Coordination tendencies are shaped by attacker and defender interactions with the goal and the ball in futsal

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ABSTRACT

This study examined how the location of the goal and ball constrained the interpersonal coordination tendencies emerging of attacker-defender dyadic systems in team sports. Additionally, we analysed how the positioning of defenders constrained the emergent coordination tendencies between the ball carrier and supporting teammates. To investigate these tendencies in team sports, ten futsal games were filmed to observe inter-individual interactions. Movement trajectories of players and ball were digitized during 52 outfield attacker-defender interactions involving thirteen goal-scoring sequences. Relative phase was used as a measure to express participant coordination tendencies in these dyadic systems (in-phase or symmetry – 0°; anti-phase or anti-symmetry – 180°). Stable in-phase patterns of coordination emerged between specific values of an attacker's distances to defenders and the goal (19% frequency from 0° to 29° of phase relations) and between specific values of distances of ball carriers to defenders and teammates (14% frequency from 0° to 29° of phase relations). A stable pattern of coordination of –60° emerged between values of an attacker's distances to defenders and the ball (18% frequency from 0° to 29° of phase relations). Distances of attackers to the goal and ball, and
distances of ball carriers to defenders, seemed to be coupled in a specific manner to guide interpersonal coordination tendencies between players during competitive performance in the team sport of futsal.

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1. Introduction

People often produce actions in social contexts, such as team sports, in which their movements are coordinated in relation to movements of others. The structure of such interpersonal coordination tendencies has been a popular topic with human movement scientists seeking to understand how people interact intentionally or sub-consciously with others in space and time (Schmidt, Fitzpatrick, Caron, & Mergeche, 2011; Travassos, Araújo, McGarry, & Vilar, 2011). Research in team sports, conducted from the perspective of ecological dynamics, has sought to explain successful performance by examining how players coordinate their movements with those of other performers, and how this coupling is regulated by information (Araújo, Davids, & Hristovski, 2006; Vilar, Araújo, Davids, & Button, 2012).

A key principle of ecological dynamics is that analysis of interpersonal coordination in social neurobiological systems, such as sports teams, should consider the individual-environment relationship as the relevant scale for understanding sport performance (Davids & Araújo, 2010). Coordination is considered to emerge from continuous spatial–temporal interactions of players (both teammates and opponents) with key task constraints, such as the location of the ball and the goal (Vilar, Araújo, Davids, & Travassos, 2012). Such constraints surround a complex system and reduce the number of organisational states that are available to it, pushing coordination of system components towards stable states of organisation (i.e. in dynamical systems language: towards attractors) (Warren, 2006).

In team sports, spatial–temporal interactions between players and key-features of the game, such as specific locations of the ball and the goal, play an important role here, since it are these constraints that players harness as information to regulate cooperative actions with teammates during successful performance. Spatial–temporal constraints in sport performance often change on a moment-to-moment basis due to the complex relations between performers (Fajen, Riley, & Turvey, 2009). For example, at any moment in the team sport of futsal (5-aside indoor association football game), a passing line between defenders may open and an opportunity to pass the ball may be offered to a ball carrier (Travassos et al., 2012). Milliseconds later a defender may move into the line of the ball's trajectory with the ball receiver, and the opportunity to perform a successful pass is no longer available. The instability that characterizes performance constraints in team sports makes opportunities for action continuously arise and dissipate instantaneously, leading to fluctuations in the organisational states of games (e.g. characterised by increased variability in the way that attackers and defenders coordinate their actions) (Araújo & Davids, 2009). When these game fluctuations are powerful enough to destabilise the existing equilibrium between attacking and defending players, a symmetry-breaking process emerges. That is, a previously stable state of the game transits to a new dynamic state of organization (e.g. an attacker dribbles past a first defender, inducing a second defender to cover and leading to a structural change in a defending team) (Davids, Glazier, Araújo, & Bartlett, 2003).

Previous research on interpersonal coordination tendencies in team sports has examined interactions within attacker-defender dyadic systems (i.e., 1v1 sub-phases of competitive matches) (Bourbousson, Sève, & McGarry, 2010a; Travassos et al., 2011). For example, in futsal, attacker and defender interpersonal coordination tendencies have been investigated using relative phase as a dynamic measure, enabling a quantitative expression of coordination processes emerging between the players entrained in a momentary dyadic system (Travassos et al., 2011). When both players in a dyad move forwards and backwards simultaneously, an in-phase (0°) coupling tendency may be identified. On the other hand, an anti-phase (180°) mode of coordination emerges when one system agent is moving forward and the other is moving backwards at the same time (Kelso, 1995). Previous analyses of movement trajectories of attacker-defender dyads comprising directly competing opponents (identi-
fied from playing position), have revealed strong in-phase attractions in both lateral (from sideline to sideline) and longitudinal directions during performance (from goal to goal) (Travassos et al., 2011).

In 1v1 sub-phases of team sports (including basketball, rugby union and association football), the relative velocity of a ball carrier and a ‘marker’ (i.e. the closest defender to that player) in a ball-carrying dyad, and the value of interpersonal distance between them, have been identified as critical variables. It has been observed that these variables lead a ball carrier-defender dyadic system to a transition towards one of two possible coordination patterns: a successful dribble or a successful defensive interception (Duarte et al., 2010; Passos et al., 2008). During competitive performance in team sports, such as futsal, outfield players not only self-organise into a single dyadic system with possession of the ball, but also other momentary dyadic systems without the ball (McGarry, Anderson, Wallace, Hughes, & Franks, 2002). Previous research has tended to only examine system interactions in ball-carrying dyads (Araújo et al., 2006; Duarte et al., 2010; Passos et al., 2009), or in all the dyads forged in a match (Bourbousson et al., 2010a; Travassos et al., 2011). There have been no attempts to identify how players involved in dyads without possession of the ball coordinate their movements with the movements of the ball-carrying dyad. Analysis of verbal reports of a player dribbling with the ball during a basketball match has suggested that, when pressurised by an immediate defender, an offensive teammate moved to offer a passing opportunity and a pass emerged (e.g., “the guard is putting pressure on me (…) there it frees up, so I make the pass”) (Bourbousson, Poizat, Saury, & Seve, 2010, p. 154). In the complex performance environment of futsal, it is possible that interpersonal distance might influence the behaviours of teammates, and such a variable might be significantly shaped by different task constraints. Important questions arise over which other variables might constrain the organisational tendencies of dyadic systems in team games.

To examine this issue, this study sought to understand how the location of the goal and the ball might act as constraints on the stability of attacker-defender dyadic systems temporarily organised during competitive team game performance. We also tried to identify how the stability of interactions in dyadic systems formed by a ball-carrier and a teammate were constrained by actions (movement trajectories) of markers (immediate defenders) of the ball carrier on court. Identification of regularities in the dynamics of relevant variables (i.e., predominant modes of coordination), might reveal the non-physical (information-based) link between players and relevant features that sustain successful performance in team sports.

2. Method

2.1. Ethics

This study was conducted within the guidelines of the American Psychological Association and the protocol was approved by a local university ethics committee.

2.2. Data collection

Seventy-one players (M = 25.31, SD = 4.73 years) from five national teams played ten futsal games in the 2009 Lusophony Games. Futsal is an indoor 5-aside soccer game approved by FIFA. Due to the rules of the game, only playing roles of the goalkeepers and the outfield defenders may be distinguished, since in this small-sided version of soccer, outfield players are free to move at will through different areas of the pitch. All matches were recorded with a digital video camera (frequency = 25 Hz) located above and behind the short axis of a futsal court, with a resolution of 1280 × 720 pixels. Thirteen sequences of play without transitions in ball possession between teams (M = 20.31, SD = 9.82 s of duration) were randomly selected for movement analysis from the total number of sequences that ended in a goal being scored (n = 79). Since in futsal the clock stops every time the ball goes out of the court or the referee identifies a foul, the selected data sequences were timed from moment of the last clock interruption before a goal was scored, to the moment the ball entered the goal. Within each randomly selected sequence of play, movement trajectories of all four attacker-defender dyads
formed by outfield players were analysed, totalling fifty-two trials, of which thirteen dyads had the ball in their possession (i.e., they were designated as ball-carrying dyads).

2.3. Data analysis

All thirteen goal sequences selected were digitized with TACTO software to convert players’ trajectories into virtual coordinates (i.e., in pixels) (Duarte et al., 2010). 2D-DLT (direct linear transformation) files were produced and used to convert pixel coordinates into actual coordinates (calibrated in m). Data were filtered using a Butterworth low pass filter (6 Hz) (Fernandes, Caixinha, & Malta, 2007). The bottom left corner of the futsal court was assigned zero coordinates, the length of the field or longitudinal direction was assigned to the $y$ axes and $x$ axes representing the width or lateral direction of movement. Starting from the $x$ and $y$ coordinates of each player and the ball, we computed distances between all outfield defenders to each attacker, defining the nearest defender to each attacker in each time frame (i.e., we identified attacker-defender dyads). That is, while the attacker in a dyadic system is permanently the same, the defender may change during play. We also calculated the interpersonal distance values between attackers and defenders, and the distances of each attacker to the ball and to the centre of the goal (see Fig. 1A). Relative phase values, calculated by the Hilbert transform (Palut & Zanone, 2005), were used to capture the state of entrainment between the distance of the attackers to the defenders and: (i) the goal, and (ii), the ball. When both players in a dyad move forwards and backwards at the same time and with the same magnitude of displacement an “in-phase” (0°) mode of coordination may be identified; On the other hand, an “anti-phase” (180°) mode of coordination emerges when one system agent is moving forward and the other is moving backwards at the same time and with the same magnitude of displacement. Variations on the frequency or on the magnitude of one player displacement in relation to the other promotes a lead lag relation (positive when player A is advanced in time and negative when is player B is advanced in time in relation to other player) (Kelso, 1995). To ensure that interpersonal distances data circled the origin, a necessary step when subjecting data to relative phase analysis using Hilbert transform, original values of

![Fig. 1. Illustration of the different variables analysed in this investigation: Fig. 1A – (a) interpersonal distance between the attacker (A) and the nearest defender (D); (b) distance of the attacker (A) to the centre of the goal; and (c), distance of the attacker (A) to the ball; Fig. 1B – (a) interpersonal distance between the ball carrier (1st attacker or 1A) and marker (1D); (d) distance of the ball carrier (1st attacker or 1A) to the 2nd attacker (2A); (e) distance of the ball carrier (1A) to the 3rd attacker (3A); and (f), distance of the ball carrier (1A) to the 4th attacker (4A).]
Interpersonal distances were subtracted from the mean value (Rosenblum, Pikovsky, Kurths, Schäfer, & Tass, 2001).

In addition, we also analysed distances of the ball to the attackers, defining the ball carrier as the nearest attacker to the ball in each time frame (1st attacker or 1A). The ball carrier and the nearest

**Fig. 2.** Attackers’ distances to the defender, and key-task constraints: (A) Analysis of distances of attacker 5 to the defender and goal in sequence number 11; (B) Analysis of the dynamics of the relative phase of attacker 5 distances to the defender and goal in sequence number 11; (C) – Frequency histogram of the relative-phases of all attacker-defender dyadic systems (n = 52) using attacker’s distances to the defender and to the goal; (D) Analysis of attacker 5 distances to the defender and ball in sequence number 11; (E) – Analysis of the dynamics of the relative phase of attacker 5 distances to the defender and ball in sequence number 11; (F) – Frequency histogram of the relative-phases of all attacker-defender dyadic systems (n = 52) using attacker’s distances to the defender and to the ball.
defender (i.e., the marker) were defined as the ball-carrying dyad. The computation of each attacker’s distance to the ball carrier, determined the location of the 2nd attacker (2A or nearest teammate), the 3rd attacker (3A or second nearest teammate) and the 4th attacker (4A or furthest teammate) in each time frame (see Fig. 1B). Relative phase was also calculated between the distances of the ball carrier to the marker and to the (i) 2nd attacker, (ii) 3rd attacker and (iii) 4th attacker. The relative phase time-series values were normalized to the total length of the analysed trials and frequency histograms were constructed for identifying preferred modes of coordination (Bourbousson, Sève, & McGarry, 2010b). All data were computed in MATLAB R2008a.

2.4. Statistical procedures

First, the relationship between the attackers’ distances to the defender, and the goal/ball were analysed using a 2 (Key-task constraint) × 12 (Relative Phase) mixed-design ANOVA, in which the within-participants factor was relative phase (−180°, −150°, −120°, −90°, −60°, −30°, 0°, 30°, 60°, 90°, 120° and 150°), and the between-participants factor was key-constraint (the locations of the goal and the ball). Second, the coordination between ball carriers’ distances to the defender, and to each teammates were analysed using a 3 (Teammates) × 12 (Relative Phase) mixed-design ANOVA, in which the within-participants factor remained the same, and the between-participants factor was teammates (2nd, 3rd and 4th attackers). The sphericity assumption for the repeated measures variable (i.e., the within-participants factor) and the interaction effects were checked using Mauchly’s test of sphericity. The Greenhouse-Geisser correction was applied to any sphericity violations (see Schutz & Gessaroli, 1987). Since the groups were composed of equal sample sizes, the homogeneity of variances requisition was assumed for the between-participants factor (see Field, 2005, p. 324). Observed significant effects were followed up using Bonferroni post hoc tests. The level of significance was set at \( p < .05 \). All statistical analyses were computed using SPSS® 19.0 software (SPSS Inc., Chicago, USA).

2.5. Intra and inter-rater assessment

One of the 13 goal sequences subjected to analysis was selected at random and the movement trajectories of the ball and players (\( n = 11 \)) were re-digitized by the same experimenter (intra-rater assessment). Data were then assessed for accuracy and reliability using technical error of measurement (TEM) and coefficient of reliability (\( R \)) (Goto & Mascie-Taylor, 2007). The intra-TEM measure yielded values of 0.245 m (2.53%), 0.255 m (2.45%) and 0.414 m (2.46%) for data on positioning of attackers, defenders and the ball, respectively. The coefficient of reliability for the intra-rater assessment showed high reliability of the data for the attackers (\( R > .97 \)), defenders (\( R > .95 \)) and ball (\( R > .99 \)).

3. Results

3.1. Constraints on the coordination between attacker and defender

Exemplar data from the attacker’s distance to the goal and values of interpersonal distance in attacker-defender dyads showed that at 38 s after trial initiation, the attacker decreased the distance to the goal (9 m). However, the nearest defender was not able to maintain system symmetry, allowing the value of their interpersonal distance to increase (4 m) (Fig. 2A). Relative phase analysis revealed an increase in variability at 31 s, and a loss of a stable mode of coordination (between 34 and 37 s) (Fig. 2B). Exemplar data from Fig. 2D depicted that, after the attacker reduced distance to the ball to 0 m (e.g., at 4, 10, 14, 28 and 36 s), the marker also reduced distance to the attacker. However, in some instances the attacker’s distance to the ball was high and interpersonal distance value in the dyadic system was low (e.g., at 19, 23 and 32 s). Near 39 s the attacker’s distance to the ball decreased to 0 m and the value of interpersonal distance increased to 4 m. The dynamics of relative phase revealed stability during some periods of time (e.g., between 8 and 19 s, and 23 and 32 s), as well as phase transitions (e.g., at 21 and 33 s) (Fig. 2E).
Statistical analyses revealed a significant main effect for relative phase, $F(5.13,523.18) = 15.05$, $p < .001$, $g = .13$, suggesting that, regardless of the key-task constraint, there were significant differences in the mean values of coordination tendencies. Post hoc tests on relative phase bins showed that mean values of frequency of coordination between the attackers’ distances to defenders and key-constraints of the task were significantly higher from $\pi/6$ to $\pi/3$ of phase relations ($M = 13.34$, $SE = 1.34$) than in the regions from $-\pi/2$ to $-\pi/1$ and $\pi/2$ to $\pi$ of phase relations. Additionally, mean values of frequency of coordination between the attackers’ distances to defenders and key-constraints of the task were significantly higher from $0$ to $2\pi/6$ ($M = 13.34$, $SE = 1.34$), and from $3\pi/6$ to $5\pi/6$ of phase relations ($M = 13.34$, $SE = 1.34$) than in the regions from $-\pi/2$ to $-\pi/1$ and $\pi/2$ to $\pi$ of phase relations (see Appendix A). Finally, statistical analyses revealed no significant main effect for key-task constraint, $F(1,102) = 1.70$, $p > .05$, $g = .02$.

Significant interaction effects were observed for key-constraint X relative phase, $F(5.13, 523.18) = 11.53$, $p < .001$, $g = .10$. Post hoc tests for interaction effects showed that, from $\pi/6$ to $0$ of phase relations, $M = 13.34$, $SE = 1.34$), and from $3\pi/6$ to $5\pi/6$ of phase relations ($M = 13.34$, $SE = 1.34$) than in the regions from $-\pi/2$ to $-\pi/1$ and $\pi/2$ to $\pi$ of phase relations (see Appendix A). Finally, statistical analyses revealed no significant main effect for key-task constraint, $F(1,102) = 1.70$, $p > .05$, $g = .02$.

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**Fig. 3.** Ball carriers’ distances to the defender, and to teammates: (A) Analysis of ball carrier’s distances to the defender and to the nearest teammate in sequence number 11; (B) – Analysis of the dynamics of the relative phase of ball carrier’s distances to the defender and to the nearest teammate in sequence number 11; (C) – Frequency histogram of the relative-phases of all ball carrier-defenders dyadic systems ($n = 13$) using ball carrier’s distances to the defender and to his nearest teammate; (D) Analysis of ball carrier’s distances to the defender and to his second nearest teammate in sequence number 11; (E) – Analysis of the dynamics of the relative phase of ball carrier’s distances to the defender and to his second nearest teammate in sequence number 11; (F) – Frequency histogram of the relative-phases of all ball carrier-defenders dyadic systems ($n = 13$) using ball carrier’s distances to the defender and to his second nearest teammate; (G) Analysis of ball carrier’s distances to the defender and to his furthest teammate in sequence number 11; (H) – Analysis of the dynamics of the relative phase of ball carrier’s distances to the defender and to his furthest teammate in sequence number 11; (I) – Frequency histogram of the relative-phases of all ball carrier-defenders dyadic systems ($n = 13$) using ball carrier’s distances to the defender and to his furthest teammate.
of phase relations, the mean values of frequency of coordination of the attackers’ distances to the defender and the goal increased \((M = 11.28, SE = 2.79)\). The mean values of frequency of coordination of the attackers’ distances to the defender and the ball decreased \((M = -9.55, SE = 2.94)\). In addition, from \(30^\circ\) to \(179^\circ\) of phase relations, the mean values frequency of coordination of the attackers’ distances to the defender and the goal decreased significantly more \((M = -14.25, SE = 2.14)\) than the mean values of frequency of coordination of the attackers’ distances to the defender and the ball \((M = -59, SE = 1.51)\).

3.2. Constraints on coordination tendencies between the ball carrier and teammates

Exemplar data from the ball carrier’s distances to the marker and to 2A revealed some periods in which the former variable decreased a few moments earlier than the latter variable (e.g. between 3 and 5 s, and 33 and 37 s) (Fig. 3A). Dynamics of relative phase showed that, although there were some periods during which the dyadic system attained some stability (e.g. between 8 and 12 s near \(300^\circ\), and between 20 and 28 s near \(400^\circ\)), this was atypical of system behaviour (Fig. 3B). Exemplar data from Fig. 3D revealed some instances when the ball carrier’s distances to the marker and to 3A decreased (e.g., between 19 and 23 s, and 32 and 37 s). Although the dynamics of relative phase revealed that both components were coupled in an in-phase mode of coordination at these instances (near \(360^\circ\) and \(720^\circ\), respectively), there were also some periods in which an anti-phase mode was maintained (e.g., between 8 and 11 s near \(250^\circ\)) (Fig. 3E). Distances of the ball carrier to the marker and 4A revealed many short periods of duration in which these interpersonal distances decreased symmetrically (e.g., between 0 and 3 s, 4 and 7 s, 8 and 11 s, 18 and 21 s, and 35 and 37 s) (Fig. 3G). The dynamics of the relative phase showed the system’s difficulty in maintaining stability, since no stable states of coordination could be identified (Fig. 3H).

Statistical analyses revealed a significant main effect for relative phase, \(F(4.92, 177.13) = 9.34, p < .001\), suggesting that, regardless of teammates, there were significant differences in the mean values of the coordination patterns. Post hoc tests on relative phase bins showed that the mean frequency of coordination between the ball carriers’ distances to defenders and teammates were significantly higher from \(0^\circ\) to \(29^\circ\) phase relations \((M = 14.04, SE = 1.34)\), than from \(-180^\circ\) to \(-31^\circ\) and \(120^\circ\) to \(179^\circ\) of phase relations (see Appendix B). Statistical analyses did not reveal a significant main effect for distance to teammates, \(F(2,36) = 1.86, p > .05, \eta = .09\). Finally, no significant interaction effects were observed for distance to teammates x relative phase, \(F(9.84, 177.13) = 1.17, p > .05, \eta = .06\).

4. Discussion

The primary goal of this study was to understand how the location of the goal and ball might act as constraints on the stability of attacker-defender dyadic systems during competitive team game performance. Additionally, we sought to identify how the stability of dyadic systems formed by the ball carrier and teammates was constrained by actions (movement trajectories) of the direct marker of the ball carrier on court. Results confirmed previous findings on 1vs.1 sub-phases in basketball (Araújo et al., 2006), showing that in-phase patterns of coordination emerged between values for distances of attackers to the defenders and to the goal. This result might be explained by perception of defenders of an increased risk of a goal being scored as attackers moved towards the goal. It would be expected that a decrease in the distance of attackers to the goal or defenders to the goal. This might be explained by perception of defenders of an increased risk of a goal being scored as attackers moved towards the goal. It would be expected that a decrease in the distance of attackers to the goal might have constrained defenders to move towards the attackers in order to restrict space and intercept a possible pass or prevent a shot at goal. Towards the end of the exemplar trial, the attacker was able to significantly decrease the distance to goal (9 m), while increasing the distance to the nearest defender (4 m), leading to a goal being scored. This result complements findings from previous work in futsal which suggested that a misalignment between a defender’s position and the location of the goal and an attacker precipitated a goal being scored (Vilar et al., 2012). More precisely, data suggested that attackers should increase their distance from immediate defenders, preventing them from intercepting the ball’s trajectory when shooting. The interpersonal distance between an attacker and defender in a dyad not only constrained the actions of the attacking player, but also
his teammates, as they perceived an opportunity for the attacker (#5) to score a goal. In this study, when a teammate coordinated actions with those of a goal scorer, the data showed how a goal may be created through teamwork, rather than through individuality (Marsh, Richardson, & Schmidt, 2009).

The value of the attacker’s distance to the ball and to the nearest defender showed a preferred pattern of coordination of \(-60^\circ\) (18%), revealing that the value for an attacker’s distance to the ball was advanced in time compared to the attacker’s distance to the defender, by one-sixth of a cycle (Oullier & Kelso, 2009). This observation suggests that the defender was able to perceive an increase in the action capabilities of attackers as they approached the location of the ball. This may have constrained the defender to move towards the attacker, in order to prevent the attacker from moving closer to the goal and score a goal. Conversely, the values of the attacker’s distance to the ball and the defender also increased simultaneously. Low values of interpersonal distance of the ball carrier and defender might possibly have constrained the furthest defenders to move backwards in the field and ensure a new level of dyadic system stability in case the ball carrier successfully broke existing system symmetry with a nearest defender. However, in some instances (e.g., 19, 23 and 32 s), despite the attacker not being close to the ball, the defender was close to attacker #5. This may have constrained the ball carrier not to pass the ball to attacker #5 due to the perception of a higher potential risk of ball possession loss through interception. Results also showed that the attacker-defender relationship is more highly constrained by the location of the goal than the location of the ball. These results possibly revealed the priority given by defenders to protecting their own goal rather than in regaining ball possession. In addition, the \(-60^\circ\) lag in the attacker-defender relationship with the ball may have been influenced by their different movement capabilities (the ball was moved with higher velocity and frequency than the players).

Values of the ball carrier’s distances to a marker, and to teammates, showed a trend towards an in-phase mode of coordination. Further work is needed to investigate this trend because it might be explained by movements of teammates towards the ball carrier to afford a possibility to pass the ball, as teammates perceived an opportunity for a defender to intercept the ball. Teammates may have perceived the spatial–temporal relations between the ball carrier and a marker, and the implication of these relations for their own positioning and movement (Richardson, Marsh, & Baron, 2007). These observations also extended findings of Passos et al. (2011) by showing how intra-team coordination processes emerge from the relations of attackers with their opponents. The data also extended Travassos’ findings (Travassos, Araújo, Davids et al., 2012a; Travassos, Araújo, Duarte, and McGarry, 2012b) by suggesting how decisions and actions of attackers and defenders are constrained by locations of the goal and ball, and that their phase relations might influence the performance behaviours of other players. Finally, no significant differences were observed in the modes in which each attacking teammate (2nd, 3rd, and 4th attackers) coordinated their distances to the ball carrier with the ball carrier’s distance to the defender. This result suggests that, despite the distances of the supporting teammates to the ball carrier, all sought to remain close to the ball carrier when they perceived an increased capability of the defender to intercept the ball.

Results from this investigation provided empirical evidence suggesting that interpersonal coordination tendencies can be regulated at the level of individual-environment relations (i.e., at the ecological scale). More precisely, data suggested that defenders coordinated their movements to decrease their opponents’ possibilities for action with information on distances of the attackers to the goal and ball. Moreover, attackers without the ball seemed to coordinate their movements (i.e., their distance to the ball carrier) with information on distances of the ball carrier to defenders, providing the ball carrier with a high number of collective possibilities for action. Because our aim was to study the importance of simultaneously considering the constraining influences of the location of the goal and the ball on movements of players during international competitive futsal performance, it is possible that these variables contained some interdependence. Having established their importance in performance, further research is needed to examine the dependence between these variables during competitive performance.
5. Conclusions

In sum, this paper emphasized the importance of considering coordination tendencies between players and key-task constraints to explain performance in team sports (Vilar et al., 2012). Results added understanding of how movement trajectories of individual players may constrain movement tendencies of teammates and opponents, whose actions, in turn, constrained possibilities for other players to act. This idea captures the rationale in ecological dynamics for studying team sports as complex, highly integrated systems whose components (competing and cooperating players) are continuously interacting to constrain each other’s actions and behaviours (Vilar et al., 2012). By capturing the spatial–temporal relations between players through analysing dynamics of coordination tendencies, ecological dynamics can help explain the why and how of behaviours that underlie the recorded performance indicators (McGarry, 2009).

Appendix A.

Table A. Post hoc results of the within-participants factor of the mixed-design ANOVA, comparing the frequency of relative phase between the attackers’ distances to the defender and key-task constraints.

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Note — = Diagonal cell.
*p < 0.05.

Table B. Post hoc results of the within-participants factor of the mixed-design ANOVA, comparing the frequency of relative phase between the ball carriers’ distances to the defender and the teammates.

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Note. — = Diagonal cell.
*p < 0.05.

References


