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Competing together: Assessing the dynamics of *team–team* and *player–team* synchrony in professional association football

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ABSTRACT

This study investigated movement synchronization of players within and between teams during competitive association football performance. Cluster phase analysis was introduced as a method to assess synchronies between whole teams and between individual players with their team as a function of time, ball possession and field direction. Measures of dispersion (*SD*) and regularity (sample entropy – SampEn – and cross sample entropy – Cross-SampEn) were used to quantify the magnitude and structure of synchrony. Large synergistic relations within each professional team sport collective were observed, particularly in the longitudinal direction of the field (0.89 ± 0.12) compared to the lateral direction (0.73 ± 0.16, $p < .01$). The coupling between the group measures of the two teams also revealed that changes in the synchrony of each team were intimately related (Cross-SampEn values of 0.02 ± 0.01). Interestingly, ball possession did not influence team synchronization levels. In player–team synchronization, individuals tended to be coordinated under near in-phase modes with team behavior (mean ranges between -7 and $5°$ of relative phase). The magnitudes of variations were low, but more irregular in time, for the longitudinal (*SD*: $18 \pm 3°$; SampEn: 0.07 ± 0.01), compared to the lateral direction (*SD*: $28 \pm 5°$; SampEn: 0.06 ± 0.01, $p < .05$) on-field. Increases in regularity were also observed between the

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first (SampEn: 0.07 ± 0.01) and second half (SampEn: 0.06 ± 0.01, $p < .05$) of the observed competitive game. Findings suggest that the method of analysis introduced in the current study may offer a suitable tool for examining team's synchronization behaviors and the mutual influence of each team's cohesiveness in competing social collectives.

1. Introduction

Competing teams in sports like Association Football are composed of different individuals interacting together to achieve performance goals. In order to succeed, individual teammates develop cooperative relations to achieve common goals and competitive relations to prevent opposing players from achieving theirs. These relations usually underlie emergent collective team behaviors that go beyond the sum of individual performances *per se* (Duarte, Araújo, Correia, & Davids, 2012; Sumpter, 2006). Indeed, many studies in the fields of psychology and biology have demonstrated the superior performance of grouping individuals over singletons in a wide range of human phenomena (Krause, Ruxton, & Krause, 2010). In the field of team sports, the nature of cooperative and competitive interaction tendencies constrains players to perform as a group, displaying intra- and inter-team spatial–temporal couplings between the players (McGarry, Anderson, Wallace, Hughes, & Franks, 2002; Passos, Araújo, & Davids, 2013; Travassos, Araújo, Correia, & Esteves, 2010). Functional groupings of structural elements in complex systems (e.g., the human body or players in a sport team), that are temporarily constrained to act as a single coherent unit, have been called *synergies* (Bernstein, 1967; Turvey, 2007). A synergy is a key concept for understanding the process in which individual system components (e.g., the players) interact to create coherent, emergent group behaviors. These processes are important to investigate since they arise from genetic to social levels of organization in neurobiological systems (Kelso, 2009). Here, we propose that the on-field spatial–temporal synchronization between players within a competitive sport team can be regarded as a functional synergy. Despite the possibility that other sub-group interactions may also be conceived of as functional synergies, in this study we defined the team system organization as the selected level of analysis. However, every complex system comprises interdependence between different scales, such as the individual players' movements and the collective movements of the whole team. This characteristic interdependence between levels of a complex system suggests a compelling need to integrate both scales of analysis in research on team sport performance (Bar-Yam, 2003, 2004). It is especially important to understand how these existing system tendencies may mutually influence each other, creating a collective synergy at the team level.

Typically, most previous studies have tended to focus either on coordination between pairs of individuals (i.e., dyads) or at the team level of organization, and not on the relations established between the two levels. Some previous research has analyzed whole team behaviors (e.g., 11-a-side in association football) using compound positional variables to capture specific cooperative and competitive interaction tendencies between teams. For example, Lames, Ertmer, and Walter (2010) demonstrated that the *geometrical centers* (i.e., average position of the outfield players) and *team ranges* (i.e., spatial length and width of players' dispersion) of competing football teams tend to be tightly coupled in the longitudinal (goal-to-goal) and lateral (side-to-side) directions on the field of play during competitive performance. Using the *stretch index* measure (i.e., mean players' dispersion around the team center), Yue, Broich, Seifriz, and Mester (2008) showed that the dispersion of teams players on-field tended to follow a dynamical counter-phase relation, that is, when the organization of one team was contracted, the shape of an opposing team tended to be expanded and vice-versa. Bourbousson, Sève, and McGarry (2010b) demonstrated that these expansion/contraction patterns of collective behaviors during performance emerged as a function of changes in ball possession between teams. These studies using compound positional variables typically assume that individual players equally contribute to the