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Effects of pacing, status and unbalance in time motion variables, heart rate and tactical behaviour when playing 5-a-side football small-sided games

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ABSTRACT

Objectives: To compare time-motion variables, heart rate and players' tactical behaviour according to game pace (slow, normal or fast), status (winning and losing) and team unbalance (superiority and inferiority) in football 5-a-side small-sided games. To identify the most discriminating variables in classifying performances according to these constraints.
Design: Cross-sectional field study.
Methods: The data were gathered using global positioning systems (5 Hz) in 5-a-side small-sided games (7 × 5 min) played by twenty-four footballers. The tactical performance was measured using dynamical positioning variables, processed by non-linear signal processing techniques (approximate entropy). ANOVA models were used to compare between constraints and discriminant analyses to identify the variables that best discriminate between pacing and status × unbalance constraints.
Results: The fast paced games had the highest mean speed value, followed by normal and slow paced games ($8.2 \pm 0.6\,km\,h^{-1}$, $7.8 \pm 0.5\,km\,h^{-1}$ and $6.2 \pm 0.4\,km\,h^{-1}$, respectively). The stronger predictor variables of pacing were the randomness in distance to team centroid and the distances covered above $13\,km\,h^{-1}$. The results also changed according to game status and team unbalance. The strongest predictor variables were the distance covered bellow $6.9\,km\,h^{-1}$, distance and randomness to team centroid, with higher values when winning in superiority conditions.
Conclusions: Practice task design manipulating game pace, status and team unbalance significantly influenced the emergent behavioural dynamics. Collective positioning variables were more accurate in discriminating these constraints and, therefore, need to be considered when planning and monitoring performance.

1. Introduction

The football training process is much focused in using small-sided games (SSG), which are modified games that are played on reduced pitch areas, using adapted rules and involving a smaller number of players.[1] Currently, the SSG are very popular training drills for all ages and standards of play given that, presumably, they concurrently improve players' physical conditioning, technical and tactical skills. In fact, it has been reported that by altering the pitch area, player number, availability of replacements balls, training regimen, presence of goalkeepers, coach encouragement or game rules, the physiological, perceptual, and physical loads can be manipulated to provide different training responses.[1] Although there are several studies focused on the impact of manipulating task constraints,[2,3] none has examined frequent situations such as game status associated with team unbalance and game pace.

The SSG formats with fewer players elicit greater heart rate (HR), blood lactate, and perceptual responses but less high-speed running than the larger formats.[1] In the available research, the numerical balance between confronting teams is frequently maintained, for example, contrasting a 3-a-side game with a 5-a-side game. One study showed similar time-motion and physiological responses to fixed and temporary numerical unbalance situations in youth players.[4] However, there were differences in the ratings of perceived exertion, with higher values in underloaded teams (5-player and 3-player teams) when compared with overloaded teams (6-player and 4-player teams). In addition, a recent study showed that an early dismissal (after 5 min of total game time) resulted in an increase of distance covered and less recovery time between high-intensity efforts by the team in numerical disadvantage.[5]

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Given that football is frequently played in numerical unbalance either momentary, for example in a fast-break, or permanently, by a player exclusion, further research is required to clarify the impact of team numerical unbalance on the players' responses during SSG. In addition, the match status is a variable to be considered because it has been demonstrated that players regulate their physical effort depending on the score-line at a particular period of the match. Therefore, different studies suggest that footballers perform at lower intensity levels when winning.[6,7]

The most frequent variables to describe performance in SSG are physiological-based, however, very recent research is also focused on teams' tactical performance by using new collective positioning-based variables.[8-10] More specifically, it has been suggested that the mean position from all team players (team centroid) 10 and players' distance to team centroid[8] are candidates to collective tactical performance indicators by capturing the teams' dynamics during the game. Therefore, the dynamics of these positional variables seem related to players cognitive processing and decision-making during the game.

Football SSG during training are often played at variable speeds, because tactical performance is based on non-physical interpersonal coordination that occurs as players dynamically adapt movement variables such as movement trajectories and individual speed levels to create space and time.[9] These different patterns of interpersonal coordination have been described using universal principles of dynamical self organizing systems,[11] however, further research is needed on describing how the constraints in game pacing affect the tactical and the physiological-related variables. Therefore, a contrast of different game paces can provide additional information about how different paces require for different cognitive processing and self-organization dynamics promoting emergent functional behaviour.

Taking into account all previously mentioned considerations, the aim of the current study was to examine heart rate, time-motion characteristics and player's tactical behaviour according to game status, team unbalance (wining and losing when in superiority and inferiority) and the pace of the game (slow, normal or fast) in football 5-a-side SSG. Also, we aimed to identify the most discriminating variables in classifying the players' performances according to these constraints. It was hypothesized that losing status and playing with a numerical disadvantage would elicit higher HR and high-speed running than winning status and playing with a numerical advantage. A second hypothesis was that higher game paces would increase physiological responses but would impair tactical performances.

2. Methods

Twenty-four male football players volunteer to participate in this study (age 20.8 ± 1.0 years, height 173.2 ± 6.3, weight 9.4 ± 2.0, and playing experience 5.2 ± 1.3 years). The subjects were part of two different teams and participate in practice sessions four times per week for a total of 360 min. After a detailed protocol explanation about the aims, benefits and risks involved with this investigation, all participants signed a written informed consent. Despite of this, they were free to withdraw from the study at any time without any penalty. The study protocol followed the guidelines stated in the Declaration of Helsinki and was approved by the Ethics Committee of the Research Centre for Sports Sciences, Health and Human Development, Vila Real, Portugal.

The head coaches divided the players into four balanced teams according to their skill levels in passing ability, close ball control, shooting and game sense.[12] There were four goalkeepers that were assigned randomly to each team. The protocol consisted in playing seven different football small-sided games. Before each testing session, there was a standardized 20-min warming-up consisting of running, stretching and a ball possession game. The first three games consisted in a continuous 5-min period playing the game at normal, slow and fast pace, interspersed with a 3-min period of passive rest. These pacing constraints were communicated verbally and at the same time to all players just before the starting of each game. The remaining four constraints had the same duration and rest and consisted of removing one player from one of the teams just before the starting of the game, forcing a superiority and inferiority conditions (5×4 and 4×5). Additionally, the players were informed verbally that their team was either wining or losing in the game. This condition was maintained across the whole bout, i.e., if the losing team scores a goal, maintains the losing status. These constraints were repeated to ensure that all players were measured twice in each condition. All games were performed in $60\,\text{m} \times 40\,\text{m}$ pitch size with natural turf and using official football rules. A high number of balls were located around the court to ensure the fast return of the ball into play. To encourage high work-rate maintenance, free verbal support was given to all players during the game.

Positional data, speed and distance covered were recorded at 5 Hz using a portable global positioning system (SPI-PRO, GPSports, Canberra, ACT, Australia). The SPI-PRO units were placed into appropriate harnesses that place the device in the upper back of each player. Data were collected in outdoor field with a clear view of the sky in accordance with guidelines by the manufacturer.[13] This technology has been widely used for measuring movement demands of team sports[8,14] and his accuracy and reliability was already identified.[15,16]

The distance covered in each predefined speed zone was selected for analysis: zone 1 (0–6.9 km h^{-1}); zone 2 (7–9.9 km h^{-1}); zone 3 (10–12.9 km h^{-1}); zone 4 (13–15.9 km h^{-1}); zone 5 (16–17.9 km h^{-1}) and zone 6 ($\geq$18 km h^{-1}).[12] The Heart rate of each player was recorded continuously via short-range radio telemetry (Polar Electro, Oy, Kempele, Finland). Exercise intensity during each SSG was assessed using percentage of HR_{max} and classified into time spend in following zones of intensity: Zone 1 (<75% HR_{max}), Zone 2 (75–84.9% HR_{max}), Zone 3 (85–89.9% HR_{max}), and Zone 4 ($\geq$90% HR_{max}).[17] The results from a Yo–Yo intermittent recovery level 2 test were used to determine the players' HRmax.[18]

The dynamic positional data provided by SPI-PRO was used to determine the centroid of each team during each game. Afterwards, the distance from each player to centroid was computed using player (P) and teams' centroid (T) positions, in the following equation:

$$D_{(P,T)} = \sqrt{}((Px - Tx) + (Py - Ty))2$$

Randomness in distance to team centroid was measured using approximate entropy values, in order to identify regularity in players' movement patterns.[8] This variable can be used as a measure of complexity from non-linear time series data.[19,20] The values from randomness range from 0 to 2, where the lower values correspond to more regular, predictable and less chaotic series.[24,27] The inputted values of a vector's length (m) were 1.0 (measures the length of a sequence of contiguous observations) and the tolerance (r) was 0.5 (measures the amount of noise in the data that is filtered out in the ensuing calculation).[21] These calculations were done in MATLAB (version 6.5; The Math-Works Inc., Natik, MA).

A two-way repeated measures ANOVA was performed to identify differences in time motion variables, heart rate and tactical variables according to match status and team unbalance. The differences in these variables according to game paces were identified using a one-way ANOVA. Pairwise differences were assessed with Bonferroni post hoc test. Two discriminant analysis models were performed to identify which of the variables best discriminated