vertical penetration, indirect penetration and start in penetration. We applied the set of ball circulation related variables to assess nine games from the finalists of UEFA Champions League season 2008-2009, Barcelona and Manchester United (final game, four semifinal games and four quarter final games). An assessment was performed through an automatic identification of game events using a finite state machine (FSM) software that selectively searched for particular classes of coding sequences in the data of ball circulation classes manually acquired from video footage. **Results:**We identified significant differences between Barcelona and Manchester United in terms ofthe ball circulation style in the classes: i) incomplete penetration dynamics in defensive pitch; ii) long ball kick on incomplete penetration dynamics in defensive pitch; iii) a back-circulation pass on incomplete penetration dynamics in offensive pitch. No differences were found for penetration styles.**Discussion:**In regards to ball circulation, more than one third of the dynamics from both teams reached the penetration zone of the opponent defense or ended with an effective offensive action (i.e. shot on goal or a cross, without a penetration). Barcelona and Manchester presented significantly more incomplete dynamics, respectively, in the offensive pitch (33.6% BAR and 25.2% MUN) and in defensive pitch (43.5% MUN and 34.9% BAR).**Conclusions:**These findings provide meaningful variables of ball circulation in soccer that may be used by coaches simply gathering data from video footages.
Keywords: Performance analysis; invasion team sports; pattern recognition; ball circulation

Introduction

Soccer teams have a great variety of ways to disrupt the opposing defensive system and create space to score. Thegeneral behaviorthat characterizesa team's approach to overcome defense defines itsoffensive game style (Fernandez-Navarro, Fradua, Zubillaga, Ford &McRobert, 2016; Hewitt, Greenham& Norton, 2016). Defining a team's game style is a main goal of performance analysis, especially when the evaluation of game style takes success rate into consideration (Hewitt, Greenham& Norton, 2016; Lago-Peñas, Gómez-Ruano& Yang, 2017). For this purpose, a permanent issue is defining accurate variablesthat assess collective and dynamic parameters to produce a sufficient description of game events.

In the literature, we find different approaches to investigatingteams' offensive playing styles. The first analyzesof accumulated frequencies of ball possession events (Collet, 2013; Harrop&Nevill, 2014; James, Mellalieu&Hollely, 2002; Lago-Peñas, Lago-Ballesteros, Dellal& Gómez 2010; Liu, Yi, Giménez, Gómez &Lago-Peñas, 2015; Luhtanen, Belinskij, Häyrinen&Väntinen, 2001; Pascual-Verdú&Carbonell-Martínez,

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2018; Papahristodoulou, 2008) were complemented by others focused on the search for recurrent events along the ball possessions (Borrie, Jonsson& Magnusson, 2002, Camerino, Chaverri, Anguera&Jonsson, 2012; Lapresa, Arana, Anguera&Garzóna, 2013) and dynamic features of group (Dutt-mazumder, Button, Robins &Barlett, 2011; Fonseca, Milho, Travassos&Araújo, 2012; Moura, Martins & Cunha, 2013; Sampaio&Maçãs, 2012) or collective tactics (Hobbs, Power, Sha, Ruiz &Lucey, 2018; Jäger, Perl &Schöllhorn, 2007;Le, Carr, Yue&Lucey, 2017; Memmert, Lemmink&Sampaio, 2017; Memmert& Perl, 2009; Perl, 2002;Perl, Grunz&Memmert, 2013; Power, Hobbs, Ruiz, Wei & Lucey, 2018).Nonetheless, it remains challenging to capture the tactical meaning of the events and, consequently, characterize a team'soffensive playingstyle (Hewitt, Greenham& Norton, 2016; Pfeiffer and Perl, 2006).

Other studies examined team collective structures through ball circulation patterns (Clemente, Silva, Martins, Kalamaras& Mendes, 2016; Gonçalves, et al., 2017; Oliveira, Clemente&Martins, 2016; Oliveira & Clemente, 2018; Seabra, 2010). Some of these analysis focused on the pass action, a main communication element between team players (Clemente, Silva, Martins, Kalamaras& Mendes, 2016; Gonçalves, et al., 2017; Oliveira, Clemente &Martins, 2016; Oliveira & Clemente, 2018), providinga quantifiable view of ball circulation (Oh, Keshri&Iyengar,2015). In complement, other studyassessed ball circulation on the pitch by considering its degree of penetration in the defensive system and the relation to offensive success. Then, it added a spatial criterion to assess communication and progression of the team while in offense mode (Seabra, 2010). This study uses a set of ball circulation classes, which aredescriptive of the degree of penetration in the defensive system. This analysis contributed with enhancement oftactical meaning in ball circulation assessment and some additional advances can be foreseeing based on this conception, such as: i) extending the categorization of ball circulation classes to encompass all possible paths on the pitch instead of only some cases of ball circulation; ii) preciselydefiningthe starting point of the ball circulation and the its possible outcomes. These improvements would attempt to deepen the interpretation of the tactical aim of the sequence (e.g.,put the ball in dispute; conserve the ball, etc.). It would also be worthwhile to evaluateball possession efficiency, considering the degree to which the defensive system was penetrated and the outcome.

Thus, the aim of this research isto develop aclassification methodof ball circulation in soccerand assessteams' offensive in terms of these ball circulation classes.Thismethod should encompass all possible ball displacements in the pitch. In addition, ball circulation patterns willbe associated to the possession outcome for evaluating team's offensive performance.

Materials and Methods

Weestablishedcriteria for defininga team's offensive classes of ball circulation. Then, we applied the resultant set of ball circulation sequences to an analysis ofteam playing style success rate, considering the most frequent classes of ball circulation and respective outcomes.

Modelling ball circulation dynamics

Classes of ball circulation were defined according to three criteria: i) events and actions of ball possession start or re-start; ii)events and actions of ball possession end; iii) ball path on the pitch and actions.A ball possession was defined as the game segment that starts when the team recovers the ball and ends when it losesor the game is interrupted. The present work focuses mainly on ball circulation patterns for the team offensive penetration with the ball until the scoring zone. Therefore, when an offensive team brought the ball back into the zone ahead of the first defensive line of the opponent (i.e.,ceased the penetration attempt to start a new one), we consideredit a new ball circulation sequence.

Ball possession start

A ball possession starts or re-starts, after: i) a game interruption; ii) ball recovery; iii) possession reset (i.e.,ball retrieval to defensive sector to start a new offense sequence).

The start after *game interruption* may occur through the following actions: a) kick off;b) take throw in;c) free kick/indirect free kick/penalty kick; d) corner kick; e) goal kick; f) dropped ball.*Ball recovery*: a) interception; b) tackle; c) recovery; d)goalkeeper ball catch. *Possession reset*: a) pass (first pass); b) drive; c) reception.

Ball possession end

A ball possession ends after: i) a turnover; ii) a ball recapture after occasional dispute or game interruption; iii) an end possession action.A*turnover*may occur through the following actions: a) losing the ball during live game after, or not, occasional dispute: interception, tackle and recovery by opponent team; b) losing the ball during a game interruption after, or not, occasional dispute: throw in, fault, offside, corner kick, goal kick by opponent team. An*occasional dispute*may occur through the following actions: a) interception incomplete; b) tackle incomplete; c) clearance; d) defensive header; e) block; f) low dispute; g) high dispute; h) incomplete goalkeeper defense. *Recapture the ball*:i) live game: recovery; ii) game interruption:throw in, fault by opponent team, corner kick, and goal kick.*Performing an end possession action*:i) long ball kick; ii) cross

without score attempt; iii) shot and head shot; iv) performing a backward ball circulation: pass (first pass), reception, drive. In this case, the action leads to a ball possession reset.

Ball displacements on the pitch were defined according to two spatial criteria: i) a pitch static partition (PSP), segmentation of the pitchinto 18 identical zones, with three and six zones, respectively, in the longitudinal and transversal axes (see Figure 1A); ii) Space of Defensive Occupation (SDO) zones (Seabra&Dantas, 2006), whose regions are determined by the defensive team positioning (see Figure 1B). SDO breaks the opponent's defensive system into longitudinal and transversal axes.

In the longitudinal axis, there are four sectors: Front zone (F) - ahead of the opposing attackers' line (facing the first defensive line); ii) Mid-fielders' zone (M) - ahead of the mid-fielders (facing the second defensive line); iii) Defenders zone (D) - ahead of the defenders (facing the third defensive line); iv) Back zone (B) – in the back of the defenders (facing the goalkeeper). Additionally, in the transversal axis, each zone (except the front zone) is divided into central and peripheral.

The combination of the two axis partitions results in zones: i) ahead of themid-fielders through center (Mc); ii) ahead of the mid-fieldersthrough periphery (Mp); iii) ahead of the defendersthrough center (Dc); iv) ahead of thedefendersthrough periphery (Dp); v) in the back of the defendersthrough center (Bc); in the backof the defenders through periphery (Bp) (Seabra&Dantas, 2006).

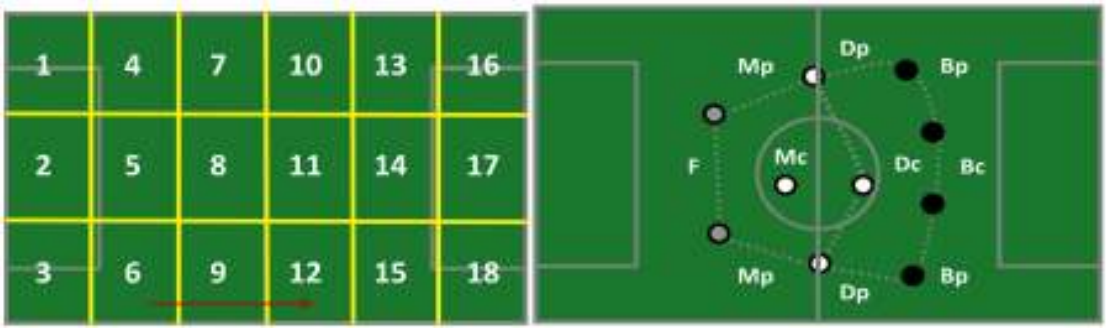

Figure 1: A: Pitch Static Partition (PSP), with 18 zones; B: Space of Defensive Occupation (SDO), with 10 zones.

The combinationof the two criteria, PSP and SDO, generated the spatial variable used for determining ball path, which considered the objective pitch position (PSP, Figure 1A) and the relative position of the ball to the defense (SDO, Figure 1B). Mc and Mp (SDO zones) were associated with left defensive field (zones 1, 4, and 7 in PSP), center defensive field (2, 5, and 8 in PSP), right defensive field (3, 6, and 9), left offensive field (10, 13, and 16), center offensive field (11, 14, and 17) and right offensive field (12, 15, and 18). F (SDO zone) was not associated with any PSP zone. Actions associated with the ball path include: pass, drive, reception, cross, long ball kick, shot, and heading (except after a cross).

The combination of these variables delimited a set of ball circulation dynamics with the following structure: i) Start: event/action/pitch zone; ii) Path: sequence of pitch zones/actions; iii) End: event/action/zone. Ball circulation classes pertaining to this set are herein denominated as elementary dynamics.Elementary dynamics were generalized in cases of non-relevant tactical paths involving twocriteria: i) returning: lateral and vertical ball displacements between mid-field SDO zones (Mc and Mp); ii) first penetration only: during the same ball possession, the team performs other penetrations, these new moves are disregarded.

The application of this structure to identify different types of ball circulation sequences during games resulted in the identification of 1268dynamics with distinct offensive meaning. Given the large number of dynamics, they were subsequently grouped according to tactical similarities in classes denominated main ball circulation dynamics.Classes of main dynamics were definedaccording to degree of success: i) incomplete penetration of the opponent'sdefensive system; ii) complete penetration of the opponent's defensive system.

Incomplete penetration dynamics are those that do not reach the last defensive line ofthe opponent's defensive system (i.e., D or B zones of the SDO).They are distinguishedbetween those that reach and not reach the offensive pitch. Complete penetration dynamics are those where the offense successfully penetrates through the last defensive line or even beyond. Thesewere sub-divided into three classes: vertical penetration (performed through a long vertical pass); indirect (elaborated) penetration (performed through short transitions between SDO zones); start in penetration (start with ball possession in the last defensive line). Theclasses of main dynamics are specifiedin Table 1.

The categorization of elementary dynamics aimed at being exhaustive in terms of ball circulation possibilities in soccer offense. The classification of elementary dynamics was based on a fundamental criterion focused on objectivity: first, whether it penetrated the opponent'sdefensive zone, and if not, whether it reached, at least, the offensive pitch.

Table 1: Classes of main dynamics of ball circulation in a team's offense.

Incomplete Dynamics	
No circulation	ball remains in the same zone (F, M into center defensive field, M into left defensive field, M into right defensive field, M into center offensive field, M into left offensive field, M into right offensive field)
Vertical forward	ball circulates along the vertical axis of the pitch, reaching SDO M zone into offensive field at most, without diagonal or lateral path (F to M into defensive field, F to M into offensive field or M into defensive field to Minto offensive field through the center, left or right)
Vertical backward	ball circulates along the vertical axis of the pitch, from an advanced to an indented SDO zone only (e.g., M into offensive field to M into defensive field; central, left, or right) without lateral circulation
Side-center	ball circulates along the horizontal axis of the pitch, including any lateral ball circulation, without reaching the opposite side (center to left, center to right, left to center, or right to center; with or without reaching the offensive field)
Side-to-side	ball circulates along the horizontal axis of the pitch, reaching the opposite side with or without vertical displacement (left to right, right to left; with or without central circulation; reaching or not reaching the offensive field)
Complete Dynamics – Vertical Penetration	
Vertical attack from defense	penetration from F SDO zone to penetration SDO zone (Dc, Dp, Bc or Bp)
Vertical attack from defensive mid field	penetration from Mc or Mp SDO zones in defensive pitch areas to penetration SDO zone (Dc, Dp, Bc or Bp) in the last third of the offensive zone of the pitch (12 to 18 PSP)
Complete Dynamics – Indirect (Elaborated) Penetration	
Full lateral	
Side to side attack	all dynamics that reach the two lateral sides of the pitch before (or at the start of) the moment of penetration (left to right, right to left; with or without central circulation or opposite side circulation in penetration)
Partial lateral	
Center to periphery attack	last transition from central SDO zones (Mc) to periphery SDO zones (Mp) before penetration action (left and right)
Peripheral to center attack	last transition from periphery SDO zones (Mp) to central SDO zones (Mc) before penetration action (left and right)
Central attack	just ball circulation in central SDO zones (Mc) before penetration with penetration transition from a central zone of the pitch (2, 5, 8, 11, 14, 17) (central to center, central to left or central to right)
Central – lateral attack	just ball circulation in central SDO zones (Mc) before penetration with penetration transition from a lateral zone of the pitch (1, 3, 4, 6, 7, 9, 10, 12, 13, 15, 16, 18) (left to center, left to left, right to center and right to right)
Periphery to periphery attack	just ball circulation in peripheral SDO zones (Mp) with penetration in peripheral SDO zones (Dp, Bp) (left or right)
Periphery to center attack	just ball circulation in peripheral SDO zones (Mp) with penetration in central SDO zones (Dc, Bc) (left or right)
Complete Dynamics – Start in Penetration	
Definition attack by set play	all dynamics that start in penetration by offensive action (cross or shot) from a set play
Definition attack by game recovery	all dynamics that start in penetration by live game recovery with offensive action and not return to M or F SDO zones
Return penetration attack	all dynamics that start in penetration and return to M or F SDO zones
No movement attack	all dynamics that start in penetration without resulting in offensive action and not return to M or F SDO zones

Experiment

The experiment was designed to test the coherence of the dynamic classes of ball circulation with the analysis of offensive playing style in soccer games. Ball circulation dynamics were used to characterize teams' circulation patterns and efficiency. Ball circulation was analyzed based on both the degree of penetration (Table 1) and the outcome of all ball circulation sequences containedin the data sample. However, the classes of the main dynamics were grouped into three: incomplete in the defensive field, incomplete in the offensive field and that reached penetration.Additionally, to investigate teams' penetration patterns, we analyzed only successful dynamics (i.e., dynamics that team managed to conclude without interrupting the other team) in order to provide insight into a team's most successful patterns. A successful dynamic is one that penetrates the last defensive line (Dc, Dp, Bc or Bp SDO zones) or that ends with an offensive action (cross, shot or head shot).

Sample

The sample consisted of all ball possessions of the two finalist teams – Barcelona and Manchester United – from nine games of the 2008-2009 UEFA Champions League. The games analyzed were the final, the semifinals (4 games), and quarterfinals (4 games). The results were as follows: Barcelona 4 vs 0 Bayern; Bayern 1 vs 1 Barcelona; Barcelona 0 vs 0 Chelsea; Chelsea 1 vs 1 Barcelona; Barcelona 2 vs 0 Manchester United; Manchester United 2 vs 2 Porto; Porto 0 vs 1 Manchester United; Manchester United 1 vs 0 Arsenal; Arsenal 1

vs 3 Manchester United. These games were selected because during the 2008-2009season Barcelona had a strong impact on soccer strategy with its emphasis on the possession style approach. Considering that this strategy is mostly related to ball possession and ball circulation efficiency, we assumed it would make an adequate sample for the study.

Data acquisition

Data encoding followed the presented structure of ball circulation dynamics (i.e., start action; ball circulation path; end action). The possible outcomes of ball possession are: i) losing ball possession; ii) winning ball possession; iii) long ball kick; iv) cross without score attempt; v) shot and head shot; vi) backward ball circulation pass.

The dynamics from the model described in Table 1 were considered as follows. Incomplete dynamics that resulted in an offensive action(vertical forward, vertical backward, side-center, side to side) were grouped in a class named *incomplete with circulation*. Incomplete dynamicsof the type"no circulation"that resulted in an offensive action weredivided into two: *no circulation from set play* and *no circulation from game recovery*.

These two classes were merged with the dynamics that initiate in penetration, generating two hybrid classes that combine contentfrom both incomplete dynamics and penetration dynamics. Hybrid classes were necessary because in no circulation situations that result in an offensive action does not the penetration degree count for dynamics discrimination. In these situations, the main discrimination criterion is how the ball possession starts,in our case, a set play or live game ball recovery.

The dynamics of ball circulation are described as a sequence of semantic annotations, each representing a different state of the game at a given time. Our model allows for semantic description of the whole game based on a sequence of still video image annotations manually created using Focus X2 performance analysis software.Each annotation captures numerous categorical characteristics including temporal, spatial, and technical-tactical aspects.

An annotation contains the following characteristics: time relative to the beginning of the game (automatically provided by Focus X2), team with ball possession, event of interest, and spatial description. Each annotation is numbered according to the order in which it was created. Therefore, each annotation and the state it represents is unique in the scope of a single game. All annotations were saved in a text file (ASCII format), with one annotation per line (tab-separated values).

We implemented a software application (analyzer) that accepts an annotation file, i.e., it reads, parses, and validates the file according to our state definition. Once an annotation file is accepted by our application, we can use the application to automatically search for a particular dynamic of interest.

To identify such dynamics, we need to describe it using a Finite State Machine (FSM), which is a computing formalism that can be used to represent behavioral models. We have defined a language to describe a dynamics of interest using a textual notation. Thus, FSM descriptions were also saved in a text file (ASCII format).

An FSM contains a (finite) number of states and numerous associated transitions. Each state defines a set of conditions related to the game that must be true at a certain point in time. These conditions are defined according to the elements defined in each category of interest and they can be very specific or general. Each state of the FSM represents a part of a modeled categorical dynamics of interest. In this sense, an FSM has one start state that describes the initial condition of this dynamics and at least one final state that describes an acceptance condition of this dynamics, i.e., a condition that finalizes the modeled behavior. Transitions are used to relate the different states of an FSM definition.

The objective of our analysis software is to identify the set of all sections of an annotated game that satisfies the modeled dynamics of interest. A section consists of a sequence (A_0, A_1, A_2 … A_N) of annotations in which annotation A_0 satisfies the initial condition of the FSM and annotation A_N satisfies a final condition of the FSM. Additionally, there is a valid sequence of transitions (T_0, T_1, T_2 … T_N) relating A_0 to A_N.

Our software can accept a set of annotation files and an FSM definition file and search all the annotation files for the dynamics of interest described in the FSM definition file, reporting the results of the analysis individually. Reliability of encoding procedures was tested by comparing computer-based search with a manual search. All manually identified dynamics were also automatically identified by our software.

Error! Reference source not found.presents an example of the data-acquisition process from footage for analysis of elementary dynamics. Comment lines are automatically suppressed from an FSM definition file as the analyzer parses this file (see Crocker, 2008 for the description of the FSM syntax using the Augmented Backus-Naur Form (ABNF) notation).

2B

1901	Away	throw_in	mp	9
1902	Away	take_trow_in	mp	9
1903	Away	reception	f	6
1904	Away	pass	f	6
1905	Away	reception	f	2
1906	Away	long_ball_kick	f	2
1907	Home	defensive_header	f	5
1908	Home	defensive_header	mc	8
1909	Home	recovery	mc	8
1910	Home	drive	mc	8
1911	Home	pass	mc	8
1912	Home	reception	mc	8
1913	Home	pass	mc	8
1914	Home	reception	f	5
1915	Home	pass	mc	8
1916	Home	reception	mc	7
1917	Home	pass	mc	10
1918	Home	reception	mc	10
1919	Home	pass	mp	10
1920	Home	first_pass	mc	10

2C

```
//FSM states: q0 initial state
q0 q1 q2

//final state
q2

//states definitions
q0: = home; tackle, interception, recovery, any_start; mc; 2, 5, 8
q1: = home; pass, first_pass, drive, reception; mc; 2, 5, 8
q2: = home; pass, first_pass, drive, reception, long_ball_kick; f; 1-18

//state transitions
q0 q1
q0 q2
q1 q1
q1 q2
```

2D

1901	Away	throw_in	mp	9
1902	Away	take_trow_in	mp	9
1903	Away	reception	f	6
1904	Away	pass	f	6
1905	Away	reception	f	2
1906	Away	long_ball_kick	f	2
1907	Home	defensive_header	f	5
1908	Home	defensive_header	mc	8
1909	Home	recovery	mc	8
1910	Home	drive	mc	8
1911	Home	pass	mc	8
1912	Home	reception	mc	8
1913	Home	pass	mc	8
1914	Home	reception	f	5
1915	Home	pass	mc	8
1916	Home	reception	mc	7
1917	Home	pass	mc	10
1918	Home	reception	mc	10
1919	Home	pass	mp	10
1920	Home	first_pass	mc	10

Figure 2:
Pictorial view of identification process of elementary dynamic, where: 2A1 to 2A6: representation of six sequential frames of ball circulation; 2B: respective encoding game representation; 2C: FSM of an elementary dynamic (no movement in Mc with back circulation pass by home team); 2D: dynamic identification in an encodedgame sequence.

Data analysis

The ball circulation performance of both Barcelona and Manchester United were analyzed for general ball circulation style and penetration style. General ball circulation style encompasses all dynamics. Penetration style refers specifically to the success dynamics (that reach penetration or ending on offensive action).Independence Chi-square testwith analysis ofresidualswas performed for analyzing statistical differences in both cases.

Results

The independence chi-square test presented significant differences in regard toball circulation style (χ^2= 52.79355/ 10 degrees of freedom) between Barcelona and Manchester United(Table 2). Standardized residuals indicated significance in three classesof ball circulation style: i) loosing ball possession on incomplete penetration dynamics in defensive pitch (LB): Barcelona: -2.87; Manchester United: 2.93; ii) long ball kick on incomplete penetration dynamics in defensive pitch (LBK): Barcelona: -2.14;Manchester United: 2.18; iii) performing a back circulation pass on incomplete penetration dynamics in offensive pitch (BKC): Barcelona: 2.70; Manchester United: -2.75.

Table 2: General ball circulation analysis. WB: winning ball possession; LB losing ball possession; LBK: long ball kick; CRO: cross without score attempt; SAT: score attempt; BKC: performing a backward circulation pass. The results are represented in absolute e relative (inside the parenthesis) values. * significant differences > 0.05.

	Incomplete in defensive pitch		Incomplete in offensive pitch		Reach penetration		Total	
	MUN	BAR	MUN	BAR	MUN	BAR	MUN	BAR
WB	40 (4,2)	48 (4,9)	44 (4,6)	61 (6,3)	48 (5,1)	55 (5,6)	132 (14,1)	164 (16,8)
LB	122 (13)*	69 (7,1)*	102(10,9)	115 (11,8)	96 (10,2)	98 (10,1)	320 (34,1)	282 (28,9)
LBK	150 (16)*	106(10,9)*	5 (0,5)	3 (0,3)	1 (0,1)	0 (0)	156 (16,6)	109 (11,2)
CRO	0 (0)	0 (0)	11 (1,2)	20 (2,1)	84 (9)	72 (7,4)	95 (10,1)	92 (9,4)
SAT	0 (0)	0 (0)	17 (1,8)	19 (1,9)	47 (5)	55 (5,6)	64 (6,8)	74 (7,6)
BKC	96 (10,2)	117 (12)	57 (6,1)*	110(11,3)*	18 (1,9)	27 (2,8)	171 (18,2)	254 (26,1)
TOTAL	408(43,5)	340 (34,9)	236(25,2)	328 (33,6)	294(31,3)	307(31,5)	938 (100)	975 (100)

In the analysis of penetration styles,no significant differences were identified between Barcelona and Manchester for overall successful attacks (χ^2= 19.63087, 13 degrees of freedom) and score attempt attacks (χ^2= 16.68671, 12 degrees of freedom).See Table 3.

Table 3: Penetration styles analysis. Score At: score attempt.

	BAR		MUN	
	Dynamics Total	Dynamics Score At.	Dynamics Total	Dynamics Score At.
Vertical attack from defense	22	3	13	0
Vertical attack from defensive mid field	36	5	35	7
Side to side attack	34	7	22	2
Peripheral to center attack	32	3	33	9
Center to periphery attack	20	3	20	3
Central attack	42	10	32	4
Central - lateral attack	25	3	30	4
Periphery to centerattack	6	1	16	1
Periphery to periphery attack	11	2	22	1
Offensive action by incomplete penetration attack with circulation	14	3	9	6
Definition attack by set play	47	17	41	15
Definition attack by game recovery	20	13	22	12
Return penetration attack	25	4	13	0
No movement attack	12	0	14	0
Total	346	74	322	64

Discussion

The main contribution of this work was to present a method to assessateam's offensive playing styleand its efficiency in soccer games based on a categorical dynamic approach.Complementary, we applied the proposed method to analysis of the performance of professional teams. The results demonstrated that the method is adequate to discriminate tactical differences in ball circulation among teams.

The method supports the design of any specific dynamic with efficient objectivity. Existing softwares,such as, SDIS-GSEQ and THEM detect temporal and sequential structures in a data set (Lapresa, Arana, Anguera&Garzóna, 2013), seeking any combination of eventsthat occur in the same order despite the temporal differences between consecutive patterns along the analyzed situation (Borrie, Jonsson& Magnusson, 2002). Nonetheless, they do not skew the search for a particular sequence type or by grouping similar sequences with structural differences but the same semantic value. The present algorithm supports a selective search of a particular class of coding sequences. Taking this into consideration, the application of automatic detection to dynamic analysis seems to be an adequate tool to support dynamic analyses of different team sports.

The sample choice was defined with consideration for the pertinence of assessing the playing patterns of Barcelona, specifically in the 2008-2009 season when itwas precursor of a popular offensive playingstyle, the possession game style (Fernandez-Navarro, Fradua, Zubillaga, Ford &McRobert, 2016). We used a sample of nine finalgames involving the two finalists of UEFA Champions League (Barcelona and Manchester United).

Thenext session turn to discuss the teams' performance, firstly based on their efficiency and secondly to present inferences related to their game style.

Ball circulation efficiency

In the ball circulation analysis,results indicated some common features of efficiency between Barcelona and Manchester United. First, more than one-third of the dynamics from both teams reached the penetration zone

of the opponent defense or ended with an effective offensive action (i.e., shot on goal or a cross, without a penetration), implying these were successful dynamics (35% BARand 34% MUN). Second, the proportion of dynamics that resulted in an offensive ending action (cross or shot on goal) was 17% for both teams.Thus, approximately 50% of the successful dynamics resultedinan offensive action (17% of 34-35%). Finally, the proportion of ball possessions that resulted in a score attempt was 7.5% for BAR and 6.8% for MAN, representing approximately one quarter of all successful dynamics.

In the literature, previous studies reported that about 10% of ball possessions resulted in finalization (Hughes & Franks, 2005; Lucey, Bialkowski, Monfort, Carr & Matthews, 2015; Pollard, Ensum& Taylor, 2004), which is slightly higher than the present findings. However, the methodology of this previous literature differs substantially from ours. In this study, the dynamics that resulted in a backward passwill finish the ball possession and automatically start a new one. Thereby, it is possible for more than one dynamic per ball possession to occur, thus increasing the number of dynamics in relation to ball possession.If the dynamics that resulted in abackward passwere excluded, the index of dynamics that resulted in a score attempt would be about 10% (10.2% BAR and 8.3% MUN), which is closerto previous results.

Ball circulation style

The significant differences between the performance of Barcelona and that of Manchester United manifested in threeways: i) backward circulation passin incomplete penetration dynamics in the offensive pitch;ii) long ball kickin incomplete penetration dynamics in the defensive field;iii) and losing ball in incomplete penetration dynamics in the defensive field. Barcelona had significantly more events resulting in backward circulation pass from incomplete penetration in the offensive field (11.3% BAR and 6.1% MUN). In contrast, Manchester United presented significantly more dynamics resulting in long ball kick from incomplete penetration in the defensive field (16% MUN and 10.9% BAR) and significantly more dynamics in incomplete penetration in defensive field, resulting in losing ball possession (13% MUN and 7.1% BAR). Thus, Barcelona presented significantly more incomplete dynamics in the offensive pitch (33.6%BAR and25.2% MUN) and Manchester United presented significantly more incomplete dynamics in the defensive pitch (43.5%MUN and34.9% BAR).

The three significant differences between Barcelona and Manchester United on keeping ball possessionevidenced some features of the general teams' offensive style. Barcelona seemedmore efficientinkeeping the ball in the defensive pitch, with less instances of losing balls in incomplete penetration dynamics inthe defensive pitch and lower number of long ball kicks dynamics than Manchester United. Moreover, the higher number (110) of backward circulation passeson incomplete penetration dynamics in the offensive pitch may indicate Barcelona's preferences to conserve ball possession and search for better opportunities to perform a penetration play.

In general, Barcelona's style is characterized by a great variety of ball circulation path, in terms of both width and depth.In analyzing Barcelona games during the 2010–2011, a previous study found two main performance indicators related to Barcelona's style: total number of lateral pass and high percentage of ball possession (Fernandez-Navarro, Fradua, Zubillaga, Ford &McRobert, 2016). The results observed in this study may indicate that these indicators can support the ball possession reset play, tactics for restarting the ball possession to wait for the right moment to try penetratingthe opponent's defensive system.By contrast, Manchester United keeping ball possessionresults could be related to its varied style, with elements of ball possession (high frequency of backward circulation pass) and direct play (high frequency of long ball kick actions), features that coincide with reported impressions of Portuguese coaches (Sarmento et al., 2013). In the direct style, progression of the ball is crucial. The aim of this strategy is to gain the ball dispute in the offensive pitch and perform a fast attack or avoid losing ball possession in a dangerous zone of the pitch. The resultsobtainedby Manchester United support the hypothesis of the avoid lose ball possession because ofthe team's greater percentage of incomplete penetration dynamics in the defensive pitchcompared to Barcelona (13% MUN and 7.1% BAR) and the low percentage of long ball kick play in relation toa dynamics totality (16% MUN).

Interchanges between efficiency and style

In regard to efficiency, Barcelona presented significantly more incomplete dynamics in the offensive pitch and less incomplete dynamics in the defensive pitch than Manchester United. However, the percentage of dynamics that reached penetration were the same (31.5% BAR and 31.3% MUN), with no differences in relation to success between the two teams. In other words, the Barcelona and Manchester United styles though different,seems to sharethe same offensive efficiency. This find may be a counter-intuitive, indicating that the tactics of keeping the ball possession withgreat variation of width and depth to create space in the opponent defensive system can present similar efficiency to anotherbased ona direct play or a varied style, with elements of ball possession play and direct play.In the literature,some studies have found similar results when comparing the ball possessions with more or less than four passes (Hughes & Franks, 2005) and ball retention and point reached in the competition (Collet, 2013).

Our analyses of penetration stylefound no significant differences between teams, with only certain trends, such as: i)periphery to center attack ($p \approx 0.1$; 1.657 standard deviation) and periphery to periphery attack ($p \approx 0.13$; 1.527 standard deviation) greater for Manchester United; ii) Return penetration attack ($p \approx 0.23$; 1.2 standard deviation) greater for Barcelona. These trends provide evidences of periphery penetration preferences for Manchester United in relation to Barcelona and preferences of Barcelona to keep the ball possession when recovers the ball in penetration situation in relation to Manchester United.

Score attempts dynamics' style

For dynamics that resulted in score attempts, there were also no differences between teams, which may have been influenced by the small sample size. The most relevant finding inthis case was the expressive occurrence of score attempts originating from a definition attack by set play (23% BAR and 23.4% MUN) and by game recovery (17.6% BAR and 18.8% MUN). These two classes togetherrepresenting 40.6% and 42.2% of the total score attempts for Barcelona and Manchester United, respectively. This finding may give a strong indication of the importance of starting ball possession in a favorable situation (advanced field's zone and high penetration's degree) to offensive success.

Finalconsiderations

Generally, the approach used in this work was efficient for detecting differences between Barcelona and Manchester United, mainly in relation to general ball circulation style. In the penetration style analysis, the few differences that were found can be explained by small sample size or by the similarity between Barcelona's and Manchester United's strategies. It is important to highlight that Barcelona and Manchester United were bothhighlywinningteams that season and they share some common style features. If the comparison was performed with lower-level teams, the differences may be higher.

This study has some limitations. It simplifies the game focusing onthe ball actions, excluding information about the players' position and the action outside of ball zones. Additionally, it lacks information on the opponent's performance (ranking in the competition) and game status. Despite that, the selected indicators were efficient to describe important features of the teams' offensive style.

Conclusion

The method in the present work was demonstrated to be sensitive to tactical features that differentiate offensive game styles of soccer teams. It provides meaningful variables that can be broadly applied by professionals simply gathering data from public video footages. In addition, the method supports technological contributions that facilitate the retrieval of relevant information and the position of all players in each scene by automated digital video analysis techniques.

Future researchmay increase resolution of the classification method, expand the tactical information set by considering the geometric arrangement of the players in each frame, and include the defenders and relevant actions outsidethe ball zone. In addition, the structure of game analysis could reflect a formal game analysis framework that recognizes complex collective actions (meta grammars of collective actions) and their concatenations.For this purpose, it is worth to develop a dataset of game dynamics (represented by grammars) and concatenation analysis of these dynamics, similar toelsewhere performed in the context of goalkeepers (Lamas, Drezner, Otranto& Barrera, 2018) and soccer defensive performance from positional data of automatic tracking system (Le, Carr, Yue&Lucey, 2017).

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