Collective team behaviour of Australian Rules football during phases of match play

ABSTRACT

Using the spatiotemporal characteristics of players, the primary aim of this study was to determine whether differences in collective team behaviour exist in Australian Rules football during different phases of match play. The secondary aim was to determine the extent to which collective team behaviour differed between competing teams and match half. Data was collected via 10 Hz global positioning system devices from a professional club during a 2 x 20 min, 15-v-15-match simulation drill. Five spatiotemporal variables from each team (*x* centroid, *y* centroid, length, width, and surface area) were collected and analysed during offensive, defensive, and contested phases. A multivariate analysis of variance comparing phase of match play (offensive, defensive, contested), Team (A & B), and Half (1 & 2) revealed that *x*-axis centroid and *y*-axis centroid showed considerable variation during all phases of match play. Length, width, and surface area were typically greater during the offensive phase comparative to defensive and contested phases. Clear differences were observed between teams with large differences recorded for length, width, and surface area during all phases of match play. Spatiotemporal variables that describe collective team behaviour can be used to understand team tactics and styles of play.

Key Words: Performance analysis, Tactics, Style of play

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Otherwise, no other comments about the abstract.

INTRODUCTION

Research into the tactics or playing styles of invasion sport teams has typically been undertaken using notational analysis. This method involves the recording of discrete actions by players and teams (i.e., number of passes, possession, turnovers) in a sequential order (Hughes and Franks, 2005; Lago, 2009; Liu, Gomez, Lago-Penas, & Sampaio, 2015; Vogelbein, Nopp, & Hokelmann, 2014). Whilst useful in determining subsequent features of team tactics or styles of play, this approach potentially underestimates the complexity of invasion sports by disregarding broader contextual information, such as player positioning in relation to teammates and opponents (Duarte, Araujo, Correia, & Davids, 2012; Travassos, Davids, Araújo, & Esteves, 2013; Vilar, Araujo, Davids, & Button, 2012).

One reason behind a lack of progress in using such contextual information may be in part due to the absence of accessible and reliable data (Memmert, Lemmink, & Sampaio, 2017). The advent of player tracking technologies has allowed for increased access to spatiotemporal data in training and matches. More recently, researchers have used this data to generate a range of variables that determine how teams position themselves across a field of play (Clemente, Couceiro, Martins, & Mendes, 2013a; Clemente, Couceiro, Martins, Mendes, & Figueiredo, 2013b; Frencken, Lemmink, Delleman, & Visscher, 2011). Common examples include: team centroid, which has been measured longitudinally, laterally, or radially (Clemente, et al., 2013a), team surface area (Castellano, Álvarez, Figueira, Coutinho, & Sampaio, 2013; Clemente, et al., 2013b; Clemente, Couceiro, Martins, Mendes, & Figueiredo, 2013c; Frencken, et al., 2011), and team length and width (Castellano, et al., 2013; Castellano and Casamichana, 2015; Clemente, et al., 2013b; Clemente, et al., 2013c; Folgado, Lemmink, Frencken, & Sampaio, 2014). The expression and interaction of these variables in different match contexts can then be used to define and understand collective team behaviour.

Such information has been used to inform team tactics or styles of play (Clemente, et al., 2013a; Clemente, et al., 2013c; Folgado, et al., 2014). In football, the team *x*-axis (longitudinal) centroid has been used to determine that teams are positioned higher up the field during home games when compared to away games (Bialkowski, Lucey, Carr, Yue, & Matthews, 2014) and in the second half compared to the first half (Clemente, et al., 2013b). Irrespective of match context, teams tend to maintain an overall position behind the centre of the field, thereby preserving a level of 'defensive stability' (Castellano, et al., 2013; Clemente, et al., 2013b; Clemente, et al., 2013c; Vilar, Araújo, Davids, & Bar-Yam, 2013). Other football research has revealed that the surface area of experienced teams was greater compared to less experienced teams (Olthof, Frencken, & Lemmink, 2015) and values decreased throughout the match when comparing the first and second half (Clemente, et al., 2013b). Further, comparative to lower ranked counterparts, higher ranking teams generally use more width than length by having more supporting players across the field than along it (Castellano and Casamichana, 2015).

Invasion sports are often separated into different phases of match play, such as offence and defence, which are typically dictated by ball possession (Clemente, et al., 2013c). Simply, the aim in offence is to advance the ball along a playing surface to score a goal, whilst the aim of defence is to prevent the opposition from achieving this same aim (Memmert, et al., 2017). However, as offence and defence are concomitant a team cannot position players to create more attacking options whilst maintaining players in supportive regions to preserve defensive stability (Grehaigne, Bouthier, & David, 1997). As such, distinct differences in player positioning may occur between phases due to the emerging requirements throughout a match (Castellano, et al., 2013; Clemente, et al., 2013b; Clemente, et al., 2013c). It has been suggested that during offence, teams generally aim to spread to opposition's defending players to create space (Vilar, et al., 2013). While during defence, players will generally aim to restrict

the area in which the opposition can attack in (Vilar, et al., 2013). Studies support this proposition with higher values of length, width, and surface area recorded during offence when compared to defence (Castellano, et al., 2013; Clemente, et al., 2013b; Clemente, et al., 2013c). Therefore, the amount of possession may influence the overall collective behaviour of teams (Castellano, et al., 2013; Clemente, et al., 2013b). Despite this, limited studies that have analysed collective team behaviour in invasion sports have compared between phases of match play (Castellano, et al., 2013; Clemente, et al., 2013b; Clemente, et al., 2013c). Those that have are limited to utilising junior players in a 7-a-side playing format (Clemente, et al., 2013c) or have not quantified the total amount of possession (Castellano, et al., 2013; Clemente, et al., 2013b). Furthermore, despite a body of research examining collective team behaviour in football, investigations into Australian Rules Football remain largely absent. Australian Rules football (AF) is a sport where teams compete on an oval shaped field (length = ~160 m, width = ~130 m) with 22 players in total, with 18 on the field and 4 on an interchange (Gray and Jenkins, 2010).

Determining collective team behaviour has become a central component of match analysis due to its influence on performance outcome (Memmert, et al., 2017). Researchers have used this information to describe team tactics or game style when it forms repetitive patterns of play (Sampaio and Macas, 2012). For a more contextual understanding of collective team behaviour studies have separated different phases of match play (Clemente, et al., 2013c). Despite this, limited studies have demarcated between phases of play. Furthermore, no investigations in Australian Football (AF) have been reported. Therefore, using the spatiotemporal characteristics of players, the primary aim of this study was to determine whether differences in collective team behaviour exist in Australian Rules football during different phases of match play. The secondary aim was to determine the extent to which collective team behavior differed between competing teams and match half.

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Commented [ja3]: Reviewer #1 also wanted a clear statement of contribution and study pertinence. Also justify the aims. Lines 85-91 are new. I feel this is a lot clearer now. While not necessary it should keep them happy.

METHODS

Data were collected from one training session with 30 male professional AF players (age 23.9 ± 4.3; height 188.0 ± 7.9; body mass 86.0 ± 9.4) recruited from a single team in the Australian Football League (AFL) competition. Participants took part in a match simulation drill as part of preseason training. All participants received information about the requirements of the study via verbal and written communication, and provided their written consent to participate. The Victoria University Ethics Committee approved the study.

Participants were randomly separated into two teams of 15 each, labeled Team A and Team B for analysis purposes. The match simulation took place on an oval shaped ground using dimensions 163.7 m x 129.8 m (length x width) with two 20-min halves and a 10-min break between periods. Data for all participants were collected using 10 Hz GPS devices (Catapult Optimeye S5, Catapult Innovations, Melbourne, Australia). The devices were housed in a fitted harness on the upper back. Previous investigations have assessed the validity and reliability of these devices (Johnston, Watsford, Kelly, Pine, & Spurrs, 2014; Varley, Fairweather, & Aughey, 2012).

Possession of the ball was determined via video observation and analysed to the nearest decisecond by the first author. The offensive phase was recorded when a team first gained possession of the ball and maintained it for at least a second and ended when the opposing team gained possession of the ball for at least a second or there was a stoppage in play (i.e., the team scored or the ball went out of bounds) (Yue, Broich, Seifriz, & Mester, 2008). Using the same conditions, the defensive phase was recorded when the opposing team had possession of the ball (Yue, et al., 2008). If neither team had possession of the ball (i.e., when the officiating umpire returned the ball to play) the phase was considered to be in

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'contest' until a team gained possession of the ball for at least a second. All periods were the ball was out of play (e.g. break between periods of play, ball out of play, celebration after goals) were excluding from the investigation.

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Spatiotemporal characteristics of participants recorded from the GPS units were exported in raw 10 Hz format. Each file contained a global time stamp and calibrated location (*x*- and *y*- location). The centre of the ground was signified as 0, 0. Each participant's file consisted of approximately 33,000 data points including time and location. Spatiotemporal data were then synchronised with ball possession using the respective global time stamps. This was established using the initial point when the two widest players converged prior to start of each quarter. Five variables (Figure 1) were derived from the data to describe collective team behaviour. First, team centroid was calculated as the mean (*x*, *y*) position of all players on the field of one team (Frencken, et al., 2011). Two measures were derived from the centroid position. These were the distance in the *x*-axis centroid (m) and the distance in the *y*-axis centroid (m) (Frencken, et al., 2011). The team surface area of each team was calculated as the total space (m) covered by a single team, referred to as a convex hull (Frencken, et al., 2011). Team length was measured as the distance between the most forward and most backward player in the *x*-axis (m) and team width was defined as the distance between the two most lateral players on the ground in the *y*-axis (m) (Frencken, et al., 2011). These variables were assessed during offence, defence, and contested phases of match play and during first and second halves. This was processed using the computational package Python version 3.2 with *Spyder*, which is part of the Anaconda software suite (www.python.org).

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Statistical Analyses

Comparison of team *x*-axis centroid, *y*-axis centroid, length, width, and surface area were assessed between phase of match play (3 levels: Offence, Defence, Contest), teams (2 levels:

Team A & Team B), and half (2 levels: Half 1 & Half 2), via a multivariate analysis or variance (MANOVA). Homogeneity was analysed using the Levene Test, which resulted in a lack of uniformity between phases of match play. The *F* test was used to combat homogeneity violations due to the fact the total number of samples is in each group was essentially equal (Vincent, 1999). Due to the non-homogeneity of the time series data, the Central Limit Theorem was considered, which allowed the assumption of normality to be made (Akritas, 2004). Cohen's conventions for effect size (*d*) were assessed, where 0.2, 0.5, and 0.8 are considered as small, medium and large, respectively (Cohen, 1988). Statistical calculations were determined using StatPlus™ (AnalystSoft, Alexandria, VA, USA) with significance set at $p < 0.05$.

RESULTS

Between phase comparison for each team for the first and second half is displayed in Figure 2. Between team comparison for the first and second half is presented in Figure 3. The *x*-axis centroid for Team B displaying possession throughout the match is displayed in Figure 4. The amount of possession for the first and second half is shown in Table 1.

**** INSERT FIGURE 1 NEAR HERE ****

Between-phase analysis for the *x*-axis centroid was mixed, as Team B was positioned higher up the field during the offensive phase when compared to the defensive phase in both the first half (ES = 0.50, 90% CI = 0.46 – 0.50) and second half (ES = 1.06, 90% CI = 1.03 – 1.10). While in the first half Team A was positioned closer to their defensive end when comparing the offensive phase to the defensive phase (ES = -0.65, 90% CI = -0.69 – -0.61).

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Makes this section very hard to read and quite long.

This paragraph is just for figure 2. There's 60 potential findings (3 phases x 2 teams x 5 metrics x 2 halves). I've only reported on medium/large effect sizes.

The *y*-axis centroid indicated both Team A () and Team B () had players situated to the right hand side of the field during offence when compared to defence in the first half. Length was greater during the offensive phase when compared to the defensive phase for Team B in the first half (ES = 0.77, 90% CI = 0.72 – 0.82) and Team A in the second half (ES = 0.94, 90% CI = 0.91 – 0.98). Length during the offensive phase was less when compared to the contested phase for Team A (ES = 0.57, 90% CI = -0.63 – -0.51) and Team B (ES = -0.90, 90% CI = -0.96 – -0.84) during the second half. Length was also smaller during the defensive phase when compared to the contested phase for Team A (ES = -0.65, 90% CI = -0.69 – -0.60) and Team B (ES = -0.77, 90% CI = -0.82 – -0.72) during the first half and for Team A (ES = -1.05, 90% CI = -1.12 – -0.99) and for Team B (ES = -1, 90% CI = -1.07 – -0.94) during the second half. Width was greater during offence when compared to defence for Team A during the first half (ES = 0.65, 90% CI = 0.62 – 0.69) and second half (ES = 1.3, 90% CI = 1.26 – 1.34). Team B also displayed greater width during offence when compared to defence during the first half (ES = 0.55, 90% CI = 0.51 – 0.58) the second half (ES = 0.94, 90% CI = 0.91 – 0.98). Width was greater in offence than contest for Team B in the first half (ES = 1.21, 90% CI = 1.16 – 1.27) and second half (ES = 1.64, 90% CI = 1.57 – 1.70). Team A displayed less width during the defensive phase when compared to the contested phase in the first half (ES = -0.59, 90% CI = -0.64 – -0.54) and second half (ES = -1.11, 90% CI = -1.17 – -1.05). In contrast, Team B had greater width during defence when compared to contest in the first half (ES = 1.01, 90% CI = 0.96 – 1.06) and second half (ES = 1.18, 90% CI = 1.11 – 1.24). Surface area was greater during the offensive phase when compared to ~~than~~ the defensive phase for Team A in the second half (ES = 0.70, 90% CI = 0.66 – 0.73) and for Team B in the first half (ES = 1.02, 90% CI = 0.98 – 1.06) and second half (ES = 0.91, 90% CI = 0.88 – 0.95). Surface area was also greater during the offensive phase compared to the contested phase for Team A in the first half (ES = 0.90, 90% CI = 0.84 – 0.97) and second half (ES = 1.16, 90% CI = 1.10 – 1.22) and

for Team B in the first half (ES = 1.32, 90% CI = 1.27 – 1.37) and second half (ES = 1.42, 90% CI = 1.36 - 1.49). When comparing defensive to contested phases, the surface area was greater for Team A during the first half (ES = 0.64, 90% CI = 0.57 – 0.70) and second half (ES = 0.56, 90% CI = 0.51 – 0.61) and for Team B during the first (ES = 0.54, 90% CI = 0.49 – 0.59) and second half (ES = 0.71, 90% CI = 0.65 – 0.77).

*** INSERT FIGURE 2 NEAR HERE***

Between-team analysis displayed the *x*-axis centroid of Team B (Figure 3) as higher up the field in all phases of match play for the first half when compared to Team A. Contrastingly, in the second half, Team A was higher up the field in all phases of play when compared to Team B. Except for width during the contested phase, Team B had greater values in length, width, and surface area during all phases of play.

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If necessary it will blow out this paragraph too. I'd have to put in another 24 separate effect sizes and confidence intervals.

INSERT FIGURE 3 NEAR HERE

Possession data displayed that Team B had greater possession of the ball in the first half, while Team A had greater possession of the ball in the second half.

INSERT FIGURE 4 NEAR HERE

INSERT TABLE 1 NEAR HERE

DISCUSSION

This is the first study to describe collective team behaviour in AF teams during different phases of match play. The central finding was that collective team behaviour was influenced by match phase. The *x*-axis centroid and *y*-axis centroid recorded large variations during all phases of match play. Length, width, and surface area were typically greater during offence when compared to defence and contest. Between-team analysis established differences in collective team behaviour with Team B recording greater values in length, width, and surface area during all phases of match play.

In the first half, Team A's *x*-axis centroid recorded the team in their defensive half during all phases of match play. This may suggest that they were displaying more conservative team behaviour by preserving players to defend their goal. However, the *x*-axis centroid during offence was further behind their *x*-axis centroid in defence. This would indicate that the players moved towards their defensive end during attacking sequences, which would be counterintuitive. Therefore, this finding may be associated with where possession was gained or lost. If possession were gained in the defensive half, it would mean attacking sequences commenced further away from the opposition's goal. As subsequent attacking sequences moved towards their scoring end a turnover of possession would mean their centroid in defence is higher up the field of play. This may be associated with the possession rate as Team B had more possession of the ball, which would require Team A to defend more often and more than likely in their defensive end. In the second half, Team A had greater possession of the ball and their *x*-axis centroid was considerably closer to their goal in all phases of match play. As a result, Team B's *x*-axis centroid signified that they defended closer to their goal in both contested and defensive phases. However, Team B did maintain a positive *x*-axis centroid during offence throughout the whole match. The *y*-axis centroid indicated that both teams attacked from the right hand side of the field in the first half. Throughout the match, Team B displayed more expansive behaviour compared to Team A regardless of match phase or team

possession. Specifically, Team B recorded consistently greater values in length, width, and surface area during all phases of match play, apart from width during the contested phase. This type of behaviour may be associated with players aiming to spread the opposition defending players to create a greater effective playing space, which allows for an easier passage of the ball (Vilar, et al., 2013).

Research undertaken in football suggests that overall; teams employ more conservative team behaviour by positioning players closer to their own goal (Clemente, et al., 2013b; Clemente, et al., 2013c; Vilar, et al., 2013). Results from this study indicate that AF teams display large variations in both positive and negative overall positioning. Whilst a formal comparison between sports has not been made here, it appears AF teams may be more willing to collectively move higher up the field if the ball is in their attacking end and conversely, reposition deeper towards their defensive end when the opposition has possession of the ball. Investigations in soccer have found that teams play with more length, width, and surface area in offence compared to defence (Clemente, et al., 2013c). Correspondingly, this study suggests AF teams have typically greater values in offence compared to defence. Furthermore, both teams had a greater surface area in both offence and defence when compared to contest. This may indicate that both teams tried to constrict space when the ball was in dispute or be a defensive mechanism to close down space quickly if the opposition gained possession of the ball.

Whilst invasion sport teams will engage certain behaviours in order to achieve success, resulting player movement is constantly influenced by athletes adapting to contextual variables (i.e., match status, opposition team tactics, time, and where ball possession takes place) (Castellano, et al., 2013; Rein and Memmert, 2016). Therefore, it is difficult to differentiate if collective team behaviour is a result of a preconceived team tactic, due to emerging contextual variables, or a combination of both (Rein and Memmert, 2016). This

conundrum is highlighted through research in football which established that when playing against lower ranked teams within the same league, higher values of length, width, and surface area were found during offence when compared to defence (Castellano, et al., 2013). However, this finding was reversed when playing against higher ranked teams, with smaller values of length, width, and surface area during offence compared to defence (Castellano, et al., 2013). Nonetheless, researchers analysing an entire season of first and second division Spanish soccer found that length in top ranking teams in first division was different to length in top ranking teams in the second division league (Castellano and Casamichana, 2015). This finding indicates a different strategy to play with more length when comparing first division and second division teams. Furthermore, longitudinal investigations in soccer also found that teams in the English Premier League may employ more conservative team behaviour by positioning players closer to their own goal during away games when compared to home games (Bialkowski, et al., 2014).

Limitations surrounding sample size and match reproducibility in this study should be considered ~~when interpreting the results~~. This study analysed collective team behavior from one match in an out of season match. Additional data from multiple matches during a competitive season are required to ensure collective team behavior in AF is consistent with this research. The authors also recommend future studies incorporate contextual variables including phase of play and position on the field.

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Don't mind this though as it will be a good lead into study 2.

Quantifying collective team behaviour on a longitudinal basis, whilst considering contextual variables, will assist in uncovering repeated patterns in player movement. This then provides sporting organisations with an enhanced understanding of teams tactics or styles of play, which can assist in improving performance. Practically, this information will assist in developing specific training regimes to promote desired tactical structures. Coaches can use this to reinforce how players should position themselves in various phases of play. This

information can also be used in gaining a competitive advantage by exploiting any perceived inefficiencies in the opposition's style of play. Specifically, whilst defending, players may position themselves higher up the field to minimise the space the attacking team can operate in. This may increase the likelihood of regaining possesssion or constraining offensive ball movement. However, this tactic may also create unguarded defensive space closer towards the opposition's goal, which may leave the team susceptible to attacking sequences that are able to penetrate the defending players. Conversely, if players maintain defensive stability by occupying space closer to goal, this may create space higher up the field. Attacking teams may utilise this space and employ a higher possession style of play to minimise potential turnovers.

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CONCLUSION

The results from this study describe the collective team behaviour of AF teams during various phases of match play. The main findings advocate that collective team behaviour is influenced by match phase. The *x*-axis centroid and *y*-axis centroid recorded large variations during all phases of match play. Length, width, and surface area were typically greater during offence when compared to defensive and contested phases. Clear differences were observed between teams with large differences recorded for length, width, and surface area during all phases of match play. Spatiotemporal variables that describe collective team behaviour can be used to understand team tactics and styles of play.

DISCLOSURE OF INTEREST

The authors report no conflicts of interest.

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