Original Article (short paper)

Exploring the effects of deep-defending vs high-press on footballers' tactical behaviour, physical and physiological performance: A pilot study

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Abstract — Aims: The aim of this study was to explore the effects of a deep-defending vs high-press defending strategy on footballers' tactical behaviour, physical and physiological responses, when in numerical difference. **Methods**: Nineteen elite professional footballers (outfield players) participated in this study, playing an 11vs10 match (simulating an early dismissal) for two halves of 10 minutes on a full-sized regulation pitch. The 11-men team was instructed by the head coach to defend closer to goal in the first half (deep-defending) and then defend higher up the pitch in the second half (high-press). Players' positional data were used to calculate the distance between team centroids, players' distance to own and to opponent centroid, teams' effective playing space (EPS), teams' length per width ratio, distance covered and player velocity. Heart rate was measured via short-range radio telemetry. **Results**: Relative-phase analysis of teams' EPS showed 61.6% of anti-phase synchronisation pattern (i.e. the values change in opposite directions) in the deep-defending game. In the high-press game, teams' centroid distances were closer (% difference in means; ±90% CL, -21.0%; ±9.5%), while players' distances to own and opponent centroids were 20% more regular. Distance covered (-19.8%; ±2.5%), player velocity (-20.0%; ±2.5%) and heart rates also decreased in the high-press game. **Conclusion**: These findings suggest that, adopting a high-press defending strategy can elicit closer centroid distances, more regular movement patterns, decreased synchronisation patterns of EPS, lower distance covered, lower player velocity, and lower heart rates. Coaches may also consider adopting a high-press strategy, when in numerical superiority, to decrease players' physical and physiological demands.

Keywords: football, soccer, behavioural dynamics, player positioning, collective movement, interpersonal dynamics, self-organization processes

Introduction

Defending is an important aspect of successful football performance. However, currently available studies on defending only take a notational analysis approach[1,2,3,4]. From findings in current literature, majority of ball recoveries in elite football matches, take place in defensive and midfield areas of the pitch[3]; while better-ranked teams are more effective in applying defensive pressure in more advanced pitch positions[2]. Almeida, Ferreira, Volossovitch[2] also observed a tendency for home teams and losing teams to defend in more advanced pitch zones. One study examined the relationship of inter-team distances and match events, and alluded to closer inter-team distances in high defensive pressure or high attacking pressure[5]. Of the various defending strategies used in football, the authors observed two general styles of defending that teams collectively employ. One style of defending is characterised by a team collectively maintaining a compact shape in a zone nearer to their goal, and only applying pressure on their opponents when the attacking play begins to reach this zone[6]. This collective behaviour is often described as a strategy of deep-defending. Another style of defending is characterised by the defending team applying collective pressure on their opponents as high up the pitch as possible, and is often described as a high-press strategy of defending[6]. Although some studies have explored defensive pressure from a notational analysis perspective, no study has examined the tactical behaviour and activity profile variables associated with defending.

While football is an evenly matched sport, numerical imbalances often occur as a microcosm of the 11-a-side game. Yet, studies on numerical imbalance in football are few[7] and mostly performed under training environments[8,9,10,11,12]. In small-sided games, one study found no significant differences in time-motion characteristics and physiological responses[8], while another study found increased heart rates (HR) and lower distances to team centroid when in numerical inferiority (4vs5)[10]. Torres-Ronda, Gonçalves, Marcelino, Torrents, Vicente, Sampaio[9] found higher distances covered playing in low numerical imbalance (3vs4 or 4vs5) than large numerical imbalance (4vs7); possibly because games of the latter nature tend to display predictable patterns of behaviour[12]. However, research considering game-like situations with larger numbers of players involved is still relatively unpopular in literature. A closer inspection of players' tactical, physical and physiological demands under these performance contexts could provide us with relevant and novel information to optimise the training process. An example of using pitch-area restrictions in a 10vs9 setting showed that limiting players' spatial exploration greatly impaired the co-adaptation between teammates' positioning while decreasing the physical and physiological performances[11]. Also, a study examining players' time-motion characteristics in the event of an early dismissal (11vs10) found that players covered greater distances as a result[7]. Recent research in performance analysis has yielded several collective movement variables that enhance our understanding of tactical behaviour on the pitch[13,14,15,16,17]. The team centroid is one such variable that represents the central position of a team. In addition, the analysis of this variable is sometimes complemented with non-linear processing technique called approximate entropy (ApEn), where some studies have shown that well-trained players demonstrate more regularity in their distances to own and opponent centroids[12,18]. The effective playing space (EPS) is another variable used by researchers to measure the occupied space of a team's players at any instance of time[19,20,21,22]. In a study performed by Duarte, Araujo, Freire, Folgado, Fernandes, Davids[21], knowledge of a team's EPS was used to explain some football principles of play; for example, when teams increase their occupied space during attack and adopt a compact shape during defence. Also in relation to space, one study introduced the length per width (LPW) ratio as a measurement that relates a team's width and depth[13]. In that study using small-sided games (SSG), younger teams had a tendency for higher LPW ratios than older teams, who displayed more tactical maturity in utilising the width of the pitch. These studies highlight the effectiveness of such variables in capturing team dynamics.

Tactical performance in football can also be described by players' interpersonal space-time interactions in a game[23,24,25]. This is based on the theory of self-organising dynamical systems and uses methods such as relative phase analysis to quantify the space-time relation between two signals[26]. In football, these signals could be two players' relative position time-series[18,27]; or the EPS and LPW ratio signals of two teams. Varying patterns of synchronisation may range from in-phase (0°), e.g. when two players are moving in the same direction, to anti-phase (±180°), e.g. when two players are moving in opposite directions.

In summary, despite mainstream interest on defensive pressing in football, there are no available research exploring the effects of pressing where tactical behaviour and physical performance measures are analysed holistically based on a complex systems approach. Therefore, this study aimed to explore the effects of using a deep-defending vs high-press strategy in footballers' tactical behaviour, physical and physiological responses in an 11vs10 match.

Methods

Participants

Nineteen elite male professional footballers (age: 24.4±4.3 years; playing experience: 7.1±2.8 years) participated in this study. Additionally, two goalkeepers were used as part of the study, but excluded from the analysis. The participants agreed with the protocol description and were notified that they could withdraw from the study at any time. The investigation was approved by the local Institutional Research Ethics Committee and conformed to the recommendations of the Declaration of Helsinki (CEIC-1325).

Procedures

The participants played an 11vs10 match on an official pitch for two halves of ten minutes each. This duration was chosen to prevent the effects of fatigue in the study variables[28]. The 11vs10 game was chosen to simulate an early dismissal, and also amplify the effects of pressing. The team with eleven players was assigned as Team A, and played with a 4-4-2 formation that comprised four defenders, four midfielders and two forwards. The team with ten players was assigned as Team B, and played with a 4-4-1 formation (four defenders, four midfielders and one forward). The players' assignments were made by coaches' subjective evaluation using specific positions, tactical/technical levels, physical performance[29]. Team A was verbally instructed by the head coach to defend lower down the pitch in the first half (deep-defending), and defend high up the pitch in the second half (high-press). The players were familiar with all these practice situations; therefore, there was no need for familiarization procedures.

Data collection and processing

Positional data of the outfield players were collected using 5 Hz GPS units (SPI-Pro, GPSports, Canberra, ACT, Australia) placed in the upper back of each player. Each player's real position file consisted of 3000 data points (geodetic coordinates) per half Data were exported from the GPS units and computed using dedicated routines in Matlab® (MathWorks, Inc., Massachusetts, USA) according to data correction guidelines from previous studies[13].

Pitch-positioning derived-variables

The centroid of each team was calculated as the mean position of the Cartesian coordinates of the team's outfield players in each individual frame[13,18]. The distance between both teams' centroids (DC-C) and players' distances to own team (DC) and opponent team's centroid (DOP) were then calculated over the time series. Each team's EPS was defined as the polygonal area formed by players located at the geometrical periphery of play . It was calculated from the convex hull of the team's outfield players[14,20]. Teams' LPW ratio was calculated by taking the maximum length of the team (difference between the two players with the highest and lowest x-coordinate) divided by the maximum width of the team (difference between the two players with the highest and lowest y-coordinate) in each frame[13]. A heat map of each team's movement data was also plotted to visually represent each team's collective movement in different areas of the pitch.

Approximate entropy (ApEn) was used to determine the regularity of players' dynamic positional data. The ApEn algorithm is used in non-linear time series by measuring the logarithmic likelihood that runs from patterns that are close (within r) to m contiguous observations and remain close (with the same tolerance-wide r) on subsequent incremental comparisons[30,31]. The values used were 2.0 for vector length (m) and 0.2 standard deviations for tolerance (r)[32]. ApEn results are unit-less real numbers ranging from 0 to 2, with lower values representing more repeatable, regular and predictable sequence of data points[30].

Relative-phase analysis was performed to identify synchronisation patterns between teams' EPS signals and LPW ratio signals. The calculations were made using a Hilbert Transform[26] and the obtained values are expressed in angles. Values close to 0° represent near-perfect movement coordination (in-phase pattern) while values close to 180° represent asynchronous patterns of coordination (anti-phase pattern). The percentage of time spent in the -30° to 30° bin was made to represent near in-phase mode of synchronisation, while that spent in the -150°

to -180° bin and 150° to 180° bin represented near anti-phase mode of synchronisation[27]. Frequencies in all other bins were deemed as 'no pattern' of synchronisation.

2.5 Physical and physiological variables

The distance covered and average velocity variables of every player were taken from the GPS units, whose validity and reliability have been extensively studied[33]. Player velocity was found by taking the average of every player's velocity. The heart rate (HR) of each player was recorded continuously via short-range radio telemetry (Polar Electro, Oy, Kempele, Finland). HR intensity was assessed as a percentage of HR_{max}, and classified as the time spent in the 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 (> 90% HR_{max})[34]. Players' HR_{max} were determined from a Yo-Yo intermittent recovery level 2 test[35].

2.6 Statistical analysis

Descriptive data analyses were reported as means ± standard deviations. Comparisons of deep-defending vs high-press data were assessed via standardised mean differences, computed with pooled variance and 90% confidence intervals[36,37]. Thresholds for effect sizes were 0.2, trivial; 0.6, small; 1.2, moderate; 2.0, large; and >2.0, very large[37]. Smallest worthwhile differences were estimated from standardised units multiplied by 0.2. Uncertainty in true differences effects was assessed using non-clinical magnitude-based inferences. If the probabilities of an effect being substantially higher and lower were > 5%, the effect was reported as unclear; the effect was otherwise clear, and reported as the magnitude of the observed value. The following scale was used: 25-75%, possible; 75-95%, likely; 95-99%, very likely; > 99%, most likely[37].

Results

Table 1 and Figure 1 present, respectively, the descriptive and inferential outcomes for both deep-defending and high-press matches. The absolute distance between both teams' centroids was very likely higher when defending deep, 8.9 ± 2.3 m, than in high-press, 7.0 ± 1.4 m (difference in means %; ± 90% CL, -21.0%; ± 9.5%, Cohens' d; ± 90% CL, d = -0.72; ± 0.05). Unclear differences were found for ApEn values of distance between centroids. Players' distances to own and opponent centroids exhibited similar trends, where the deep-defending game presented slightly higher absolute values (possible trivial to DC and likely small to DOP). The ApEn values for these two variables presented a very likely/most likely ~ 20% decrease, with moderate effect, when it came to the high-press game. There was a most likely very large decrease in distance covered and player velocity during high-press (d = -2.08; ± 0.29 and d = -2.09; ± 0.29, respectively). Time spent in HR Zone 1 was very likely higher in the high-press game, while that in HR Zones 2 and 3 presented very/most likely decrease. Unclear values were identified in Zone 4.

Synchronisation values of both teams' EPS were in near-anti-phase for 61.6% of time, and near-in-phase for 15.2%, in the game defending deep. In high-press, EPS frequencies had no pattern 51.5% of the time; near-in-phase synchronisation 34.8% of the time; and near-anti-phase synchronisation 13.7% of the time. These results are shown in Figure 2. Synchronisation of both teams' LPW ratio was near-in-phase 54.5% of the time in game defending deep. Near-anti-phase synchronisation took place 9.1% of the time; and no pattern was found 36.4% of the time. These results were very similarly repeated in the high-press scenario, with near-in-phase synchronisation again achieved 54.5% of the time; near-anti-phase synchronisation 10.9% of the time; and no pattern was found 34.6% of the time. These are shown in Figure 2.

Results from the heat map showed that the game defending deep had a more even distribution of players' movement in all areas of the pitch whereas in the high-press match, majority of movement took place in the half of Team B. This is seen in Figure 3.

Table 1. Descriptive analysis for both deep-defending and high-press variables.

Variables	Deep-defending	High-press	Difference in means (%; ±90% CL)	Uncertainty in true differences
Distances between teams' centroids				
Metres	8.9±2.3	7.0±1.4	-21.0; ±9.5	Very likely ↓
ApEn	0.17±0.08	0.18±0.08	10.32; ±31.0	Unclear
Distances to own team centroid				
Metres	15.4±4.9	14.4±4.3	-5.8; ±7.5	Possibly ↓
ApEn	0.13±0.03	0.10±0.03	-20.4; ±9.1	Very likely ↓
Distances to opponent team centroid				
Metres	17.7±5.7	15.9±5.1	-9.9; ±6.2	Likely ↓
ApEn	0.14±0.03	0.11±0.03	-20.8; ±7.6	Most likely ↓
Distance and speed				
Distance covered (m)	1169.2±99.3	940.5±109.1	-19.8; ±2.5	Most likely ↓
Player velocity (km/h)	7.0±0.6	5.6±0.7	-20.0; ±2.5	Most likely ↓
Heart rate				
<75% HR_{max} (mins)	4.2±1.9	6.9±2.3	67.9; ±48.0	Very likely ↑
75-84.5% HR_{max} (mins)	4.3±1.5	2.2±1.4	-52.1; ±14.6	Most likely ↓
85-89.9% HR_{max} (mins)	1.2±1.2	0.4±0.6	-53.4; ±28.4	Very likely ↓
≥90% HR_{max} (mins)	0.4±0.5	0.2±0.4	-21.8; ±164.2	Unclear

Note: ↓ denotes decrease; ↑ denotes increase; CL = confidence limits; ApEn = approximate entropy.

Figure 1. Standardised Cohen's differences in tactical, physical and physiological variables according to deep-defending vs high-press. Error bars indicate uncertainty in true mean changes with 90% confidence intervals. ApEn=Approximate Entropy; t=trivial; s=small; mod=moderate; HR=heart rate.

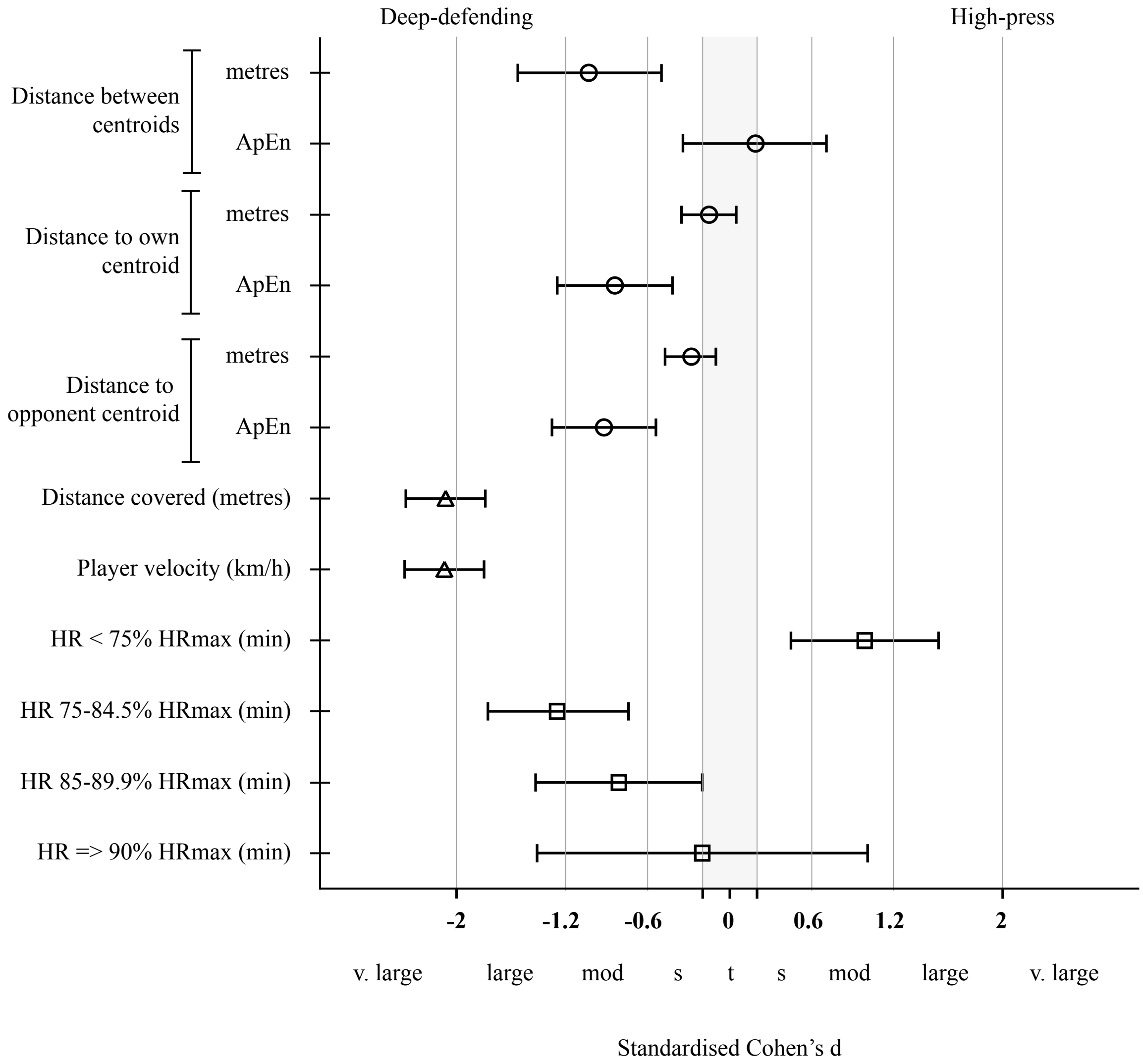


Figure 2. Relative phase of effective playing space (EPS) and length per width (LPW) ratio. Near in-phase represents the percentage of time spent in -30° to 30° bin. Near anti-phase represents the percentage of time spent in -150° to -180° bin and 150° to 180° bin. No pattern represents the percentage of time in all other bins.

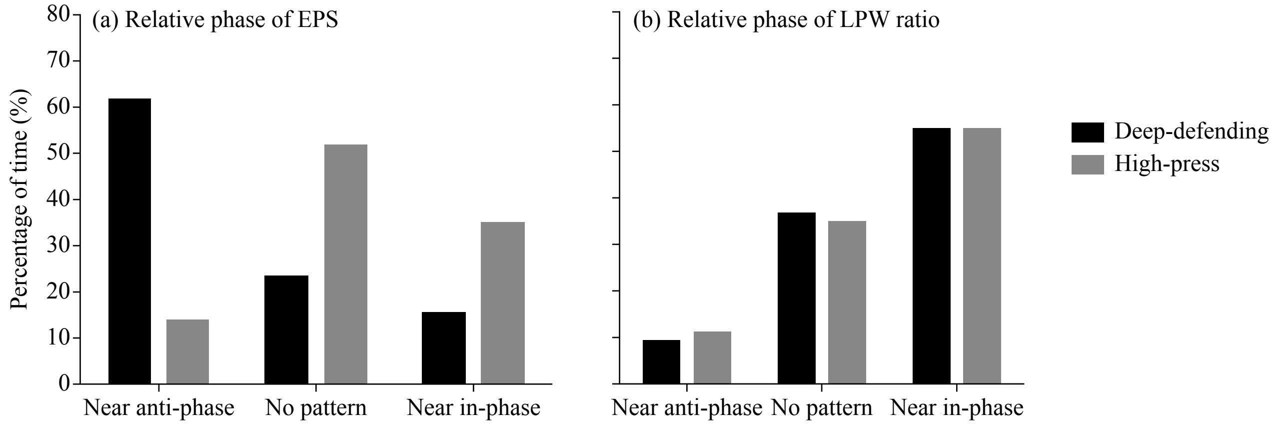
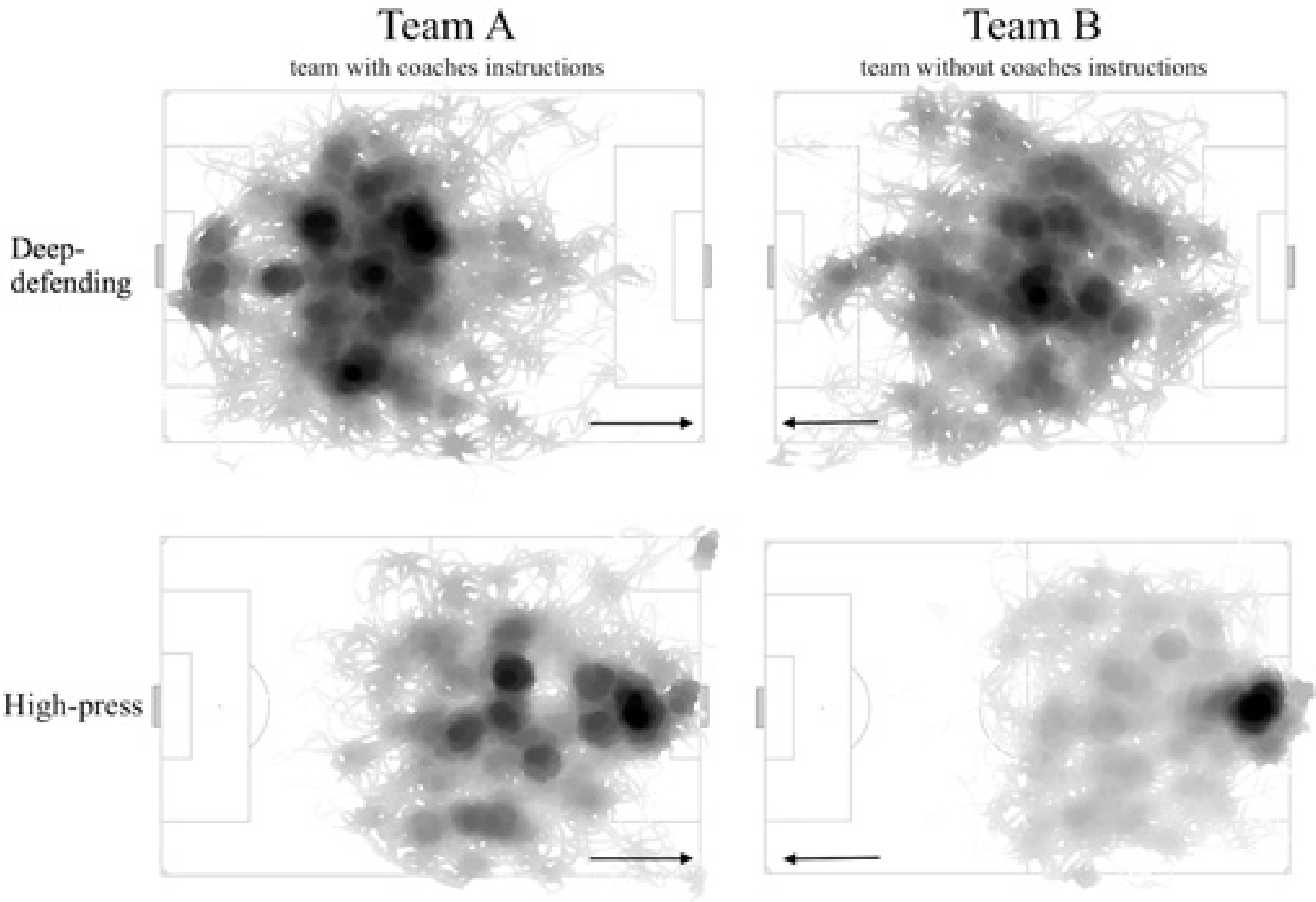


Figure 3. Heat maps of players' position data when playing in deep-defending and high-press matches. Darker colours represent more time spent in pitch areas. Arrows represent the team's direction of attack.



Discussion

This study aimed to explore differences in tactical behaviour, physical and physiological performance when a numerically superior team applied a deep-defending and high-press strategy of play. In general, the data processed allowed us to identify several differences in the deep-defending and high-press games, that can help inform coaches in their choice of defending strategy during matches.

Both teams played significantly closer to each other in the high-press game, which was an expected effect of the enforced task constraints. Since a high-press strategy requires the defending team to win the ball in advanced pitch positions, they inevitably become closer to their opponents. Conversely, a deep-defending strategy requires players to retreat closer to their own goal when possession is lost, resulting in further distances between the teams. This behaviour also explains the higher standard deviation of the distance between centroids; since retreating when losing the ball typically increases the distance between both teams' centroids, and absorbing pressure or attacking with penetration typically decreases that distance. These findings corroborate the studies by[5] who showed that short distances between teams' centroids indicate either high defensive pressure on the attacking team or high attacking pressure of the attacking team on the defending team. Findings from that study also concluded that changes in the standard deviation of inter-team centroid distance reflect an altered style of play, or altered match strategy – which supports the findings of this study, since the deep-defending and high-press games elicited differences in standard deviations of inter-team centroid distance.

While the effects of a high-press strategy on players' DC and DOP were small, the corresponding effects on ApEn values were higher. This represents an overall game pattern where players had more regular positioning, when a high-press defending strategy was applied. Observations from the heat maps suggest that this was characterised by the dominance of play taking place in Team B's half of the field.

The predominant anti-phase synchronisation of EPS patterns in the deep-defending game suggests transitions in ball possession. This is coherent with football principles of play[38,39]; the defending team adopts a compact defensive shape, while the team in possession spreads out to provide more attacking options.

The opposite happens when there is a turnover in possession. These simultaneous collective behaviours result in the observed anti-phase synchronisation. However, existing research that studied EPS behaviour[14,19,21] could not find this anti-synchronous pattern, though hypothesised, possibly because they were done in SSG, whereby the speed of play did not allow sufficient time for reciprocal changes in EPS to take place. In the high-press game, the large decrease in anti-phase synchronisation suggests that few transitions in ball possession took place. With fewer transitions, reciprocal changes in teams' EPS, and the anti-synchronous patterns that follow, are consequently fewer.

The synchronisation values of both teams' LPW ratio were similar to that found by Olthof, Frencken, Lemmink[40]. This suggests that there is a certain way elite teams change their length and width distances according to the interaction with the opponents. In this study, the normalised frequency of synchronisation in anti-phase, no pattern and in-phase, were remarkably similar for both deep-defending and high-press games. This means that both teams were mostly increasing and decreasing their LPW ratios together in the same direction. It may also indicate that the deep-defending and high-press strategy had no effect in the way teams adjust their length and width ratios. However, these interaction patterns of LPW synchronisation need further investigation to obtain more meaningful insights.

Players' physiological and physical demands were significantly lower in the high-press game. Observations from the heat map suggested that this was due to the numerically inferior team adopting a strategic focus on defending the area in front of goal; and consequently, the players in the numerically superior team would not need great efforts to overcome them. These illustrations, together with the decreased physiological activity and regular movement patterns, support the arguments from previous studies[8,9,10,12] that numerically imbalanced teams adopt predictable defensive patterns that avoid risk and reduce fatigue.

Further studies should explore if physical and physiological responses in numerical imbalance are linked to players' perceptions of task difficulty. Though speculative, it seems reasonable to suggest that higher physical and physiological responses tend to be found when the constraints were perceived to be surmountable by the numerically inferior team, e.g. 4vs3, 4vs5[9,10] and 11vs10[7], because players work hard to compensate for the one-player shortage. In this study, these demands of physical and physiological responses were observed in the deep-defending game, where distance covered, player velocity and time spent in HR zones 2 and 3 were significantly higher. Observations of players' movement data and EPS patterns suggest that this was because the deep-defending game allowed the numerically inferior team more ball possession, and possibly resulting in a perception that the numerical imbalance can be overcome. Conversely, constraints from numerical imbalances that were deemed to be insurmountable (e.g. 4vs7) may elicit lower physical and physiological responses[9] and more regular movement patterns[12], as the disadvantaged teams focus on an economy-of-effort strategy by defending the area closest to goal. In this study, these behaviours were found in the high-press game.

Nevertheless, further studies on this topic can extend the finding of this research by addressing several relevant questions. For example, by extending the duration of observed conditions to improve the understanding of tactical-related constraints on the longer-term behavioural dynamics of players. Also, it would be interesting to consider a cumulative treatment effect by conducting cross-over design procedures and numerically balanced matches.

Conclusion

This exploratory study found differences in tactical behaviour, physical and physiological performances of footballers when a numerically superior team used a strategy of deep-defending and high-press defending. In an 11vs10 game of numerical superiority, a high-press defending strategy elicited closer centroid distances, higher regularity of DC and DOP, decreased synchronisation patterns of EPS, lower distance covered, lower player velocity, and increased time spent in the lowest HR zone. In practical application, coaches may consider the benefits of a high-press defending strategy when in numerical superiority, due to the reduced physical and physiological demands, and more regular game pattern. Findings from this research provide indicative knowledge that enhance our understanding about the deep-defending and high-press strategies on footballers' collective behaviour and physical and physiological performance.

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