Effect of Defensive Pressure on Movement Behaviour During an Under-18 Basketball Game

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Key words
- team sports
- decision-making
- dynamical systems
- collective behaviour

Abstract

The aim of this study was to examine the effect of defensive pressure on movement behaviour during an under-18 basketball game. 20 international male players (age: $M=16.05$, $SD=2.09$ years old; weekly practice: $M=10.9$, $SD=1.94$ h; playing experience: $M=7.1$, $SD=1.1$ years) played two 10-min basketball quarters, using man-to-man ¼-court for the first 4 min (F¼), man-to-man full court defence for the next 3 min (FULL), and man-to-man ¼-court defence for the last 3 min (S¼). The positional data were captured by the Ubisense Real Time Location System and analysed with non-linear signal processing methods (approximate entropy) and repeated measures ANOVA. There were differences in the regularity values between F¼ and FULL in distance to the basket and to the opponents' basket. A stronger in-phase attraction in both lateral and longitudinal directions was identified; however, the centroids (i.e., the mean position from all team players) were closer and revealed higher values of irregularity in lateral displacements for all defensive systems. The individual speed displacements became more coordinated with teammates, particularly in the offensive court. Overall, this study provided evidence on how changing the level of defensive pressure promotes different collective behaviours.

Introduction

Performance analysis in basketball has traditionally focused on describing game-related physical and physiological demands [23, 39] and competition [13, 16]. In recent approaches, there were suggestions pointing out the need to address the game dynamic and self-organized perspective [6, 14], aiming to understand emergent player behaviour within the game's ecological environment [6, 41]. In addition, positioning and decision-making have been identified as the key tactical skills that best predict adult performance level [22]. Under this approach, the assessment of players' tactical behaviour and inter-player coordination tendencies are important topics in understanding performance in team sports [8, 35]. For example, research in three-a-side small-sided football games has shown how the teams' coordination patterns change over time in the areas nearest the scoring zone. It identified a strong symmetric relationship between team centroids (i.e., the mean position from all team players) in attacking and defending situations and, additionally, a significant increase in occupied area during the offensive process [9]. In fact, team centroid seems to provide valid information about intra-team coordination processes and collective tactical performance [31, 34]. Other research addressed the basketball game using, for example, decision-making of attackers and defenders in one-a-side situations by measuring relative positioning to the basket in different court locations [10], and space-time dynamic coordination of players and teams during competition [3, 4].

Although the decision-making process is influenced by the players' characteristics, the task and the environment, there are several strategic decisions that constrain behaviour during basketball games [16, 31]. One of the most important is the level of defensive pressure due to its strong influence on game pace and, consequently, on teams' performance and success. The most frequent level of defensive pressure is the man-to-man ¼-court defence, where the defensive players only defend their direct opposing player when he is positioned in the offensive ¼-court [2, 15]. This defence is frequently extended to the full court level, with the aim of delaying the ball transition from defence to offense and, thereby, consuming the 24-s ball possession time for the offensive

accepted after revision
November 11, 2013

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DOI http://dx.doi.org/10.1055/s-0033-1363237
Published online: 2014
Int J Sports Med
© Georg Thieme Verlag KG Stuttgart · New York
ISSN 0172-4622

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team [15]. All decision-making for the offensive team should be affected by this strategic behaviour; however, there are no studies describing these frequent situations using positional derived variables. Therefore, the aim of this study was to examine the effect of 3 different defensive situations (i.e., ¼-court man-to-man, full court man-to-man and a second time period of ¼-court man-to-man) on basketball players' court positioning, as measured by positional variables (distance to team and opposing team centroid; distance between centroids; accumulated distance between oscillation movements of the centroids and their relative-phase in both lateral and longitudinal displacements). It was hypothesized that man-to-man ¼-court defence situations would promote higher regularity in game collective behaviours and that increasing activity workload across the game quarters would impair movement behaviour.

Methods

Participants

20 under-18 international male basketball players volunteered to take part in this study (age: M=16.05, SD=2.09 years old; weight: M=73.13, SD=8.10 Kg; height: M=183.10, SD=5.88 cm; weekly practice: M=10.9, SD=1.94 h and playing experience: M=7.1, SD=1.1 years). The players belong to the Austrian national team and competed for different clubs in the Austrian junior division (2011/2012 season). All players, their parents or legal guardians were familiar with the Ubisense Real Time Location System and were informed in detail about all of the measurements to be taken in the study before signing an informed consent. All players were in good health, free from musculoskeletal dysfunctions and injuries. The study conformed the ethical standards of the International Journal of Sports Medicine [18] and was approved by the Ethics Committee from the University of Vienna.

Experimental design

The data were collected during a simulated basketball game that was played during the competitive period of the season and that consisted of 4 quarters of 10 min each, reproducing as much as possible the official game, including the usage of 3 experienced referees. The game was played in an indoor official wood floor surface court (dimensions: 28 m by 15 m) and started at 10:30 h with optimal environmental conditions (temperature 18–21 °C, relative humidity 45–55 %). The 20 players were divided into 4 balanced teams (Teams A, B, C and D) using the coaches' subjective evaluations of playing performance, i.e., skill levels in passing ability, ball handling, shooting and game sense [19,34]. Each team played 2 quarters interspersed with 15-min of passive recovery (A vs. B played 1st and 3rd quarter; C vs. D played 2nd and 4th quarter). All quarters were interspersed with 2 time-outs at the 4th and 7th minutes to switch the defensive system and simulate the recovery periods from the games. The players were instructed to use man-to-man ¼-court defence until the 4th minute (F¼), man-to-man full court defence from the 4th to the 7th minute (FULL), and man-to-man ¼-court defence from the 7th to the 10th minute (S¼) for each quarter. Identification of performance predictors in team sports should preferably be done directly in game situations [1]. Research based on task constraints during team sports simulated games has been demonstrated to be an important environmental manipulation [41]. Consequently, these approaches allow overcoming the limitations from the most traditional descriptive studies, which merely document statistics of sports performance [5,41]. A counterbalanced design would account for the order effect in the 2 defensive systems. However, coaching interest is in describing the specific order that was used, rather than accounting for the order effects. Therefore, this design responds to the aim of describing the specific order of starting a quarter employing man-to-man ¼ court defence, changing to FULL and returning to the previous man-to-man ¼ court defence.

Measurements

Positional data was gathered using the Ubisense Real Time Location System, which is used primarily for manufacturing processes in industry, location-driven security tasks and military training [40]. The system captures positioning in game sports activities with a mean deviation of M=0.09, SD=5.43 % [26]. The setup of the Ubisense system consisted of 6 base stations mounted around the basketball court (outside of the court at each corner and in the middle of the long side-lines) at a height of about 5 m, covering an area of about 33 × 18 m. The positions of the players were calculated via time-difference-of-arrival and angle-of-arrival measurements of ultra-wide-band radio-signals which were sent by mobile transmitters (worn by the players in brackets atop their heads) to the base stations [26]. The mean sampling rate of the position measurements was 3.74 (SD=0.45) Hz per transmitter/player. The data obtained by the Ubisense software were post-processed via a combination of Kalman and low pass filtering. The location system used provides the positional data for all transmitters consecutively, meaning that for each time instance of position measurement, only the values for one transmitter are available. However, in order to obtain the pairs of x and y-coordinates of each tag for all time instances, the data were interpolated accordingly.
The individual positional data (x and y-coordinates) was used to determine the teams' centroids, as determined by the mean position of all 5 players from each team, computed across the game duration. Afterwards the distances from each player to each centroid and basket (team and opposing team) were calculated. The dynamic relationships between the oscillation movements of centroids were measured for lateral and longitudinal court directions. The relationships between both speed displacement of players-centroid and centroid-centroid were determined for both the offensive and defensive courts across the game.
All game quarters were video recorded with a standard digital camera located 5 m above the basketball court. A notational analysis was performed using Simi Scout software (version 2.0.0.174, Simi Reality Motion Systems GmbH, 2007) to determine the effective field goal percentage [32]. In order to allow comparisons between the defensive systems and account for differences in game pace, the data was normalized to 100 ball possessions per minute of play [25,33]. An experienced researcher in performance analysis gathered this data, and reliability was assured (ICC = 1.00).

Data processing and analysis

The positional data were exported to MATLAB (version 6.5; The Math-Works Inc., Natik, MA) for processing and analysis. The approximate entropy (ApEn) values were used with the aim of identifying irregularity in non-linear dynamic positional data [35]. The values used to calculate ApEn were 1.0 for length (m) and 0.5 for tolerance (r) [37]. The calculated values of the ApEn

Table 1 Results from positional variables (absolute values and ApEn values) and effective field goal percentage by defensive system.

Variable	F¼ Mean ± SD	FULL Mean ± SD	S¼ Mean ± SD	Cohen's d	95 %CI
absolute values (meters)					
distance to centroid	3.7 ± 0.3[a]	4.3 ± 0.7[c]	3.9 ± 0.4	a (1.14), c (0.72)	a (0.84–1.27) c (0.41–0.90)
distance to opponents' centroid	4.2 ± 0.4[a,b]	4.8 ± 0.8	4.5 ± 0.5	a (0.97), b (0.68)	a (0.62–1.15) b (0.46–0.86)
distance between centroids	1.8 ± 0.1[b]	2.1 ± 0.2	2.2 ± 0.2	b (2.60)	b (2.51–2.64)
distance to basket	13.1 ± 3.0	13.1 ± 3.4	12.9 ± 3.5	–	–
distance to opponents' basket	14.4 ± 3.0	14.5 ± 3.5	14.6 ± 3.5	–	–
distance from centroid to basket (defensive-court)	6.5 ± 1.9	7.0 ± 1.9	6.7 ± 2.0	–	–
distance from centroid to basket (offensive-court)	7.1 ± 2.2	7.9 ± 2.0	7.3 ± 2.3	–	–
ApEn values (a.u.)					
distance to centroid	0.86 ± 0.08	0.86 ± 0.11	0.84 ± 0.10	–	–
distance to opponents' centroid	0.99 ± 0.07	0.95 ± 0.11	0.98 ± 0.10	–	–
distance between centroids	0.50 ± 0.04	0.56 ± 0.09	0.60 ± 0.07	–	–
distance to basket	1.03 ± 0.15[a]	0.91 ± 0.22	0.98 ± 0.19	a (0.64)	a (0.59–0.75)
distance to opponents' basket	1.02 ± 0.16[a]	0.92 ± 0.22	0.99 ± 0.17	a (0.53)	a (0.46–0.63)
distance from centroid to basket (defensive-court)	1.09 ± 0.49	0.94 ± 0.38	0.94 ± 0.40	–	–
distance from centroid to basket (offensive-court)	1.12 ± 0.30	1.03 ± 0.37	1.00 ± 0.44	–	–
effective field goal percentage (%)	10.9 ± 2.2	11.9 ± 7.8	16.6 ± 7.5	–	–

Significant differences are between: a) F¼ vs. FULL; b) F¼ vs. S¼; c) FULL vs. S¼

ranged between 0 and 2, with lower values corresponding to more regular and predictable series [29,30]. In a functional sense, lower ApEn values represent higher regularity in movement variations from the players with both centroids and basket from the team and opposing team (i.e., informational constraints for decision-making and action).

The coordination patterns for the oscillating signals were obtained by calculating relative-phase using a Hilbert transform [27]. The obtained results are expressed in angles, meaning that values close to 0° identify synchronous patterns of coordination (in-phase pattern) and values close to 180° identify asynchronous patterns of coordination (anti-phase pattern) [36]. In more practical terms, the relative-phase was used with the aim of identifying how the oscillating signals were coupled and coordinated across the game.

The differences in both ApEn values and absolute distances according to the defensive systems were identified using repeated measures ANOVA. The sphericity was assessed using Mauchly's test and, when necessary, the Greenhouse-Geisser correction procedure was used to adjust the degrees of freedom. Pairwise differences were assessed with a Bonferroni post-hoc test. In addition, the effect sizes (ES) with confidence limits were calculated and interpreted based on the following criteria: <0.20 = trivial; 0.20 to 0.59 = small; 0.60 to 1.19 = moderate, 1.20 to 2.0 = large, >2.0 = very large [20]. The effective field goal percentage were presented as median and interquartile ranges (IQR) and compared using the Friedman test. All data sets were tested for the corresponding assumptions of each statistical technique. These calculations were done in SPSS Software (version 18.0, Chicago, Illinois, USA), and the statistical significance was maintained at 5%.

Results

The results from the positional data transformed in potential dynamic and fixed informational constraints (i.e., the team centroids and the baskets, respectively) and the effective field goal percentages, according to the 3 defensive conditions (F¼; FULL; S¼) are presented in **Table 1**. The absolute distance to centroid was significantly higher when in FULL condition (F (2,38) = 14.1, p < 0.001). The distance to opponents' centroid was also significantly different (F (2,38) = 9.8, p < 0.001) between F¼ and FULL (ES = 0.97), and between F¼ and S¼ (ES = 0.68). Additionally, the distance between centroids increased across defensive systems (F (2,4) = 6.9, p = 0.006) with significant differences between F¼ and S¼ (ES = 2.60) (**Table 1**). No differences were found in the ApEn values or in distance to basket and opponents' basket (**Table 1**). There were differences in ApEn from the distances to basket (F (2,38) = 3.8, p = 0.026) and to opponents' basket (F (2,38) = 3.3, p = 0.042) values between F¼ and FULL (ES = 0.64 and ES = 0.53, respectively) (**Table 1**). The distance from centroid to basket in both defensive and offensive courts presented high variability, with irregularity decreasing across defensive systems. Despite higher values in the effective field goal percentage during S¼ (M = 16.6, SD = 7.5), no differences were found between defensive systems.

Fig. 1 presents the results from the accumulated distances between oscillation movements of the centroids (**Fig. 1a, b**) and relative-phase (**Fig. 1c, d**) in both lateral and longitudinal displacements across the defensive systems. Also, the ApEn was calculated for each of the considered variables (**Fig. 1e**). Stronger in-phase attractions in both latitudinal and longitudinal directions were revealed (**Fig. 1c, d**). However, the centroids were nearer and revealed higher values of irregularity in lateral displacements for all defensive systems (**Fig. 1a, e**, respectively). The ApEn results showed a higher variability in both lateral and longitudinal displacement in the FULL and S¼ conditions (**Fig. 1e**).

The irregularity of relative-phase in speed displacement between player and centroid and between centroids in both defensive and offensive courts is presented in **Fig. 2**. Overall, the ApEn values decreased across the game to different defensive systems. The irregularity between players and centroid in offensive court was significantly higher during F¼ condition (F (2,38) = 4.8, p = 0.010) compared to both FULL (ES = 0.62) and S¼ (ES = 0.66).

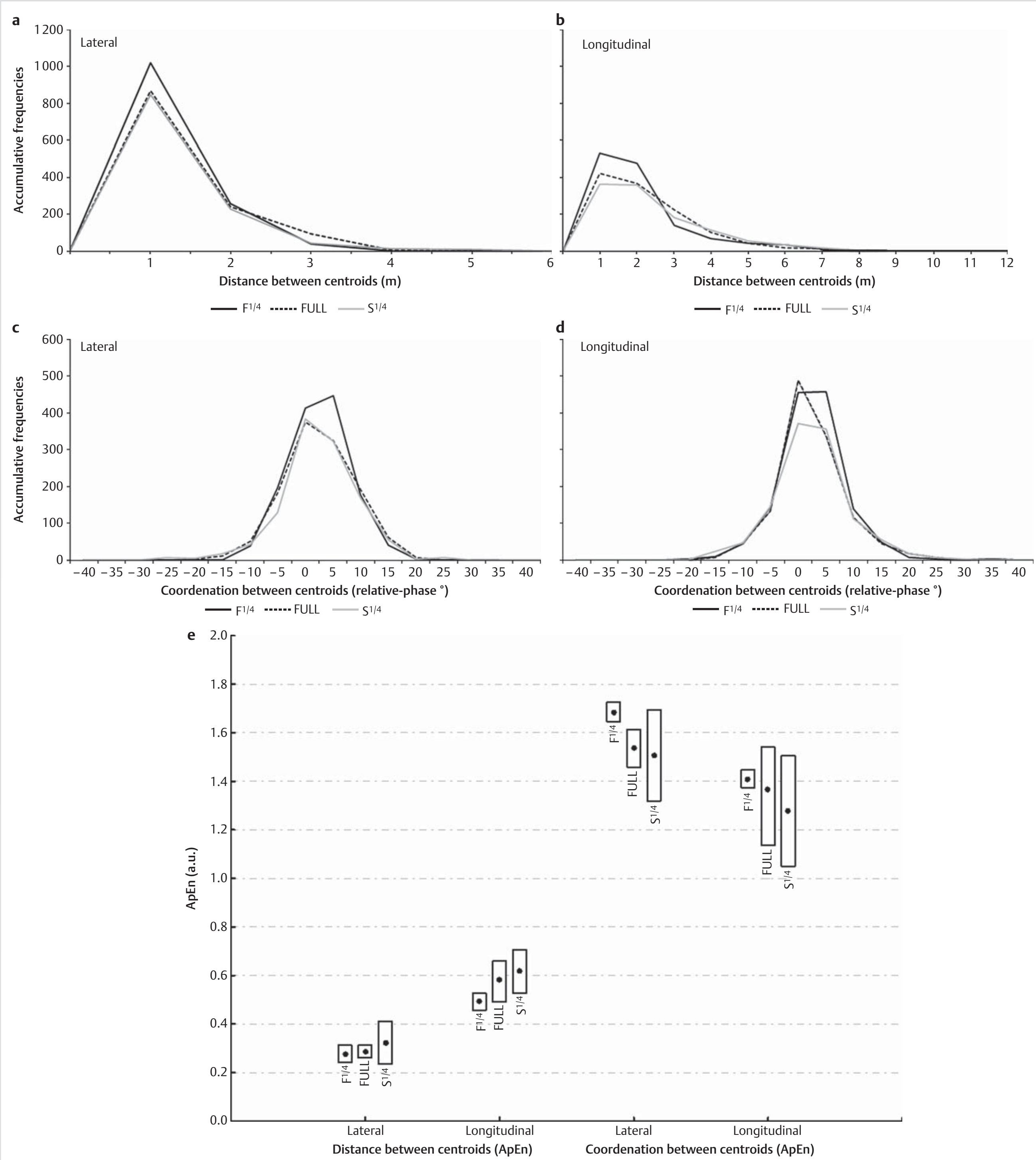

Fig. 1 Accumulative of the absolute distance between centroids across the game (upper-panel). Relativephase analysis between the spatial oscillation centroids of the 2 teams (medium-panel). ApEn values for the presented variables (lower-panel). All variables were analyzed individually for both lateral and longitudinal court directions and according to the considered defensive systems.

Discussion

The aim of this study was to examine the effect of level of defensive pressure on basketball players' court positioning, as measured by positional variables. The FULL defensive system increased the distance from the players to both team and opponents' centroid. This finding may be explained by the defensive positioning of the players aimed at the opponents in the full length of the court [44]. Interestingly, the results showed that after the FULL defensive system period, the players were able to restore their previous distances to team centroid, but not their distances to the opponents' centroid. Consequently, the distance between centroids increased across the 10-min quarter, reaching significant differences between F¼ and S¼. In general, in the course of the game, the players increased their inter-distances possibly because of the effects of accumulated activity work-

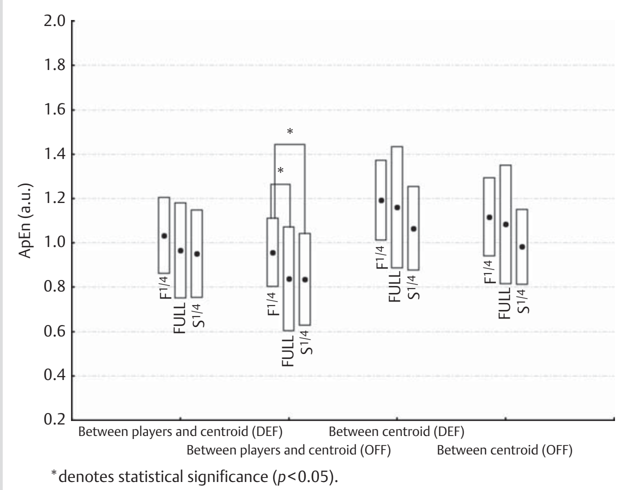

Fig. 2 ApEn values of the relative-phase analysis between speed displacement of the players-centroid and centroid-centroid in both defensive and offensive courts.

load. A recent approach suggested that higher workload activity may be linked to more irregularity in players positioning and, consequently, in teams' space-time performance indicators [31]. This evidence seems to suggest that the players' decisions across the game are mainly influenced by the relationships established with their nearest teammates and not by their direct opponents, allowing the emergence of self-organization interactions and, consequently, collective movement solutions [7,41]. The results also lead to other interesting findings, for example, identifying a gradual increase in the distance between teams' centroids in the final moments of the game quarters (from F¼ to S¼), which may be linked to a proportional spacing between players, usually triggered by the defenders. This evidence may reveal a higher degree of defensive coordination with players trying to competitively protect their basket and the rebound area or, by trying to stop penetrations to the basket, releasing defence from their assigned players. Occasionally this strategy has the opposite effect in the attackers. Thus, having more space and time to decide may increase individual actions in the final moments of the game periods. [38,43]. Interestingly, the variability in effective field goal percentages increased across time, without being impaired, suggesting that increased workload might have positive effects in visual anticipation tasks, decision-making process and team coordination [24,31]. In this sense, inducing low-to-moderate levels of fatigue to training drills may improve their representativeness.

The ApEn has been demonstrated to be useful in measuring tactical behaviour in sport context such in football [17,34] and basketball [31]. For example, successful performances in one-a-side youths seem to be linked to the attackers' unpredictable movements [8]. In the current study, the ApEn results showed higher irregularity in the distance to opponents' centroid, which may be understood as an offensive performance indicator. Additionally, for the emergent behavioural patterns to be unpredictable, they should not be predetermined and, consequently, may be considered to be a key component of in-game creative behaviour from the players [21].

According to the mean of absolute values of the distance to one's own and opponents' basket, the players spent more time in defence and transition to offense situations. Additionally, the distance from centroid to basket in both the defensive and offensive court presented lower absolute values, despite the evident increase in irregularity and variability, which is probably explained by the different playing position-specific behaviours during the game [3]. It has been suggested that field positioning of attacker-defender pairs and their proximity to fixed informational constraints for decision-making and action (such as baskets) may be considered important in stabilizing players' behaviours and an environmental constraint in the symmetry-breaking behaviour of attackers [28,42]. Furthermore, a recent study demonstrated that the attacker's relative position to the basket may influence the outcome of the attacker-defender interaction [10]. Therefore, both team and opponents' baskets seem to be an important informational constraint to provide a stable and rational reference to space-time distribution during the game.

The analysis of the centroids spatial oscillation indicated a strong in-phase relation in lateral and longitudinal court directions for all defensive situations. Similar findings have been reported in basketball [4] and in football [9,11], showing that opposing teams' displacements tend to move in the same direction over the course of the game. However, the centroids were closer and revealed higher values of irregularity in lateral direction. Such information identifies the lateral displacements as the main contributor in unsettling the opposing team. In this sense, critical match periods have been associated with changes in football teams' lateral distance, which is related to players' movements after sideways passing [12]. Additionally, a recent study showed that system symmetry maintained between futsal defenders and attackers may be disrupted by using lateral displacement to increase the angle with the goal and the defender position [42]. Thus, optimizing lateral space-time distribution seems to be key in generating deceptive movements and disrupting the opponents' organization to gain advantage [4].

Based on the ApEn values of the relative phase from the speed displacements, it seems that individual movements became more coordinated with teammates, particularly in the offensive court. In fact, the offensive team's behaviour seems to depend highly on skills developed in practice, whereas the defensive process is also a reaction to the opponents' behaviour. Moreover, the attacking players are usually stimulated to develop an irregular and creative spatiotemporal synchrony with defenders, which may impair defensive performance [8].

This study provided evidence on how the positioning variables are related to the levels of defensive pressure, as well as how changing these levels during the game promotes different emergent collective behaviour. This is the first report showing how defensive system constraints affect the emergent behavioural dynamics in simulated basketball games. These results reveal new insights for kinesologists, as they introduce new variables contributing to an explanation of perception-action cycles (dynamic and fixed informational constraints). In addition, this information can help coaching young basketball players by providing an accurate understanding of player and team responses when selecting different defensive systems. For example, based on ApEn information coaches are able to identify the level of irregularity in player's displacement and coordination. Additionally, coaches are able to use feedbacks with real distances between teammates and between their opponents to thereby design superior representative tasks in training sessions. Further research should overcome the limitations of the present study, i.e., the small sample size and the uniqueness of the data collection in a single game. Furthermore, physiological variables can also be considered in order to measure the players' fatigue and obtain a holistic overview of all results.

Acknowledgements

This study was supported by PTDC/DES/098693/2008 project: "Evaluating training and competition in team sports. Aggregating tactical analysis, external and internal workload" financed by the Portuguese Foundation for Science and Technology (FCT).

Conflict of interest: The authors have no conflict of interest to declare.

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