Human Movement Science 31 (2012) 1652–1659

Contents lists available at SciVerse ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

Spatial dynamics of team sports exposed by Voronoi diagrams

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ARTICLE INFO

Article history:
Available online 5 July 2012

PsycINFO classification:
3720
2260
3020

Keywords:
Interaction patterns
Team sports
Voronoi diagrams

ABSTRACT

Team sports represent complex systems: players interact continuously during a game, and exhibit intricate patterns of interaction, which can be identified and investigated at both individual and collective levels. We used Voronoi diagrams to identify and investigate the spatial dynamics of players' behavior in Futsal. Using this tool, we examined 19 plays of a sub-phase of a Futsal game played in a reduced area (20 m^2) from which we extracted the trajectories of all players. Results obtained from a comparative analysis of player's Voronoi area (dominant region) and nearest teammate distance revealed different patterns of interaction between attackers and defenders, both at the level of individual players and teams. We found that, compared to defenders, larger dominant regions were associated with attackers. Furthermore, these regions were more variable in size among players from the same team but, at the player level, the attackers' dominant regions were more regular than those associated with each of the defenders. These findings support a formal description of the dynamic spatial interaction of the players, at least during the particular sub-phase of Futsal investigated. The adopted approach may be extended to other team

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0167-9457/$ - see front matter
http://dx.doi.org/10.1016/j.humov.2012.04.006

behaviors where the actions taken at any instant in time by each of the involved agents are associated with the space they occupy at that particular time.

1. Introduction

Team sports can be viewed as complex systems in that the players, the agents of the system, interact continuously during a game (Davids, Araújo, & Shuttleworth, 2005; McGarry, Anderson, Wallace, Hughes, & Franks, 2002). Their interaction determines the occurrence of specific events during a game (Passos et al., 2008). Therefore, having a good understanding of this dynamic behavior would not only allow a better characterization of these systems but could also help coaches to anticipate some outcomes or events.

Players' interaction behavior can be assessed from a spatial perspective. For instance, players change their location continuously during a game as they adjust their relative positions according to the information they (can) perceive (Passos et al., 2008; Travassos, Araújo, Vilar, & McGarry, 2011), acting collectively as a result of phenomena such as cooperation and competition. Thus, players, collective behavior cannot be explained by the simple addition of behaviors from each player (Gréhaigne, Bouthier, & David, 1997); instead, players' behaviors should be considered in terms of the entire dynamic system that they compose (Glazier, 2010; McGarry, 2009; Passos et al., 2009), where both time (Araújo, Davids, & Hristovskic, 2006) and space (Davids, Handford, & Williams, 1994; Schöllhorn, 2003) need to be brought into the equation. Considering both space and time, it is possible to evaluate the spatial configuration players present during game play.

To illustrate, spatial configurations can be classified as random, regular or clustered. A configuration may be considered as random when players are at random distances from each other in the field, as regular when players are equally distant from each other in the field, and as clustered when we can identify different groups of players aggregated in different parts of the field (Fig. 1). These spatial distribution patterns can be easily identified by measuring interpersonal distances, in particular the minimum interpersonal distance, or nearest neighbor distance (Clark & Evans, 1954).

The spatial distribution of the players in a field, and hence the space within which players have to act, is dependent on a large number of constraints that change continuously throughout a game, with ball possession being an obvious one. In principle, the attacking team normally tries to free-up space while the defending team tries to tie-up space (Gréhaigne et al., 1997; McGarry et al., 2002). Therefore, in terms of nearness, it is expected that the interpersonal distance between players is kept greater by the attacker team and smaller by the defender team, resulting in more space for the attack. This relationship was already observed using surface area (Frencken, Lemmink, Delleman, & Visscher, 2011) and stretch index variables (Bourbousson, Sève, & McGarry, 2010).

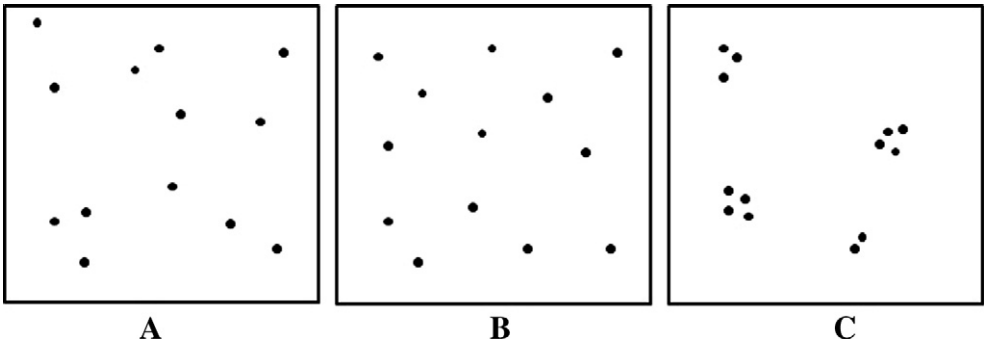

Fig. 1. Example of spatial distribution patterns (A) random, (B) regular and (C) clustered.