The Ecological Dynamics of 1v1 Sub-Phases in Association Football

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Abstract: The purpose of this study was to analyze the informational constraints that influence the dynamics of 1v1 situations in football. Specifically, we analyzed the contribution of interpersonal distance and relative velocity to explain phase transitions that occurred between stable and unstable coordinative states in 1v1 in football. Participants were six, U13 level football players (Mean age: 11.8±0.4 yrs), who performed 5 trials of a representative task at four different start distances (1, 1.5, 2 and 2.5 meters) between the defender and the ball (5 repetitions x 6 players x 4 distances = 120 1v1 trials). Players' motion was captured by digital video camera. For image treatment and to extract data on player movement coordinates, we used the TACTO 8.0 software at 25 Hz. Following, we constructed plots with the time-series of these two control parameters candidates associated with the time-series of players' distance to the end line. Graphical inspection showed in all trials a clear tendency for greater relative velocity and lower interpersonal distance values during phase transitions between coordinative states. To confirm this interpretation, we computed a time-series analysis of Z-scores of relative velocity and interpersonal distance data, and a time-series analysis of Z-score differences between these variables. Mean data showed that maximum peaks in Z-score differences were related to all phase transitions.

INTRODUCTION

Association football constitutes an open complex system characterized by adaptive behaviour as result of dynamic interactions of the players [1]. Interpersonal interactions at a microscopic level of organization (e.g., between attackers and defenders in 1 v 1 sub-phases) can prompt nonlinear transitions in macroscopic patterns of behaviour (e.g., patterns of play in games) [2]. Despite the enormous variability and complexity of a football match, theoretical and experimental evidence suggests the existence of dynamic patterns of interpersonal coordination between players, at various levels of analysis [3]. These pattern-forming dynamics emerge in the complex interpersonal interactions of performers regulated through their direct perceptual processes [4,5]. The 1v1 sub-phase near a target/goal area is the most studied sub-system in team sports from this perspective. For example, in basketball, critical values of interpersonal distance were identified as a potential control parameter that pushes the system to phase transitions [6]. In rugby, interpersonal distance has also been identified as a candidate control parameter [7]. However, that research showed that for interpersonal distances values of less than 4 m, relative velocity assumed crucial importance as the control parameter responsible for the phase transitions in the dyadic systems [7]. In football, the difference between the distance of the attacker and the defender to a target zone (for example, the goal or the free space behind the defender) can be defined as a potential order parameter [3,8], identifying two qualitative states: (1) when the defender is nearer the target zone than the attacker, and (2) when the attacker passes the defender and approaches the target zone. Based on the ecological dynamics approach [5], the purpose of this study was to investigate the informational constraints that influence the dynamics of 1v1 sub-phases in football. Specifically, our aim was to analyze interpersonal distance and relative velocity as control parameter candidates that influence the phase transition between the two organizational states in 1 v 1 sub-phases of association football.

METHODS

Participants were six, U13 experienced football players (Mean age: 11.8±0.4 yrs; training experience: 3.6±1.1 yrs). The task consisted of a representative situation in which the attacker tried to destabilize a dyad formed with a defender to explore the free space behind him and create shooting opportunities. In addition, the defender tried to maintain dyadic system stability by preventing the attacker from shooting (see Fig. **1**).

Players performed five 1v1 trials each at four different start distances (1, 1.5, 2 and 2.5 m) between the defender and the ball (5 repetitions x 6 players x 4 distances = 120 1v1 trials). Based on previous criteria, we excluded 31 null trials and accepted 89 for further analysis. To simulate performance constraints, we created a 1v1 competition between players. Players' motion was captured by digital video camera. For image treatment and to extract data on player movement coordinates, we used the TACTO 8.0 software

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[9], digitizing action at 25 Hz. The procedure consisted of following with the mouse the earlier tested working point in the middle of the feet. After 7 days of training, the reliability of digitizing action was r=0.99 to x, and r=0.98 to y coordinates. After calibration with real measures of six control points, the x and y virtual coordinates of the players were extracted. To transform the virtual into real coordinates we used the Direct Linear Transformation Parameters (PDLT) [10]. Subsequently, position and velocity data of all players in all trials were computed and analyzed with MATLAB software.
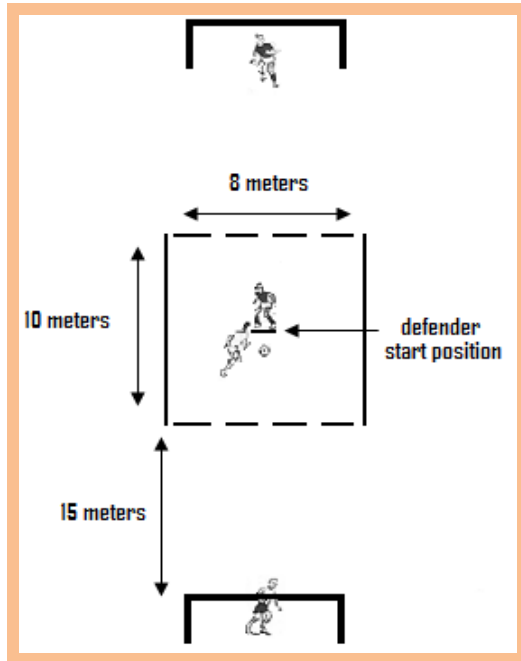
RESULTS

Results showed no statistical differences for all outcome measures analyzed to discriminate differences between the various initial start distances (as in previous research on basketball and rugby union [6,7] we studied percentage of time spent in symmetry, anti-symmetry and undifferentiated state; time and distance to the target zone of first and last phase transitions; and the number of zero crossings).

To analyze the contribution of interpersonal distance and relative velocity as variables to explain phase transitions in 1v1 sub-phases of football, we constructed plots of the time-series of these two candidate control parameters related to the time-series of players' distance to the target zone. Graphical inspection of the data showed that in all trials there was a clear tendency for higher relative velocity and lower interpersonal distance values during phase transitions between the two coordinative states (see Fig. **2**).

To confirm this interpretation, we computed a time-series analysis of Z-scores of relative velocity and interpersonal distance data, and a time-series analysis of Z-score differences between these variables (see Fig. **3**). Mean data showed that maximum peaks in Z-score differences were related to all phase transitions.

DISCUSSION

Analysis of the moment of phase transitions showed that this instant was related to lower values of interpersonal distance and higher values of relative velocity. When these control parameters were expressed as a single variable (see Z-score difference in Fig. **3**), maximum peaks were related to the exact moment of phase transition. The findings of the present study suggest that dyadic system behaviours emerge in an environmental exploratory process [4,6] that cannot be explained exclusively by only one control parameter. These results are similar to the study of 1v1 sub-phases in rugby union [7], in which it was shown that for interpersonal dis-
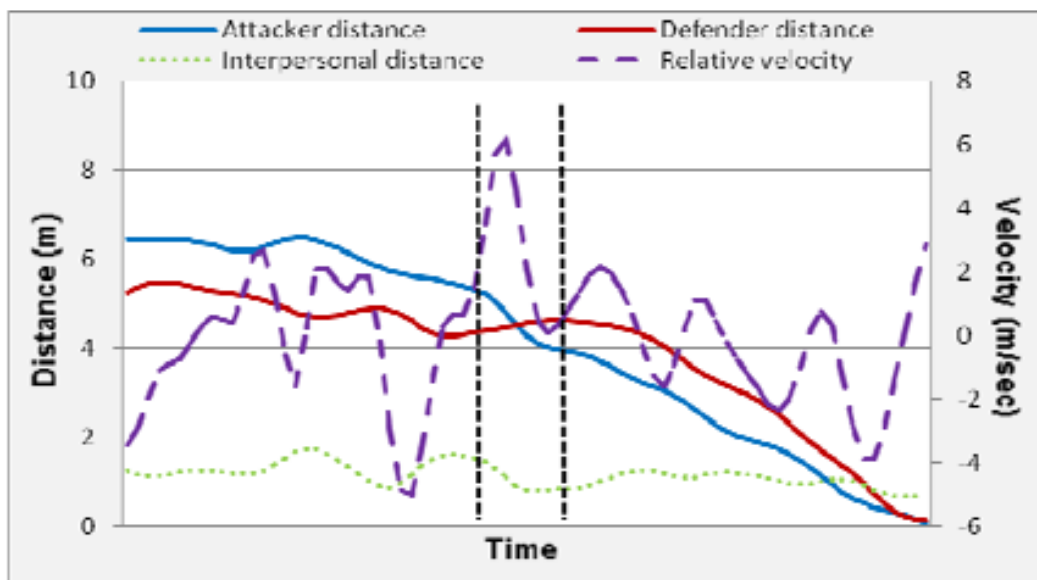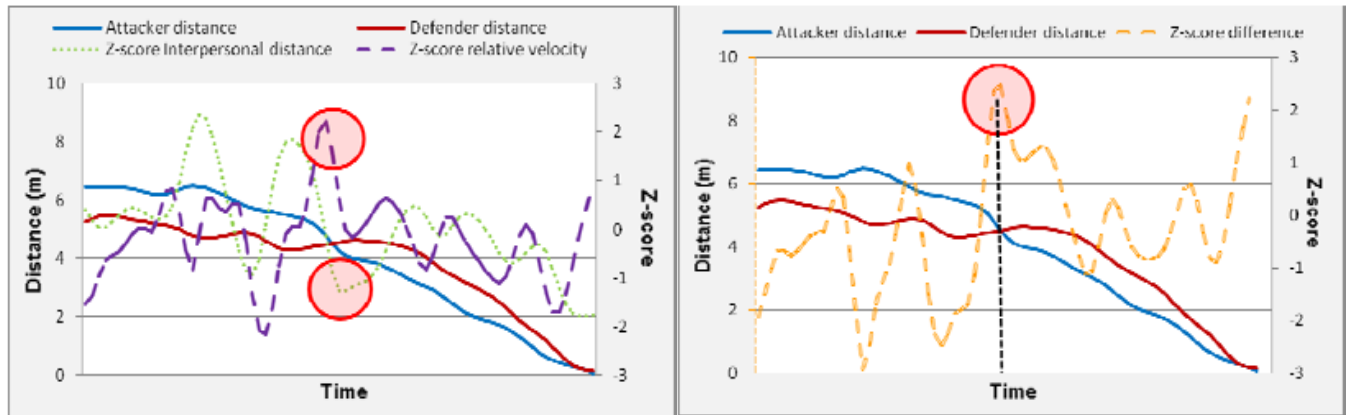

Fig. (1). Experimental task schematic representation.

Fig. (2). Example of the identified tendency in one random selected trial.

Fig. (3). Time-series of Z-scores in the same trial. On the left, Z-scores of relative velocity and interpersonal distance showed higher and lower values associated to phase transition. On the right, the difference between Z-scores of relative velocity and interpersonal distance (Z-score difference) showed a maximum peak in the exact moment of the phase transition.

tance values of less than 4 m, relative velocity was the control parameter responsible for the phase transitions. In this study of association football, to represent the specific task constraints of 1v1 sub-phases, the different initial start distances were less than 4 m (between 1 and 2.5 meters). This fact can attributed to the importance assumed for relative velocity in destabilizing the attacker-defender dyad. However, this control parameter was strongly associated with lower values of interpersonal distances in all trials. Summarizing, at critical values of interpersonal distance in football, attackers can destabilize dyads by altering the difference between his/her velocity and the defender's velocity. These results have several implications for training task design in football. Attackers should be encouraged to explore the exact moment at which the affordance to drive past a defender emerges [3-5]. These affordances emerge at lower values of interpersonal distance, particularly when the difference between the relative velocities of the players is higher. On the other hand, defenders should be encouraged to maintain appropriate interpersonal distance with attackers to maintain stability of the 1v1 sub-system.

Moreover, we observed that the same physical variables constrained the dynamics of performer-environment interactions despite variations in initial start distances between players. This observation shows high levels of consistency in the players using the same informational constraints to guide their actions in 1 v 1 sub-phases of football.

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