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Do contextual variables influence the spatial organisations of elite-level Brazilian professional soccer players?

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ABSTRACT

Purpose. This study investigated the influence of contextual variables on individual and collective team spatial organisation in professional Brazilian players.

Methods. Seventeen matches were analysed during the 1st division Brazilian National football League of 2019. Global Positioning System devices were used to track players' in-game movements. The data were analysed using Matlab to calculate linear tactical variables. The selected tactical variables were 'Distance from the last defender to the goal'; 'Width and length'; 'LpWratio'; 'Spread'; 'Space exploration index' and 'Stretch index'. Five contextual variables were considered: (i) playing time, (ii) match location, (ii) ranking of the opposition, (iii) match outcome, and (iv) match status.

Results. Results demonstrated that the LpWratio values were significantly greater during the second half of matches when compared with the first half (p = 0.03; d = 0.62). Significantly greater length and spread values were identified when the team was playing against a bottom six team when compared with the medium eight teams (p = 0.05; d = 1.58–1.60). Significantly higher stretch index values were reported when playing a top six opposition team when compared with the medium eight opposition teams. During losses, the stretch index was significantly higher when compared with wins and draws, respectively (p = 0.01; d = 1.47–1.89). Finally, the LpWratio values were significantly higher during periods when the team was losing, when compared with periods of drawing and winning (p = 0.01; d = 1.07–1.12).

Conclusions. In conclusion, the spatiotemporal organisations of professional-level Brazilian club players are significantly influenced by contextual variables. The current findings support the use of GPS devices in soccer as a time-efficient and logistically viable method to characterise tactical behaviour and examine spatiotemporal movement patterns.

Key words: soccer, organisations, performance analysis, time-motion, tactical behaviours

Introduction

Soccer is a team sport with a high degree of complexity, wherein successful match-play is suggested to be governed by well-developed physical conditioning to cope with the games' high physiological demands [1, 2], technical capacity [3] and tactical proficiency and organisation [4]. Regarding the latter, the use of position data in match analysis has enabled coaches and researchers to gain a greater understanding of the spatial organisation patterns (such as temporal player positioning, interpersonal distance values and occupied spaces) soccer players exhibit during match-play [5]. In recent years, a range of different variables have been developed to systematically quantify players' movements and positional structures during the matches, such as spread, stretch index and space exploration index [6]. Furthermore, this process of obtaining positional data has been facilitated by the use of various microtechnologies, such as Global positioning system (GPS) and local positioning system (LPS) devices [7].

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Research investigating the collective spatial organisations of soccer players has lately proliferated in different competitive leagues around the world [8–10]. Furthermore, the continued emergence of these studies is a necessary prerequisite in order for coaches and researchers to identify reference values for these tactical behaviours and collective dynamics, which may in turn be used to inform training processes and tactical strategies [11, 12]. For instance, a recent systematic review by [12] investigated a number of relevant variables, such as the space exploration index, width, depth, and compression during official matches, which may be relevant to these processes.

Additionally, other work has also reported similarities in these variables when comparing small-sided games with matches [6, 13] and further work in the area may present valuable guidance for coaches who seek to tactically manipulate training practices with referenced values and contextual factors which are similar to those demonstrated during competition [11]. Overall, while empirical evidence highlighting the effects of contextual variables on the collective space organisations of soccer players is growing, the influence of many factors remains yet to be demonstrated in elite-level players [12, 14].

Contextual variables such as match half time [15], location [14] and level of the opposition [16] have been reported to significantly influence players' spatial organisation. Importantly, the majority of data highlighting these interactions have been collected in European countries, such as Spain and Portugal [8, 9, 13] while less research has been conducted in South America. Further, differences in style of play [17], environmental conditions [18] and in-game workloads [19] between these different regions may influence the spatial and tactical organisations of players during competitive match-play. Indeed, preliminary research conducted in South American soccer has demonstrated that significantly higher spread values (322.9 ± 0.8 to 387.8 ± 1.0 m) were associated with shots on goal during elite Brazilian championship matches [20]. In contrast, an additional study in the Brazilian state championship reported no significant interaction between playing time and GPS-recorded spatial organisations [15]. Importantly, a range of other variables which have previously been associated with match outcome, such as spread and distance from the last defender to the goal, have yet to be investigated. In conclusion, most of the work available assessing the tactical variables of South American players utilise video tracking systems, which is a generally time inefficient process, thereby limiting its practical applicability in a professional soccer setting [10, 20].

Overall, the lack of applied and specific studies in the area of team-sport spatial organisation means there is an apparent need to explore tactical variables, particularly by means of a time-efficient, user-friendly and logistically viable monitoring tool (such as GPS devices) which are readily accessible to practitioners working within professional Brazilian soccer. Furthermore, it is also necessary to understand how various contextual variables can influence players' behaviour during match-play, as this can provide coaches with valuable information with which to inform and guide representative training tasks, tactical decisions, and the manipulation of contextual constraints to elicit a desired training outcome. Therefore, the aim of the present study was to identify the influence of contextual variables on the spatial organisations of elite soccer players in Brazil. The authors hypothesised that match time, match location, opponent's level, final and momentary results would influence both collective and individual tactical variables.

Material and methods

Experimental overview

The present observational study analysed 17 matches during the elite Brazilian championship of the 2019 season. This competitive phase of this league runs from May to December each year. The league consists of 20 teams participating in both home and away matches, wherein each team plays a total of 38 matches.

Participants

Data were collected from 20 professional soccer players from the same team (age: 25.7 ± 4.4 years; height: 180.1 ± 6.1 cm; body mass: 75.4 ± 7.8 kg) who were actively participating in a professional team during the 1st Brazilian National League. All competitive championship matches in which the team was monitored using the same GPS device were considered for analysis. The team played 38 matches, nine matches were excluded because the team used a different GPS model, and 12 matches were excluded because they did not have access to the raw data. Goalkeepers and outfield players who started the match after 90 min were excluded.

Contextual variables

Five contextual variables were considered in this study: (i) Playing time: 1st half = 16 matches; 2nd half =

14 matches; (ii) Match location: Home = 8 matches; Away = 9 matches; (iii) ranking of the opposition as defined by the final championship score [19]: top six = 3 matches; eight medium = 7 matches; bottom six = 6 matches; (iv) match outcome: Win, *n* = 7 matches; Draw, *n* = 5 matches; Loss, *n* = 5 matches and (v) momentary score: winning minutes = 427; drawing minutes = 864; losing minutes = 149.

Procedures

Players' movements during match-play were tracked using 10-Hz GPS units (Viper pod, STATSports, Belfast, UK). The units were held in place using an appropriately sized vest specifically designed to reduce movement interference, which was positioned on the upper back between the scapulae. The units were activated 15-minutes before the pre-match warm up as per the manufacturer's guidelines, while each player used the same GPS device in each match to avoid any inter-unit variability. The validity and reliability of this GPS model have been previously demonstrated [21].

Following each match, the raw data files were exported from the STATSports software analysis platform in CSV format spreadsheets and uploaded to the Matlab software (The MathWorks Inc., Natick, USA). The geographic coordinates of latitude and longitude were converted into Cartesian coordinates on the axes (x, y) and smoothed by a third-order digital filter (cutoff frequency 0.3 Hz) prior to analysis. Seven linear tactical variables were selected and calculated (Table 1) based on previous studies [13, and these analyses were performed using a toolbox designed in Matlab.

Statistical analysis

The assumptions of normality and homogeneity of variances were tested using the Shapiro-Wilk and Levene test, respectively. Data were presented as mean and standard deviation. Paired samples *t*-tests were performed to compare the match times (1st vs. 2nd half) and location (home vs. away) for parametric data, while the Wilcoxon test was employed for non-parametric data (LpWratio, Length, Team Spread). One-way analysis of variance was used to compare the momentary score and the classification of the opposition, while the Bonferroni post-hoc test was used to observe the interactions when a significant difference was identified. Effect sizes (Cohen's *d*) were calculated for each pairwise comparison and classified as small (0.2), medium (0.5) or large (≥ 0.8) [22]. The statistical significance of the results was accepted at $p \leq 0.05$. All statistical analyses were performed using the Jasp Software (version 0.14.1 Netherlands).

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Ethics Committee of Universidade do Estado do Rio de Janeiro (approval No.: 3.712.816).

Informed consent

Informed consent was obtained from all individuals included in this study.

Table 1. Tactical variables assessed

Distance from last defender to goal (m)	The distance in metres in a straight line from the last defender closest to the defensive goal base line at each point in time (10 frames per second).
Width (m)	Considering the farthest players to the right and left, and the length.
Length (m)	The distance from the most advanced and deep players.
LpWratio (au)	The ration of the width and length of the team.
Spread (m^2)	The distance from each player to his teammate at each frame (10 frames per second) and the team's calculated average.
Space exploration index (m)	The average difference between the player's current position at each point in time and his average position.
Stretch index (m)	The average distance of each player to the centroid (calculated using the mean values of all field players' positions in each individual frame) of the team at each point in time.

Results

LpWratio values were demonstrated to be significantly lower during the 2nd half of the matches when compared with the 1st (t = 2.337; p = 0.03; d = 0.62, medium) while no other variables were observed to be significantly different between halves of play ($p > 0.05$) (Table 2). There were also no significant differences for any of the tactical variables according to the location of the match ($p > 0.05$) (Table 3).

Both the tactical length variable (p = 0.03, d = 1.58, large) and spread variable (p = 0.05; d = 1.60, large) were significantly higher for the team when playing a bottom six opposition team when compared with the medium eight opposition teams. The Stretch index variable values were also significantly higher when playing against the top six opposition when compared with the medium eight opposition (p = 0.03; d = 1.75, large) (Table 4).

When comparing match results, the stretch index was significantly larger during losses when compared with both draws (p = 0.01; d = 1.89, large) and wins (p = 0.05; d = 1.47; large), respectively (Table 5). Finally, the LpWratio values were significantly larger during momentary losing time periods when compared with winning (p = 0.01; d = 1.07, large) and drawing (p = 0.01; d = 1.12, large) time periods (Table 6).

Discussion

The aim of the present study was to analyse the influence of contextual variables on the spatial organisations of professional soccer players in a professional Brazilian Division 1 team. The number of contextual factors were demonstrated to significantly influence tactical behaviour in the current analysis (Tables 3–6). Taken together, these collective results reinforce the premise that the players' spatial organisations can be modulated by the context factors during match-play.

A key finding of this work was that larger LpWratio values (a variable which is indicative of player positioning that is greater in depth than in width) [14] were identified during the 2nd half of games when compared with the 1st half. This style of positioning is common in situations where the team is configured in direct attacking formations and during defensive phases, when it may be advantageous to become more compacted and protective [14, 15]. Moreover, when taking into account that physical and mental fatigue have been reported to lead to changes in the spatial organisations and tactical behaviour of soccer teams [23, 24], it is reasonable to hypothesise that mechanisms of fatigue may have contributed in part to the between-half changes. Nonetheless, with this premise in mind, it was somewhat surprising that there were no other between-half differences in the other tactical

Table 2. Values of tactical variables according to match time (mean ± *SD*)

	1° Half	2° Half
Distance from last defender to goal (m)	33.25 ± 5.7	34.60 ± 7.67
Width (m)	44.52 ± 1.7	45.57 ± 4.3
Length (m)	38.44 ± 2.71	41.48 ± 5.06
LpWratio (au)	0.89 ± 0.05	0.93 ± 0.06*
Spread (m²)	247.18 ± 10.32	251.21 ± 23.18
Space exploration index (m)	19.95 ± 2.30	21.30 ± 2.51
Stretch index (m)	16.07 ± 0.67	16.41 ± 1.73

* $p \leq 0.05$

Table 3. Values of tactical variables according to match location (mean ± *SD*)

	Home	Away
Distance from last defender to goal (m)	35.93 ± 3.24	31.45 ± 7.27
Width (m)	44.93 ± 2.64	45.37 ± 3.72
Length (m)	40.00 ± 1.68	40.45 ± 4.44
LpWratio (au)	0.92 ± 0.04	0.91 ± 0.05
Spread (m²)	248.55 ± 10.80	250.18 ± 19.65
Space exploration index (m)	21.18 ± 3.01	20.54 ± 1.52
Stretch index (m)	16.59 ± 1.93	19.15 ± 0.96

Table 4. Values of tactical variables according to opponent classification (mean ± *SD*)

	Top six	Eight medium	Bottom six
Distance from last defender to goal (m)	35.77 ± 3.44	36.11 ± 4.32	29.07 ± 7.06
Width (m)	44.94 ± 3.71	43.38 ± 2.11	47.40 ± 3.06
Length (m)	39.32 ± 1.91	38.31 ± 1.54	42.98 ± 4.02#
LpWratio (au)	0.90 ± 0.06	0.91 ± 0.03	0.93 ± 0.05
Spread (m^2)	250.78 ± 17.54	239.68 ± 8.19	260.23 ± 16.80#
Space exploration index (m)	21.84 ± 4.6	20.16 ± 1.09	21.10 ± 1.89
Stretch index (m)	17.84 ± 2.56*	15.47 ± 0.50	16.62 ± 0.82

* top six > eight medium; # bottom six > eight medium

Table 5. Values of tactical variables according to match outcome (mean ± *SD*)

	Win	Draw	Loss
Distance from last defender to goal (m)	36.67 ± 5.02	32.72 ± 2.47	28.56 ± 8.53
Width (m)	44.93 ± 3.32	44.02 ± 2.30	47.08 ± 3.84
Length (m)	40.02 ± 2.39	38.68 ± 2.13	42.62 ± 5.42
LpWratio (au)	0.91 ± 0.04	0.90 ± 0.04	0.94 ± 0.06
Spread (m^2)	261.88 ± 21.15	241 ± 17.90	248.17 ± 14.44
Space exploration index (m)	20.38 ± 2.24	20.92 ± 0.64	21.48 ± 3.63
Stretch index (m)	16.06 ± 0.82	15.46 ± 0.58	17.94 ± 1.88*#

* loss > draw; # loss > win

Table 6. Values of tactical variables according to momentary status (mean ± *SD*)

	Winning	Drawing	Losing
Distance from last defender to goal (m)	37.26 ± 9.31	33.43±4.79	30.92 ± 7.56
Width (m)	45.14 ± 3.94	43.66 ± 2.93	45.56 ± 5.45
Length (m)	38.93 ± 4.76	38.33 ± 2.96	43.00 ± 9.18
LpWratio (au)	0.89 ± 0.06	0.90 ± 0.05	1.04 ± 0.14*#
Spread (m^2)	244.50 ± 17.07	244.25 ± 17.03	254.98 ± 35.90
Space exploration index (m)	20.46 ± 3.31	20.81 ± 1.82	20.89 ± 4.50
Stretch index (m)	15.68 ± 1.06	15.89 ± 1.15	16.11 ± 2.09

* losing > winning; # losing > drawing

variables examined. Nonetheless, the strong technical-tactical ability [20] and well-developed physical conditioning levels [25] of the presently investigated elite level players may have allowed them to preserve most physical and tactical performance outcomes throughout the match. Subsequently, these players may have been sufficiently equipped to maintain the planned and prescribed tactical formation and model, thereby potentially contributing to the low levels of between-half alterations in tactical behaviour reported in the current analysis.

In contrast to prior work demonstrating the influence of match location on physical and technical variables in professional soccer players [26, 27], the current study exhibited no significant differences between home and away match locations for the measured outcomes. During home matches, players are generally reported to exhibit more aggressive spatial organisations when compared to away matches (e.g., more regularly creating scoring opportunities) [27]. This common finding may be underpinned by a range of possible factors, such as greater support from the home crowd, pitch familiarity and reduced travel times, which may collectively reduce the burden of mental fatigue (and the potential accompanying psychophysiological fatigue responses) associated with match-play [28]. Indeed, away matches have been demonstrated to increase the time it takes for players to recover [27, 29]. However, in the present study, no differences were identified between home and away matches, which contradicts these and other findings [14] in Brazilian youth players, which demonstrated that the space exploration index and

LpWratio were higher during home matches [14]. However, it is worth mentioning that this study was carried out during the Covid-19 pandemic, which made it impossible for the public to be present at the stadiums [14]. This is important to consider as home crowds have been demonstrated to influence both tactical and physical match performance outcomes during match play [30]. In addition to match location, investigating the influence of other factors, such as the level of opposition and match result, could yield valuable insights in understanding players' spatial organisations and how these can vary in different contexts.

The finding that the team displayed greater distance in length and greater spread against the bottom six opponents when compared to matches against the medium eight opponents may be associated with the greater ball possession often reported against lower ranked teams [31]. During periods when the team is in possession of the ball, players typically seek to play in greater width and length, which may consequently increase the level of spread [10] and may subsequently help to explain the current results. In contrast, the absence of a significant difference between greater distance in length and spread during matches played against the bottom six and top six opposition teams may further emphasise the complexity of players' spatial movements, their interaction with an array of evolving contextual variables and the influence of other possible cofounding factors (such as player-specific tactical roles, in-game demands and the team's positional set up against a certain opposition team) [19, 30]. Intriguingly, there is an apparent divergence within the literature outlining the physical demands of match-play in elite-level Brazilian football, where, for instance, one study indicates higher values against weaker opponents [26] whilst another demonstrates higher values against stronger opponents [32]. The present analysis identified that the stretch index was greater during matches played against the top six opponents when compared with matches against the medium eight opponents (Table 4). This finding may be partly explained by the ability of stronger teams (i.e., top six) to impose a larger magnitude and/or duration of attacking play on the opposition, thereby provoking the opposing players into defensive and possibly disorganised tactical formations as a means to cope [20].

Notably, during games when the team lost, the stretch index values were higher than during games ending in a draw. To the best of the authors' knowledge, information on the influence of the match outcome on spatial organisation remains scarce in soccer specifically and in other team sports, and it is consequently difficult to speculate as to the possible mechanisms which may underpin this finding. Nevertheless, a conceivable explanation for this result may be that when the team is losing the match, physical actions are often elevated, and this higher physical output may have coincided with an increase in the teams' stretch indexes [33]. Furthermore, the LpWratio variable similarly displayed higher values during periods when the team was losing, and it is also possible that this increase may correspond with the increased physical demands associated with losing [33]. Indeed, the higher LpWratio values may be representative of the teams' forward movements and aggressive style of play owing to the circumstantial necessity to score goals in an attempt to equalise the match.

This study has a number of limitations that readers should consider when interpreting its findings. Firstly, only one team was analysed in the present work, meaning caution should be exercised when generalising these results (particularly among teams of a different playing standard or sex), where factors such as the in-game physical or tactical-technical demands may be different. Secondly, possible cofounding factors such as differences in physical conditioning, time of season, player-specific tactical roles, weather conditions and pitch conditions were not accounted for and may have influenced the results. Nonetheless, the study was conducted across 17 different competitive matches and consequently presents relatively high ecological validity. In addition, the use of GPS devices makes it impossible to identify, and subsequently characterise and quantify, the distinctive phases and moments of the match. For example, it could provide valuable insight for coaches to analyse specific periods with and without possession of the ball. Therefore, future studies should also consider analysing other tactical variables using GPS data, which could further improve contemporary understanding within the domain. Lastly, owing to the influence of physiological attributes and environmental constraints (such as pitch altitude and/or heat/humidity levels) on the in-game workload parameters, future work exploring the interplay between these variables and technical-tactical outcomes could inform practitioners and researchers who seek to monitor players' match and training movements and prescribe training with specific tactical and physiological variables in mind.

These results support the use of GPS devices in professional soccer as a time-efficient method to identify and examine a team's spatiotemporal patterns, characterise tactical behaviour and highlight the influence of contextual factors on these variables. The inter-

actions highlighted may be utilised by coaches and sports scientists to adapt and tailor training methods and tactical tasks. They may also serve as benchmarks to identify desirable and sub-optimal spatial organisations that they may seek to encourage or avoid in training or match situations.

Conclusions

The level of tactical competence and organisation changes according to the context when playing soccer, particularly at elite levels. The findings from this study suggest that the spatial organisations of elite-level Brazilian soccer players are influenced by a range of contextual factors during competitive match-play. More specifically, the LpWratio is higher in the first half of the match and in periods when the team is losing. In addition, the stretch index is higher in matches that end in losses and against strong opposition, whereas against weak opposition, the team showed greater spread. In contrast, match location did not influence the collective and individual space organisations recorded during match-play.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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