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Explorando la distribución espacial colectiva en el baloncesto

Exploring collective spatial distribution in basketball

Explorando a distribuição espacial coletiva no basquetebol

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Resumen: Este estudio tuvo como objetivo analizar la distribución espacial de los jugadores de acuerdo con la eficacia de las acciones de juego de baloncesto. Tres partidos oficiales de baloncesto, campeonato portugués U14, fueron filmados y después analizados con el fin de seleccionar 10 secuencias de juego que terminaron en éxito ofensivo o defensivo. Las trayectorias de los jugadores en la cancha fueron digitalizadas con el fin de acceder a sus coordenadas reales con software TACTO. Este procedimiento ha permitido calcular el número de atacantes, defensores y ratio atacantes/defensores en cada uno de las siete áreas de la cancha (A1, A2, A3, A4, A5, A6, A7), sobre una base de momento a momento en toda la secuencia de juego. La distribución espacial de los jugadores ha ocurrido en función de la posición relativa a la canasta. En particular, la superioridad numérica defensiva en las zonas más cercanas a la canasta (A3) se relacionó con una mayor eficacia ofensiva. Estos resultados sugieren que la interacción entre constreñimientos, probablemente relacionados con la proximidad a la canasta, la ineficacia de las habilidades defensivas y la eficacia de la movilidad atacante pueden haber desencadenado patrones colectivos distintivos de distribución espacial.
Palabras clave: Toma de decisiones, Análisis del comportamiento, Creatividad

Abstract: this study aimed to analyse players' spatial distribution according to their performance outcomes in basketball. Three competitive games of U14 portuguese basketball teams were filmed and then analysed in order to select 10 sequences of play ending in successful offense or successful defence. Movement displacement trajectories of performers were digitized in order to access their real world coordinates using TACTO software. This procedure allowed computing the number of attackers, defenders and ratio attackers/defenders on each of seven court locations (A1, A2, A3, A4, A5, A6 and A7) throughout the sequence of play, on a moment-to-moment basis. We found that player's spatial distribution proceeds in function of the relative position to the basket. Particularly, defensive numerical superiority in closer areas to the basket (A3) was related with higher offensive efficacy. These results suggest that interacting constraints, probably related with the proximity to the basket, inefficacy of defensive skills and superior attacker mobility might have shaped distinctive collective patterns of spatial distribution.
Key-words: Decision making, Behaviour analysis, Creativity.

Resumo: este estudo teve como objetivo investigar a distribuição espacial de jogadores em função da eficácia das suas ações no jogo de basquetebol. Três jogos de basquetebol do escalão de sub-14 masculinos, do campeonato português, foram filmados e posteriormente analisados com o intuito de selecionar 10 sequências de jogo que terminaram com sucesso ofensivo ou defensivo. Procedeu-se à digitalização das trajetórias de deslocamento dos jogadores para assim se aceder às suas coordenadas reais mediante a utilização do software TACTO. Em seguida, calculou-se o número de atacantes, defensores e rácio de atacantes/defensores em cada uma das sete localizações (A1, A2, A3, A4, A5, A6, A7), a cada momento da sequência de jogo. Os resultados indicam que a distribuição espacial dos jogadores desenvolve-se em função da posição relativa ao cesto. Em particular, a superioridade numérica defensiva em áreas próximas do cesto (A3) associou-se a uma maior eficácia ofensiva. Estes resultados sugerem que a interação de constrangimentos, provavelmente relacionados com a proximidade ao cesto, ineficácia das habilidades defensivas e superior mobilidade ofensiva possam ter despoletado diferentes padrões coletivos de distribuição espacial.
Palavras chave: Tomada de decisão, Análise de performance, Criatividade.

Introduction

Spatial and temporal constraints have been widely reported in the literature has highly impacting assets of functional behaviours within sports settings (Travassos et al., 2012). This means that performers engage on a process of prospective exploration of the immediate environment to search for relevant information to guide behaviours over time (Araújo, Davids, & Hristovski, 2006).

Either from the individual to the collective level of analysis, recent investigations in team sports, and in basketball in

particular (Esteves, de Oliveira, & Araújo, 2011), have been concerned in explaining how functional behaviours occur in immersive performance environments. Goldsberry (2012) examined shooting attempts profile of NBA players in terms of efficacy and preferred locations. Despite the fact that a clear tendency has been depicted, this approach did not considered the dynamics of players' interactions that originated those behavioural outcomes (i.e., shots) as well as evolving game conditions.

From a collective level, coordination between players has been inspected using spatial (geometric) centre of the team (i.e., mean players' position on court). A study conducted by Bourbousson, Sève and McGarry, (2009)

showed that relative-phase analysis of team spatial centres presented more inter-team stability in the basket-to-basket perspective (i.e., longitudinal axis) than on the lateral line-to-lateral line perspective (i.e., lateral axis.) However, the methods applied are not that sensitive to different individual contributions to the collective spatial metric and to the differential effect of specific court locations on performance. In fact, it is perfectly admissible that some individual behaviours might be more significant than others to collective patterns of performance (McGarry, 2009). A recent investigation expanded the application to this method in basketball by considering the effect of defensive pressure on collective behaviours of young performers (Leite et al., 2014). Worth of note was the consideration of the distance of each player to the team spatial centre and to the basket as measures of collective patterns of performance upon individual contributions.

The literature has consistently pointed out that successful performance in basketball is related with the way teams create numerical superiority over the opponent, in function of specific court locations, to explore the opportunities to successfully shoot at the basket (Crean & Pim, 2008; Ibañez et al., 2008). To our knowledge, the issue of how performers of opposing teams struggle to occupy specific locations on court, in order to reach their respective goals, has not been sufficiently addressed by the literature. Interestingly, in football, there has already been an attempt to analyse how team occupy sub-areas of the field as the ball changes location (Vilar, Araújo, Davids, & Bar-Yam, 2012). Authors found that teams in the defensive phase of play consistently presented more players in specific locations close to their own goal, even that the a link with performance outcome was not considered. Of interest, is the association between outcome and performance in team sports that is somewhat disregarded by the literature (McGarry, 2009). Distinctively collective patterns of behaviour may arise as the team in ball possession manages to successfully convert a shot in basketball, for example, comparing when the defensive team recovers ball possession due to an interception.

To our knowledge, in team sports in general and in basketball in particular, there is a relevant gap concerning how performers of opposing teams interact to occupy specific location of the court in accordance with the outcome of collective performance. The goal of this exploratory study was to describe and explain spatial collective distribution according to the outcome of the sequence of play. We hypothesized that collective distribution would be markedly different across different performance areas. In addition, we expected greater offensive and defensive distribution near ball location as a mean to, respectively, convert a shot or recover ball possession.

Method

The experimental design used in this investigation is aligned with the descriptive research by considering that athletes' behaviour was directly observed in competitive performance environment and analysed though the use of a set of pre-determined categories (Ato, López, & Benavente, 2013).

Three competitive games from three U14 teams, participating in the first phase of portuguese national basketball championship, were analysed. Movement displacement trajectories of performers were recorded using a digital video camera (Canon Legria HF M52) with a frequency of 25 Hz. This camera was intentionally placed outside the court at a height of 8 m, near the lateral line. First, we edited video footage in order to select offensive sequences of play that fulfilled the following criteria: all players positioned between the line of the ball (i.e., line that intersects the ball, orthogonal to court lateral line) and basket as the attacker in ball possession moves past half-court line. Our intention was to select sequences of play, developed in the offensive half-court, that could start with relative stability of all players involved (i.e., set offense). Therefore, we disregarded all sequences of play such as fast breaks. Within the aforementioned criteria, a total of 10 sequences of play were selected for analysis, according to two different outcomes:

i) Successful offense, when a sequence of play ended with a converted shot by the attackers (n=5);

ii) Unsuccessful offense, when a sequence of play ended with a ball possession lost by the attackers, either as a result of a missed shot or due to ball interception by the defenders (n=5).

Digitization of the movement displacement trajectories of the players, within the selected sequences of play, was performed with Tacto 7.0 (Fernandes, Folgado, Duarte, & Malta, 2010). This process consisted of following with a computer mouse the displacement trajectory (i.e., the projection on the floor of the center of gravity) of the attackers and the defenders involved in each offensive play. This software allowed us to extract participants' virtual bi-dimensional coordinates (in pixels). Afterwards, we performed a direct linear transformation (2D-DLT) to real court coordinates and applied Butterworth 6Hz low pass filter for smoothing purposes (Winter, 2005). The bottom left corner of the basketball court was assigned as origin of a Cartesian coordinate system while the length of the court (i.e. lateral line) was assigned as y-axis and the width of the court (end line) as x-axis. In this study, the intra and inter-rater reliability estimate, obtained by the digitization, over three consecutive days of an exemplar trial of participant's displacement movement trajectories was, respectively, a = .99 and a = .99. In parallel, an experienced basketball coach (with 11 years of officiating experience and

Level 2 Certificate in coaching Basketball) visually inspected video images of participants' performance to notate ball trajectory over Area 1 and Area 2 of performance (further information below) in the selected sequences of play. Intra and inter-observer reliability for the categorization process was, respectively, a = 1.00 and a = 1.00.

In order to examine the relative position of attackers and defenders we considered seven performance areas: i) A1, longitudinal half correspondent to the ball location; ii) A2, longitudinal half opposite to the ball location; iii) A3, "painted area" and iv) half-court divided in 4 sub-areas, using free-throw line as reference, A4, A5, A6, and A7) (Fig.1).

Figure 1. Offensive half-court divided in seven different performance areas (A1 a A7). In this case, attacker in ball possession (grey oval) and his closest defender (black oval) are positioned, simultaneously, in Area 1 and Area 5, expressing a ratio Attackers - Defenders = 0.
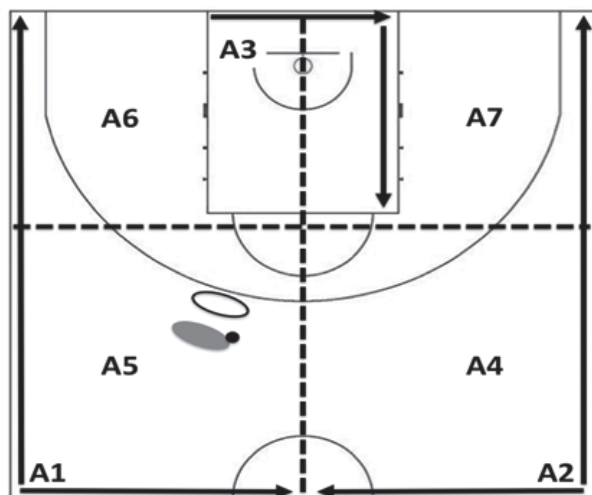
Given the official court dimensions, we used real court coordinates of player movement trajectories over the selected sequences of play to compute, on a moment-to-moment basis, the spatial position of each player according to the seven areas of performance. This procedure allowed obtaining three dependent variables, in function of the position of the attackers and defender over time in each area of performance:

  i) Number of attackers (NA);
  ii) Number of defenders (ND);
  iii) Ratio attackers - defenders (RAD), equals number of attackers (NA) subtracted by the number of defenders (ND).

All data were computed in MATLAB®, R2008a software (The MathWorks Inc, Natick, MA, USA).

The number of attackers (NA) and number of defenders (ND) were submitted to a Multivariate Analysis of Variance, with the two different outcomes (2 levels: successful offense and unsuccessful offense) and the seven performance areas (7 levels: A1, A2, A3, A4, A5, A6 e A7). In all cases we used a significance level of $p < .05$. The ratio attackers - defenders (RAD) was submitted to a 2x7 mixed-design ANOVA, being the two different outcomes (2 levels: successful offense and unsuccessful offense) as between-participant factor and the seven performance areas (7 levels: A1, A2, A3, A4, A5, A6 e A7) as within-participant factor. All statistics were computed with SPSS® 20.0 software (IBM SPSS Inc., Chicago, IL, USA).

This study was conducted within the guidelines of the American Psychological Association (6th Edition) and a local university ethics committee approved the protocol. The procedures followed were in accordance with the Helsinki Declaration of 1975, as revised in 2000.

Results

We found a main effect of performance area on both the number of attackers and defenders, respectively, $F(6, 56) = 46.36$, $p < .01$, $\eta^2 = .83$, and $F(6, 56) = 38.22$, $p < .01$, $\eta^2 = .80$. Area 1 presented larger values on the number of attackers (M = 2.91, SD = .11), followed by Area 2 (M = 2.1, SD = .11). Area 1 presented larger values on the number of defenders (M = 2.35, SD = .16), followed by area 7 (M = 2.13, SD = .16). There was also a significant interaction between the outcome of the sequence of play x performance area on the number of defenders, $F(1, 56) = 2.48$, $p < .05$, $\eta^2 = .82$. Area 3 presented higher number of defenders for successful offense (M = 2.27, SD = .23) and a lower number of defenders for unsuccessful offense (M = 1.31, SD = .23) (Fig.2). These results suggest that a larger number of defenders in frontal and closer areas to the basket (Area 3) was related to successful offense. We found no significant interaction between the outcome of the sequence of play x performance area on the number of attackers (NA), $F(1, 56) = 1.09$, $p = .38$, $\eta^2 = .38$.

Figure 2. Mean number of defenders per area of performance (A1 to A7) on sequences of play correspondent to offensive success and defensive success.
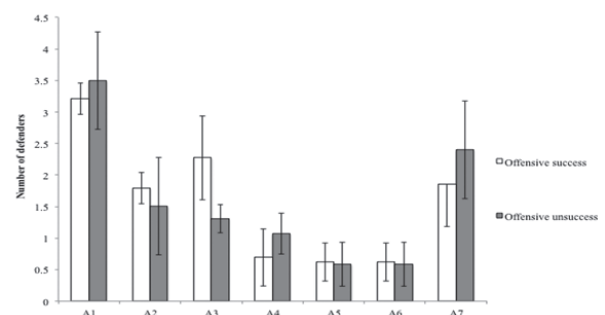
We identified a main effect of the performance area on the ratio attackers - defenders, $F(1, 56) = 16.91$, $p < .01$, $\eta^2 = .64$. Area 3 presented lower ratio than the remaining areas of performance ($M = -1.06$, $SD = .56$) There was no interaction effect between the outcome of the sequence of play x performance area, $F(1, 56) = 2.08$, $p = .07$, $\eta^2 = .18$ (Fig. 3). These results indicated the presence of a larger number of defenders than attackers on frontal and closer areas to the basket (Area 3).

Figure 3. Mean Ratio Attackers - Defenders per area of performance (A1 to A7).
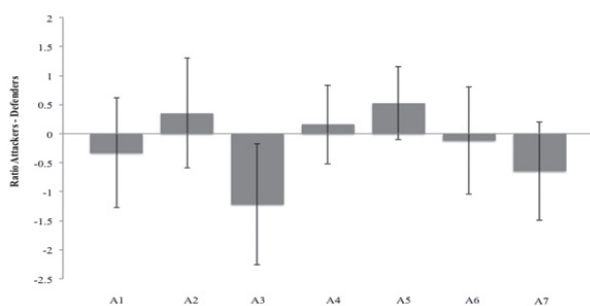
We also considered the dynamics of the number of attackers, number of defenders and ratio attackers – defenders, on performance Area 3, over an exemplar trial ending with successful offense (Fig. 4).

Figure 4. Exemplar trial showing the dynamics of number of attackers (NA), number of defenders (ND) and ratio Attackers-Defenders (RAD), on performance area 3, along a sequence of play ending with successful offense. Vertical lines signalize an increase in the number of attackers.
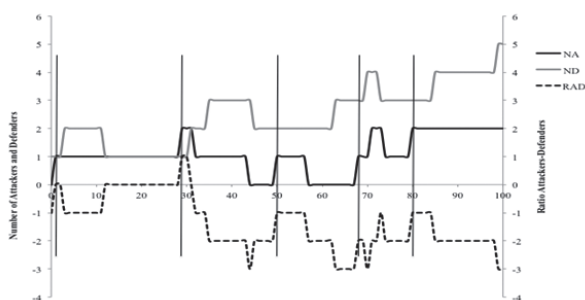
The vertical black lines signalled the moment in time correspondent to the increase of the number of attackers, respectively i) in the beginning of the sequence of play, ii) around 29% of time, iii) 50% of time, iv) 68% of time and v) 80% of time. Apparently, changes in the number of attackers triggered subsequent changes on the number of defenders. After

each of these key events it was possible to ascertain a respective increase on the number of defenders, with a certain delay, respectively: i) in the beginning of the sequence of play, ii) around 30% of time, iii) 65% of time, iv) 72% of time and v) 85% of time.

Discussion

In this exploratory study we aimed to describe and explain spatial collective distribution according to the outcome of the sequence of play. With that purpose we considered how the number of attackers, number of defenders and ratio attackers - defenders varied over the selected sequences of play, in seven different performance areas. In line with our expectations, collective distribution was markedly different across different performance areas. We confirmed that both attackers and defenders tend to be spatially distributed near ball location. Interestingly, we found an association between a larger number of defenders on closer areas to the basket and successful offense.

First, we found an effect of the performance area, separately, on the number of attacker and number of defenders. This means that there were distinctive patterns of spatial distribution, for attackers and defenders, across the different areas of performance. Area 1 (i.e., the ball side) appeared to attract the exploration of a largest number of attackers and defenders. Area 2 (longitudinal half opposite to the ball location) and Area 7 (painted area) appeared as the second most explored areas, respectively for attackers and defenders. These results are in accordance with the basketball literature that praises that on ball side attackers should create and explore advantages in order to convert a shot. On the defenders perspective, help-side behaviors should be used to prevent disadvantages by taking in reference ball position and basket-to-basket-axis (Wootten & Wootten, 2013). Previous research has already alluded to the fact that basketball performers adapt their behaviors according to specific relative positions (i.e., angular positions) to the basket. Interpersonal patterns of coordination between attacker-defender dyads were arguably regulated by the spatial-temporal information available to both performers (Esteves et al., 2012). The present investigation goes beyond angular relations between attacker-defender dyads by showing that collective behaviors, in terms of spatial occupation, seem to be constrained by ball position and proximity to the basket.

Interestingly, greater spatial exploration by the defenders on closer areas to the basket was associated to successful offense. Area 3 (i.e., painted area) presented significantly larger number of defenders when sequences of play ended with converted shots by the attackers that when ending with ball recovery by the defenders. This tendency was also supported by the analysis of attackers-defenders ratio as smaller values

were also depicted on area 3 (i.e., larger number of defenders and smaller number of attackers). However, no relations were found between the ratio attackers-defenders and the outcome of the sequence of play. Hence, the observed outcome could not be conjunctly explained by the spatial occupation of both attackers and defenders, but essentially by the latter. The fact that increasing number of defenders near the basket appeared to promote offensive goal-achievement raises a possible explanation rooted on the fragility of the defensive skills. When interacting with the opponents, defenders may have resorted to occupy closer areas to the basket as they failed to follow-up the mobility of the attackers. This may have created conditions for losing their individual reference in the defensive system and creating more available space for the attackers to shoot at the basket. From this perspective, as the defenders struggled to reach their respective goals (i.e., protect the basket and regain ball possession) interacting constraints related with the proximity to the basket, inefficacy of defensive skills and superior attacker mobility may have shaped performers' interactions at the level of perception-action couplings (Davids, Araújo, Vilar, Renshaw, & Pinder, 2013). Our exemplar trial, concerning the dynamics of the number of attackers, number of defenders and ratio attackers-defenders over a sequence of play seemed to support this assertion. Apparently, changes on the number of attackers triggered later changes on the variable number of defenders, with a certain delay, that might have compromised defensive goal-achievement.

In sum, our exploratory investigation suggested that players' spatial distribution proceeds in function of the opponents, the relative position to the basket and ball position which adds on previous investigation focused on the spatial-temporal patterns of collective behaviour (Lucey, Bialkowski, Carr, Yue, & Matthews, 2014). Particularly, greater spatial occupation by the defenders on closer areas to the basket was related with successful offense. Further research is demanded to clarify if this tendency is extended to larger samples and different competitive levels.

Practical applications

By highlighting the impact of specific court locations on the patterns of spatial distribution, within this competitive level and development phase, relevant practical implications may be outlined in two major domains: i) training task design and ii) performance analysis. In the first case, task constraints may be manipulated in order to "invite" attackers and/or defenders to explore the possibilities resulting from numerical superiority/inferiority in particular court locations. For example, a 3x3 half-court situation could be enriched by using flat markers to limit the presence of defenders on the painted area, affording the exploration of the information related with the numerical superiority by the attacker closer to the scoring target. The same task design could be used to limit the presence of attackers/defenders, expressing the ratio (RAD) advanced by this investigation. In this case, the level of task complexity would be higher in which would require the performers to permanently decide and act on information about their position, not only with respect to team colleagues but also to the opponents. Concerning the performance analysis domain, coaches could use information related with the spatial distribution of their team during competitive performance to ascertain on the level of congruence between their principles of play and the effective team behaviours, and adjust training process, if necessary. We refer, for example, to the efficacy of the help side, overload near the ball, post moves and defensive 2x1 on ball carrier.

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