INFLUENCE OF SITUATIONAL VARIABLES, TEAM FORMATION AND PLAYING POSITION ON MATCH RUNNING PERFORMANCE AND SOCIAL NETWORK ANALYSIS OF BRAZILIAN PROFESSIONAL SOCCER PLAYERS

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ABSTRACT

The purpose of this study was to investigate the independent and interactive effects of situational variables, opposition team formation, and playing position on running performance and network analysis in Brazilian professional soccer players (n=22). Global Positioning System technology was used to determine total distance covered, mean speed, maximum running speed, and distance covered in six speed ranges. Social network analysis was used to assess interpersonal coordination (team interactions characterized as successful passes (n=3033) between teammates). Observations of match running performance (n=129), and network analysis (n=108) were obtained. The main results were: (i) no interactive effects between team formation and playing position were observed for running and network variables (*unclear* to *possibly*); (ii) matches played at home or against 'weaker' opponents presented greater running demands and individual/global metrics of network analysis (*likely* to *almost certain*); (iii) match outcome demonstrated influence only for running performance; matches in which the reference team won resulted in higher values than in lost matches; (iv) when the reference team competed in 1-4-4-2 formation, this resulted in greater running demands than 1-4-2-3-1 formation (*likely* to *almost certain*); (v) reduced values of running performance variables were reported in central defenders compared to other positions. Central/external midfielders reported greater closeness/betweenness centrality, out-degree and eigenvector compared to central/external defenders and forwards (*likely* to *almost certain*). The results from this study provide practical information to potentially impact on physical, tactical and technical training.

KEY WORDS: association football; time-motion analysis; interpersonal coordination; sports sciences.

INTRODUCTION

Team sports performance is dependent upon the cooperative and competitive interactions between performers, and there is a need to determine the individual and collective contributions to achieve high standard performance (38). The complexity of these interactions emerging between players has been analyzed using novel investigative methods such as dynamical systems (14, 41). Indeed, contemporary empirical research recommends social network analyses to verify interpersonal coordination/interactions between soccer players; notably using completed passes between teammates (12, 20). While this approach provides novel insights into the complexity of cooperative relationships, previous research has not analyzed the influence of different contextual variables that can affect playing performance on individual and global metrics emerging from network analysis (33).

In contrast, an extensive body of literature investigating a myriad of contextual variables that affect match running performance is currently available (11). It is suggested that these contextual factors might play a substantial role in the data collection, analysis, and interpretation of performance variables (43), e.g. metrics of network analysis and running outputs. The situational variables (e.g. competition stage, match location, quality of opposition, and match status (score-line during the match) or match outcome (final result of a match)) have been identified as impacting on team sports performance (18). Soccer is dominated by strategic/tactical factors; therefore, it is reasonable to suggest that situational variables influence team and player performance (1, 26, 27, 29). For example, when a team is winning, it possible that its players adopt a ball retention strategy, slowing down the match resulting in lower physical demands (6, 30). Additional key contextual factors identified include team formation (8, 10), and playing position (3, 5, 9). However, these factors have not been simultaneously analyzed in the same study. In one of the aforementioned studies, Carling (10) examined the effects of opposition team formation and playing position on running and skill-related

performance in a French League 1 club. The author did not observe interaction effects between these variables and recommended additional research. Indeed, a combined analysis of contextual effects on running performance and network analysis can provide more rounded information to improve understanding of the demands of match-play.

Therefore, the aim of this study was to examine the independent and interactive effects of situational variables (i.e. competition stage, match location, quality of opposition, match outcome), opposition team formation, and playing position on running performance and network analysis in Brazilian professional soccer players during official match-play.

METHODS

Experimental Approach to the Problem

An observational design was considered to examine the influence of independent variables on running performance and network analysis in a single reference Brazilian professional soccer team. A total of 18 matches played in the 3rd Brazilian Division in 2017 were included (May 13 to September 09; 6th place in the end-league ranking). The matches were performed in official stadiums (FIFA recommendations: natural grass, ~105 m x 68m), between 3:00 to 9:00 pm. A range of independent variables were analyzed jointly: situational (i.e. competition stage, match location, quality of opposition, match outcome), opposition team formation, and playing position. Match running performance was assessed using Global Positioning System (GPS) units, and network analysis by a performance analyst.

Participants and match analysis data

Match running performance (129 observations) and network analysis data (108 observations) were obtained from 22 players [mean (standard deviation)]: age 27.9 (3.9) yrs; height 180.1 (5.2) cm; body mass 79.3 (8.6) kg). Inclusion required participation in ≥ 90 min play. GPS Sports® devices

(QSTARZ; 1 Hz; Taipei, Taiwan) and a digital video camera (CASIO EX-FH25; 30 Hz; 720 x 480 pixel) were used for data collection. While a previous study reported good reliability for similar GPS technology (3), a complementary control-quality assessment was conducted. The players wearing the GPS device covered a known distance (calculated by tape measure) at different intensities (Low-intensity Running [LIR]: 11.01-14 km·h^{-1}; Moderate-intensity Running [MIR]: 14.01-19 km·h^{-1}; High-intensity Running [HIR]: 19.01-23 km·h^{-1}; Sprinting [SPR]: ≥ 23.01 km·h^{-1}). The error rate was < 5% for all running categories. The players used the same unit throughout the season (24). Local University ethical approval was obtained and the participants signed a consent form (School of Physical Education and Sport, Ribeirão Preto, Brazil; protocol number: 61884716.9.0000.5659).

Dependent Variables

Match Running Performance: After the matches, the 2D reconstruction of the geographic coordinates (latitude and longitude) of each player at each time point were exported to a CSV format file through QSports software (Taipei, Taiwan) for analysis in Matlab environment (The MathWorks Inc Natick, USA). Using specific routines, the geographic coordinates were converted to cartesian coordinates (xy) and were smoothed by a Butterworth digital filter (third order; cutoff frequency = 0.4 Hz) to calculate total distance covered (TD), mean speed, maximum running speed (MRS), and distances travelled in six speed ranges (4): jogging = 4.91-11 km·h^{-1}; LIR = 11.01-14 km·h^{-1}; MIR = 14.01-19 km·h^{-1}; HIR = 19.01-23 km·h^{-1}; SPR ≥ 23.01 km·h^{-1}; High-intensity Activities (HIA) = HIR + SPR; Number of sprints = efforts ≥ 23.01 km·h^{-1}.

Network Analysis: Interpersonal coordination was assessed through network analysis (38). Completed passes between teammates can be considered the most consequential form of interaction in soccer matches, and can be used to verify the 'orchestration' of group production (20). Here, a total of 3033 passes were subsequently analyzed. Individual metrics evaluated included (7, 17, 21, 38): in-degree, i.e. the number of passes that the player receives effectively; out-degree, i.e. the number of passes

that the player performs effectively; closeness centrality represents how close the player is to other teammates players, where players with low closeness score have little proximity to others; betweenness centrality indicates the amount of network that a particular player "controls", and; eigenvector identifies potential key-players who play a crucial role in organizing the offensive phases. Density and clustering coefficients were assessed as global (i.e. collective) metrics. Density describes the overall level of cooperation/coordination shown by teammates (15), i.e., higher values identify a better homogeneity of interactions between players of the same team; this may be related to team success (20). Clustering coefficients provide coaches with knowledge about subgroups of players who coordinate their actions through passes more frequently (i.e. high values of this metric represents team capacity to form functional clusters (32). Both individual and global metrics were calculated using the software Gephi (version 0.9.1). Figure 1 describes a representation of cooperative and competitive interaction between performers.

<<<Insert Figure 1 near here>>>

Independent Variables

For data analysis, four independent variables were considered: (i) Situational variables were identified as competition stage (matches 1-9 [1st stage: n=61] vs. matches 10-18 [2nd stage: n=68]), match location (home [n=65] vs. away [n=64]), quality of opposition (strong [n=91] vs. weak [n=38]) and match outcome (final result of the matches; lost [n=35] vs. draw [n=54] vs. won [n=40]). The quality of opposition was calculated according to k-means cluster analysis based on end-league ranking (2, 30); reference team: 6th place. Two clusters were identified, "higher-ranking" (strong opposition [1-7 teams ranking]) and "lower-ranking" (weak opposition [8-10 teams ranking]). (ii) Opposition team formation (1-4-4-2 vs. 1-4-4-2/1-4-2-3-1 [n=66], 1-4-1-4-1 vs. 1-4-4-2/1-4-2-3-1 [n=63]) was determined by a Brazilian Soccer Confederation qualified coach for each match (3). (iii) Playing

position for each player was also defined by the same coach (central defenders [n=26] vs. external defenders [n=31] vs. central midfielders [n=26] vs. external midfielders [n=22] vs. forwards [n=24]).

Statistical Analysis

Data are presented as mean values (standard deviation). The normality and homogeneity of variance were checked by Shapiro-Wilk and Levene tests, respectively. Comparisons between competition stages, match location, quality of opposition, and opposition team formation were performed using t-test for independent samples. Match outcome and playing position were compared by a univariate general linear model for independent samples. Threshold values of partial eta-squared (η^2) were > 0.01 (small), > 0.06 (moderate), > 0.15 (large) (13). Interactions effects were also verified. When necessary, non-parametric counterpart tests and Bonferroni post-hoc tests were employed. Forward stepwise discriminant function analysis was employed to identify the smallest set of variables that maximized differences between the groups, using only variables that were statistically significant, and calculating the unique contribution of each variable to the discriminant function (40). The p-value threshold was pre-fixed at 5% ($p < 0.05$). Analyses were performed using the software IBM SPSS Statistics for Windows, version 22.0 (Armonk, NY: IBM Corporation®). In addition, a magnitude-based inferential (MBI) statistical approach was used (22, 42) (confidence level = 90%). Raw data outcomes in standardized Cohen units were used (Effect Size [ES]). Quantitative chances of higher or lower differences were assessed qualitatively as follows (22): <1%, almost certainly not; 1 − 5%, very unlikely; 5 − 25%, unlikely; 25 − 75%, possibly; 75 − 95%, likely; 95 − 99%, very likely; >99%, almost certain. If the chance of higher or lower differences was >5%, the true difference was assumed as unclear. Otherwise, the effect was deemed clear (22). Regarding the greater impact of the present results in the field, only likely chances that the differences were true (>75%) were considered (25).

RESULTS

Match Running Performance

Table 1 shows the independent effects of match situational variables on running performance. The 1st and 2nd competition stage did not differ for all variables (t_{127} = -1.393 to 1.735; p = 0.08 to 0.91; ES = 0.01 to 0.28 [*unclear* to *possibly*]). Home matches presented higher values for TD, mean speed, jogging, LIR, and HIR compared to away matches (t_{127} = -2.329 to 2.934; p = 0.004 to 0.04; ES = 0.35 to 0.51 [*likely* to *very likely*]), with exception for MRS. In matches against weak opponents, the reference team showed greater running demands (TD, mean speed, LIR, MIR, and HIR) than against strong opposition (t_{127} = -1.993 to -2.464; p = 0.01 to 0.04; ES = 0.57 to 0.72 [*likely* to *very likely*]). In summary, when the reference team won, greater values were reported for TD, mean speed, jogging, LIR, MIR, and HIR in comparisons to matches it lost ($F_{2,126}$ = 3.245 to 6.992; p = 0.001 to 0.04; η^2 = 0.04 to 0.10; ES = 0.52 to 0.82 [*likely* to *very likely*]). Interaction effects of match location*quality of opposition*match outcome on match running performance were not significant ($F_{1,121}$ = 0.033 to 2.751; p = 0.10 to 0.67; η^2 = 0.001 to 0.02 [small]).

<<<Insert Table 1 near here>>>

Interaction effects of both opposition team formation and playing position were not significant ($F_{12,109}$ = 0.646 to 1.350; p = 0.20 to 0.80; η^2 = 0.06 to 0.12 [moderate]). However, when the reference team competed in a 1-4-4-2 formation, greater running demands (i.e. TD, mean speed, jogging, LIR, MIR, HIR) were observed against a 1-4-4-2 compared to 1-4-2-3-1 formation (p < 0.01; ES = 0.61 to 1.00 [*very likely* to *almost certain*]) (Table 2). In contrast, no difference was reported for the reference team competing in 1-4-1-4-1 against 1-4-4-2 and 1-4-2-3-1 formation (p ≥ 0.05; ES = 0.01 to 0.13 [*unclear*]) (Supplemental file 1).

<<<Insert Table 2 near here>>>

Independent analysis of playing position showed reduced values for central defenders compared to other positions in all running performance variables ($p < 0.05$; ES = 0.74 to 5.18 [*likely* to *almost certain*]), with the exception being MRS. External defenders and midfielders run more in HIR, sprinting, and HIA than central midfielders ($p < 0.01$; ES = 0.82 to 1.25 [*very likely* to *almost certain*]). Central midfielders covered greater distances jogging than external defenders ($p = 0.03$; ES = 0.67 [*very likely*]), and forwards ($p = 0.02$; ES = 0.83 [*very likely*]). External midfielders showed higher values of LIR and MIR compared to central midfielders ($p = 0.01$; ES = 0.84 [*almost certain*]), and forwards ($p = 0.007$, ES = 0.74 [*very likely*]; and $p = 0.005$, ES = 0.80 [*very likely*] – respectively). Forwards covered greater distances in HIA than central midfielders ($p = 0.02$; ES = 1.18 [*almost certain*]). Finally, external defenders performed a greater number of sprints than other positions ($p < 0.01$; ES = 0.66 to 1.50 [*very likely* to *almost certain*]) (Table 3).

<<<Insert Table 3 near here>>>

The stepwise discriminant function showed the results for the smallest set of variables that best discriminated between each playing position. In the first discriminant function (eigenvalue = 0.94; Wilks' lambda = 0.32; canonical correlation = 0.67; chi-squared = 142.267; $p < 0.001$), the order of variables was: HIR, LIR, jogging, and number of sprints. The other independent variables that showed a significant difference for match running performance (i.e., match location, quality of oppositions, match outcome, and opposition team formation) demonstrated greater values of Wilks' Lambda (0.89 to 0.95), and reduced values for canonical correlation (0.21 to 0.33) meaning low importance to predict the separation between the aforementioned independent variables, and reduced effect size, respectively.

Network Analysis

Individual and global metrics were not significant in the comparisons between 1st vs. 2nd competition stage (U = 1,113.500 to 1,633.000 to p = 0.06 to 0.98; ES = 0.07 to 0.22 [*unclear* to *possibly*]). In home matches, the reference team reported greater in-degree, out-degree, and clustering compared to away games (U = 1,058.500 to 1,125.500; p = 0.02 to 0.04; ES = 0.32 to 0.42 [*likely*]). Matches played against weak opposition demonstrated higher values of individual (in-degree, out-degree, closeness centrality, clustering) and global metrics (density, clustering coefficients) than against strong opposition (U = 1,528.000 to 1,821.000; p < 0.001 to p = 0.04; ES 0.49 to 1.18 [*likely* to *almost certain*]). According to match outcome, no significant differences were reported for individual and global metrics (H_2 = 0.151 to 3.056; p = 0.22 to 0.92; ES = 0.02 to 0.30 [*unclear* to *possibly*]) (Table 4). Comparisons of individual and global metrics between matches played in 1-4-4-2 vs. 1-4-2-3-1/1-4-4-2 and 1-4-1-4-1 vs. 1-4-2-3-1/1-4-4-2 team formation showed none were significantly different (H_3 = 0.443 to 3.739; p = 0.30 to 0.93; ES = 0.01 to 0.52 [*unclear* to *possibly*]) (Supplemental file 2 and 3, respectively).

<<<Insert Table 4 near here>>>

Playing position confirmed significant differences for individual metrics. External defenders showed higher in-degree and eigenvector than central defenders (p = 0.01, ES = 0.43 [*likely*], p = 0.001, ES = 0.56 [*likely*]; respectively), but reduced out-degree and eigenvector compared to external midfielders (p = 0.03, ES = 0.76 [*almost certain*]; p = 0.001, ES = 1.04 [*almost certain*]; respectively). Central defenders and central midfielders reported greater values of out-degree, closeness, and betweenness centrality compared to forwards (p < 0.001 to p = 0.03; ES = 0.64 to 1.83 [*likely* to *almost certain*]). External midfielders showed greater values for all individual metrics compared to forwards (p < 0.001 to p = 0.02, ES = 0.46 to 1.61 [*likely* to *almost certain*]), with exception for clustering. In addition, central midfielders reported greater closeness centrality compared to external

defenders (p = 0.003; ES = 0.57 [*likely*]) (Table 5). No interactive effects were observed for all independent variables in the network analysis.

<<<Insert Table 5 near here>>>

DISCUSSION

This study investigated the influence of independent variables on running performance and network analysis in a reference Brazilian professional soccer team during official match-play. The results highlighted that: (i) interactive effects were not significant for either of the indicators of performance (running output and network analysis), and no differences were observed for comparisons between 1st vs. 2nd competition stage; (ii) matches played at home or against weak opposition presented greater running demands and individual/global metrics of network analysis compared to their counterparts; (iii) match outcome demonstrated influence only for running performance with the team reporting higher values in matches won versus lost; (iv) when the team competed in a 1-4-4-2 formation, greater running demands were observed against a 1-4-4-2 compared to 1-4-2-3-1 formation; (v) reduced values for running performance variables were reported in central defenders compared to peers in the other positions. Central/external midfielders reported greater closeness/betweenness centrality, out-degree, and eigenvector compared to central/external defenders and forwards.

In this study, greater running outputs (e.g. TD, mean speed, HIR) were reported in home compared to away matches. In addition, the number of passes that players received and successfully completed was higher (i.e. in- and out-degree metrics) in home matches. The reference team obtained 80% of the points disputed in home matches (i.e. noticeable home advantage). This finding confirms the results of a meta-analysis showing that home advantage in soccer (23). Several factors associated with home advantage have been discussed (34-36): local crowd support, travel fatigue for opposition, familiarity with local conditions, referee bias to home team, territoriality, and psychological factors.

In relation to the quality of opposition, greater intensity running and interpersonal coordination were observed in matches against weak opposition. These findings suggest that against weaker opposition the reference team presented a better homogeneity of interactions between players and team capacity to play more collectively. These results concur with the findings reported by Lago (29) and Lago-Peñas and Dellal (27) which reported that top-ranked teams tend to control matches, since greater in- and out-degree were observed against weak opposition. Furthermore, the higher values of closeness centrality (i.e. how close the player is to others) observed in the present study explain the greater intensity running (large correlations between closeness centrality and HIR [results not shown]). These findings contrast with those reported in previous research which has shown greater running demands against strong opposition (1, 37). In other countries the team quality also influences match performance variables. For example, in the Chinese super league (44) the top-ranked group of teams presented greater physical (sprinting distance, total distance covered without ball possession) and technical performance (possession in opponents' half, number of entry passes in the final 1/3 of the field and the penalty area) compared to middle/lower-ranked groups.

In this study, the match outcome only seemed to influence running performance. Greater intensity running distances were observed in matches that the team won as opposed to losing. This result can be related to different styles of play during the matches. Previous research demonstrated four styles (see more details in (28)): possession, set pieces attack, counterattacking, and transitional. The coaching staff of the reference team provided information on the strategies adopted according to score-line. When winning matches for example, the team adopted a counterattacking style, i.e. a direct style of play (long and fast passes; see Lago (29)), and this can induce higher match intensity running (1). On the other hand, when losing the matches, used possession style of play with the purpose to "control" the match. Therefore, in this study, winning teams' exhibit different and consistent profiles compared to losing teams (19). In particular, these findings indicate that physical demands vary according to the style of play adopted in different moments of the match. In addition, the present

study verified the influence of opposition team formation on match running performance. When the reference team competed in a 1–4–4–2, greater running performance (i.e. mean speed, HIR) was observed against a 1-4-4-2 compared to a 1-4-2-3-1 formation. Carling (10) also demonstrated that players in possession competing in a 1–4–3–3/1–4–5–1 covered greater distances in matches in 1–4–4–2 compared to a 1–4–2–3–1 formation in French League 1. The same study (10) also identified variations on skill-related performance according to opposition formation whereas here, network analysis did not show a significant difference. These results may be useful to aid coaches and practitioners in their tactical preparation (10).

The analysis of playing position on running and skill-related performance has received extensive coverage (9, 16, 39). In Brazilian soccer however, a few studies have addressed this topic but only for match running performance (3, 5, 31). To the best knowledge of the present authors, the current study is the first to provide a detailed investigation of running and network analysis of professional soccer players in all playing positions. This study identified that distance covered in HIR is the best variable for discriminating running outputs across playing positions. According to the network analysis, in general, central/external midfielders reported greater closeness/betweenness centrality, out-degree, and eigenvector compared to central/external defenders and forwards, i.e. midfielders are more effective in performing passes, they are closer to the other players in the field, "control" as many networks, and are key players for the organization of offensive phases. Therefore, it seems relevant that coaching staff adopt a position-specific approach during training.

This study presented some limitations; therefore, the results should be interpreted with caution. First, a relatively small number of matches were analyzed, with a limited sample for analysis of interactive effects between independent vs. dependent variables. However, this low number was due to the combined analysis of running performance and interpersonal coordination in the same matches. Here, we reported the main team formation used by the reference/opposition teams. Future research should

analyze the effects of team formation according to different phases of play (in possession, out of possession), and transitions. Finally, the unbalanced number of home and away matches is a further limitation. On the other hand, this study has strengths, namely: (i) the use of a more holistic analysis, i.e. running performance and interpersonal coordination (network analysis); and (ii) inclusion of the main recognized independent variables that affect the performance of soccer players.

PRACTICAL APPLICATION

The current findings are novel and provide pertinent information on physical and technical-tactical requirements which can inform training. The results show mainly the independent influence of situational variables, opposition team formation, and playing position on running performance and network analysis in Brazilian soccer players during official matches. Home matches or against weak opposition place greater physical, technical, and tactical demands on players. Therefore, coaches and practitioners account for this when prescribing training intensity in close proximity to home matches. In matches won by the reference team, the players presented greater values for TD, mean speed, LIR, MIR, and HIR than matches that were lost. This information can aid coaches to adapt post-match recovery strategies and the intensity of subsequent training sessions. Players should be physically prepared for competing in the 1-4-4-2 versus the opposition in the 1-4-4-2 formation. Finally, specific running and technical-tactical demands were observed for the five playing positions studied; thus, position-specific approach should be adopted in training.

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Legend:

Figure 1. Graphical representation of cooperative and competitive interactions between soccer players. The team is displayed in 1-4-4-2 team formation. Grey arrows indicate the pass direction. The origin of the arrow indicates the player who passed the ball and the arrowhead indicates the player who received the ball. The width and color of each arrow represents the quantity of passes completed between players during the matches (thicker arrows represent a greater quantity of passes between players (38)). Gk = Goalkeeper; CD = Central Defenders; ED = External Defenders; CM = Central Midfielders; EM = External Midfielders; F = Forwards.

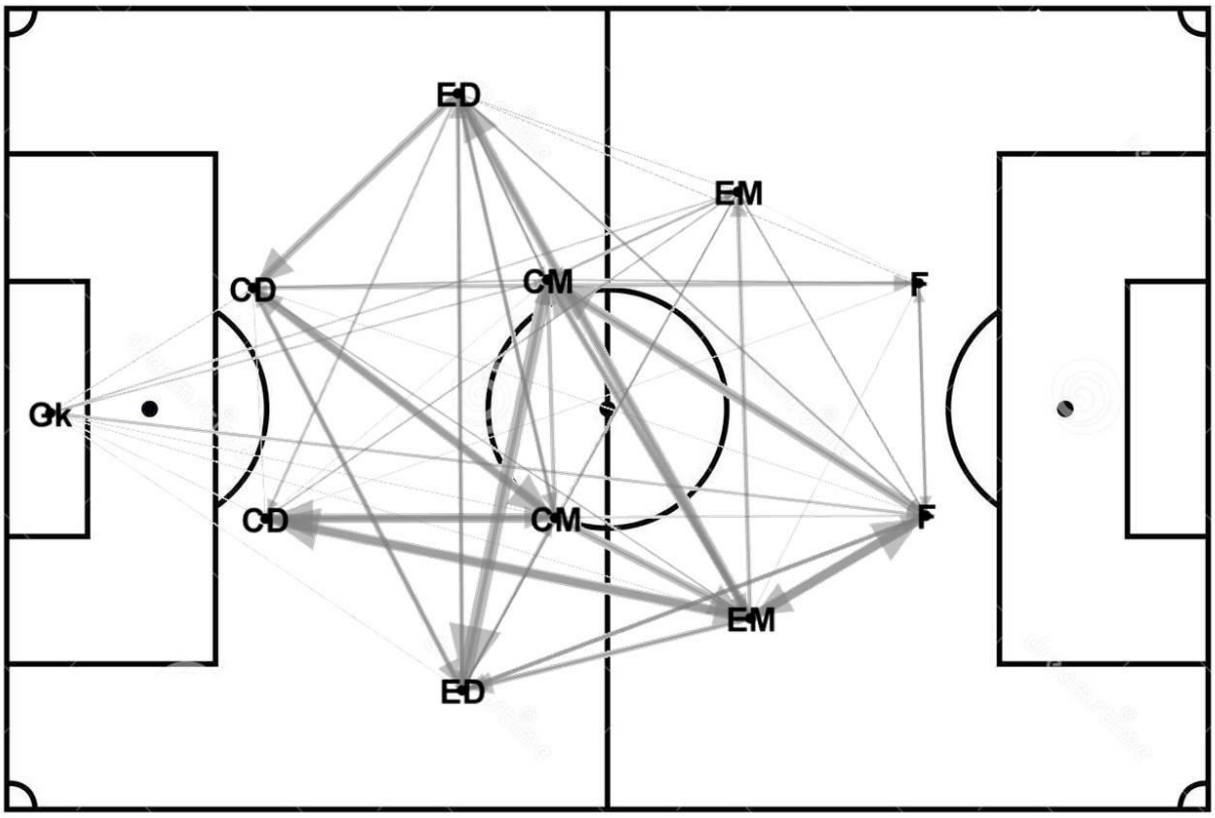

Table 1. Effects of match situational variables on match running performance in Brazilian professional soccer players [mean (standard deviation)].

Variables	Competition Stage		Match Location		Quality of Oppositions		Match Outcome		
	1st Stage	2nd Stage	Away	Home	Strong	Weak	Lost	Draw	Won
TD (m)	8739.4 (1466.4)	9105.5 (1511.7)	8632.3 (1483.0)	9227.8 (1460.1)^{*,a}	8762.1 (1437.9)	9340.1 (1571.8)^{*,c}	8384.3 (1682.5)	9019.0 (1310.7)^{*,d}	9295.0 (1458.5)^{**,e}
Mean Speed (km·h^{-1})	5.6 (0.9)	5.7 (0.9)	5.4 (0.9)	5.9 (0.9)^{**,a}	5.6 (0.8)	5.9 (1.0)^{*,c}	5.28 (0.92)	5.64 (0.81)^{*,d}	6.01 (0.82)^{**,e,f}
MRS (km·h^{-1})	31.3 (3.1)	30.4 (2.9)	31.5 (3.0)	30.2 (3.0)^{*,b}	31.1 (3.1)	30.3 (3.0)	31.4 (2.7)	31.2 (3.3)	29.9 (2.9)
Jogging (m)	3463.9 (692.5)	3498.0 (696.7)	3343.1 (564.9)	3618.4 (705.6)^{*,a}	3446.5 (712.8)	3566.6 (641.3)	3156.2 (684.1)	3561.5 (670.6)	3659.2 (645.9)^{**,e}
LIR (m)	1253.2 (428.5)	1343.0 (471.9)	1217.4 (427.6)	1382.4 (464.4)^{*,a}	1238.3 (423.2)	1449.5 (490.0)^{**,c}	1156.5 (468.4)	1306.5 (410.4)	1418.4 (467.8)^{**,e}
MIR (m)	1120.3 (429.9)	1213.3 (535.3)	1090.1 (481.5)	1247.4 (486.8)	1102.3 (435.5)	1329.8 (572.2)^{**,c}	1049.5 (535.4)	1151.8 (436.3)	1297.8 (495.0)^{*,e}
HIR (m)	341.6 (193.0)	369.4 (214.2)	316.3 (180.4)	395.6 (219.4)^{*,a}	332.5 (191.5)	413.1 (224.1)^{*,c}	301.8 (185.5)	350.7 (189.0)	411.4 (228.9)^{*,e}
SPR (m)	232.3 (151.0)	225.4 (164.4)	222.1 (148.8)	235.1 (166.8)	219.7 (154.9)	250.1 (164.0)	211.0 (129.6)	231.1 (161.5)	240.8 (176.1)
HIA (m)	573.9 (320.0)	594.8 (353.4)	538.4 (301.0)	630.6 (365.4)	552.2 (323.9)	663.3 (358.4)	512.8 (281.8)	581.8 (239.1)	652.1 (382.9)
NS (a.u.)	28.0 (21.6)	28.8 (22.9)	26.7 (20.7)	30.2 (23.6)	26.4 (22.0)	33.4 (22.2)	25.9 (17.9)	27.1 (23.0)	32.5 (24.3)

Note: TD = Total Distance covered. MRS = Maximal Running Speed. LIR = Low-intensity Running (11.01-14 km·h^{-1}). MIR = Moderate-intensity Running (14.01-19 km·h^{-1}). HIR = High-intensity Running (19.01-23 km·h^{-1}). SPR = Sprinting (≥ 23.01 km·h^{-1}). HIA = High-intensity Activities (HIR + SPR). NS = Number of Sprints [a.u. (arbitrary units)], characterized by frequencies of efforts ≥ 23.01 km·h^{-1}. * p-value < 0.05. ** p-value < 0.01. [a] Home > Away. [b] Home < Away. [c] Weak > Strong. [d] Draw > Lost. [e] Won > Lost. [f] Won > Draw.

Table 2. Effects of opposition team formation (1-4-4-2 vs. 1-4-2-3-1 or 1-4-4-2) according to playing position on match running performance in Brazilian professional soccer players [mean (standard deviation)].

Position	Opposition Team Formation	TD (m)	Mean Speed (km·h^{-1})	MRS (km·h^{-1})	Jogging (m)	LIR (m)	MIR (m)	HIR (m)	SPR (m)	HIA (m)	NS (a.u.)
	1-4-4-2 vs.										
CD	1-4-2-3-1	7517.7 (817.8)	4.6 (0.5)	29.9 (3.1)	2871.8 (572.8)	805.9 (275.1)	609.1 (164.8)	154.9 (51.4)	163.3 (173.7)	318.2 (207.2)	13.6 (12.3)
CD	1-4-4-2	8017.8 (515.2)	4.8 (0.5)	28.4 (1.7)	3075.2 (619)	843.7 (264.8)	722.2 (214.2)	149.0 (72.0)	80.4 (39.7)	229.4 (103.1)	8.2 (4.1)
ED	1-4-2-3-1	9020.4 (1442.3)	5.5 (0.9)	32.2 (2.3)	3136.3 (445.1)	1217.3 (429.3)	1279.2 (565.3)	460.3 (228)	310.9 (167.7)	771.2 (374.6)	46.0 (22.9)
ED	1-4-4-2	10442.3 (1056.3)	6.4 (0.6)	30.8 (2.5)	3717.5 (759)	1641.5 (244.8)	1530.2 (457.2)	569.3 (185.8)	359.9 (241.6)	929.2 (393.3)	53.1 (34.6)
CM	1-4-2-3-1	8873.3 (884.6)	5.5 (0.5)	32.1 (2.7)	3762.4 (531)	1361.0 (450.2)	1001.5 (252.8)	214.7 (55.6)	174.8 (64.2)	389.6 (91.1)	16.4 (7.0)
CM	1-4-4-2	10144.6 (971.9)	6.4 (0.5)	27.8 (3.6)	4444.7 (415.7)	1837.4 (314.6)	1529.4 (416.6)	304.0 (106.0)	113.5 (71)	417.5 (152.1)	14.4 (9.0)
EM	1-4-2-3-1	7607.3 (3468.4)	5.0 (1.5)	30.8 (1.9)	2880.5 (1348.5)	1080.7 (596.7)	1075.8 (608.7)	329.4 (231.4)	181.8 (68.2)	511.2 (288.3)	20.0 (10.0)
EM	1-4-4-2	10025.8 (1404.3)	6.4 (0.7)	30.4 (2.2)	3748.8 (535.1)	1668.1 (504)	1629.9 (538.2)	548.7 (192.2)	272.4 (98.3)	821.1 (247.5)	29.3 (13.2)
F	1-4-2-3-1	8135 (1108.1)	5.4 (0.2)	31.6 (3.7)	3153.5 (497.7)	1080.6 (277.6)	995.8 (259.3)	288.2 (72.4)	231.3 (56.9)	519.5 (57.8)	26.0 (8.9)
F	1-4-4-2	9227.8 (1132.9)	6.0 (0.3)	31.0 (3.4)	3746.6 (604.3)	1291.2 (305.3)	1232.5 (226)	436.7 (135.8)	291.6 (148.9)	728.3 (265.6)	35.0 (17.8)
Mean All Positions	1-4-2-3-1	8316.8 (1589.4)	5.2 (0.8)	31.4 (2.8)	3186.6 (699.2)	1116.0 (425.1)	993.3 (437.9)	291.2 (178.8)	217.8 (132.2)	508.9 (281.8)	25.4 (18.5)
Mean All Positions	1-4-4-2	9575.7 (1320.4)**,a	6.0 (0.8)**,a	29.9 (2.9)	3724.3 (699)**,a	1441.5 (458.6)**,a	1326.3 (480.1)**,a	417.4 (208.4)**,a	240.8 (177.6)	658.2 (360.3)	30.5 (25.1)

Note: CD = Central Defenders. ED = External Defenders. CM = Central Midfielders. EM = External Midfielders. F = Forwards. TD = Total Distance covered. MRS = Maximal Running Speed. LIR = Low-intensity Running (11.01-14 km·h^{-1}). MIR = Moderate-intensity Running (14.01-19 km·h^{-1}). HIR = High-intensity Running (19.01-23 km·h^{-1}). SPR = Sprinting (≥ 23.01 km·h^{-1}). HIA = High-intensity Activities (HIR + SPR). NS = Number of Sprints [a.u. (arbitrary units)], characterized by frequencies of efforts ≥ 23.01 km·h^{-1}. ** p-value < 0.01. [a] 1-4-4-2 vs. 1-4-4-2 > 1-4-4-2 vs. 1-4-2-3-1.

Table 3. Effects of playing position on match running performance in Brazilian professional soccer players [mean (standard deviation)].

Variables	**Playing Position**				
	CD	ED	CM	EM	F
TD (m)	7525.2 (922.2)	9602.5 (1188.6)^{**,a}	9216.1 (1244.6)^{**,b}	9576.1 (1981.2)^{**,c}	8693.7 (1013.9)^{**,d}
Mean Speed (km·h^{-1})	4.6 (0.6)	5.9 (0.7)^{**,a}	5.8 (0.8)^{**,b}	6.2 (1)^{**,c}	5.7 (0.4)^{**,d}
MRS (km·h^{-1})	29.9 (3)	32.1 (2.5)	30.2 (3.2)	30.6 (3.1)	31.3 (3.3)
Jogging (m)	2968.1 (629.4)	3451.1 (536.4)^{*,a}	3946.4 (613.6)^{**,b,e,f}	3659.8 (809.1)^{**,c}	3411.8 (524.1)^{*,d}
LIR (m)	845 (267.1)	1404.4 (353.6)^{**,a}	1477.1 (444.8)^{**,b}	1590.5 (518.6)^{**,c,g}	1202.8 (251)^{**,d}
MIR (m)	627 (205.5)	1398.5 (457.5)^{**,a}	1163.8 (424.8)^{**,b}	1537.3 (504.5)^{**,c,g,h}	1129.6 (217.7)^{**,d}
HIR (m)	143.1 (69.7)	504.4 (194.2)^{**,a,i}	267.5 (158.5)^{*,b}	467.4 (196.2)^{**,c,h}	390.1 (110.2)^{**,d}
SPR (m)	126.6 (138.5)	338.7 (183.3)^{**,a,i}	147.4 (99.4)^{*,b}	259.7 (128.7)^{**,c,h}	256.5 (102.2)^{**,d}
HIA (m)	269.8 (182.4)	843.1 (354)^{**,a,i}	414.9 (234.5)^{*,b}	727.1 (294.2)^{**,c,h}	646.6 (187)^{**,d,j}
NS (a.u.)	10.9 (8.6)	49.1 (25.6)^{**,a,i,k,l}	17.5 (14.1)^{*,b}	30.1 (19.4)^{**,c}	31.2 (13.4)^{**,d}

Note: CD = Central Defenders. ED = External Defenders. CM = Central Midfielders. EM = External Midfielders. F = Forwards. TD = Total Distance covered. MRS = Maximal Running Speed. LIR = Low-intensity Running (11.01-14 km·h^{-1}). MIR = Moderate-intensity Running (14.01-19 km·h^{-1}). HIR = High-intensity Running (19.01-23 km·h^{-1}). SPR = Sprinting (≥ 23.01 km·h^{-1}). HIA = High-intensity Activities (HIR + SPR). NS = Number of Sprints [a.u. (arbitrary units)], characterized by frequencies of efforts ≥ 23.01 km·h^{-1}. * p-value < 0.05. ** p-value < 0.01. [a] ED > CD. [b] CM > CD. [c] EM > CD. [d] F > CD. [e] CM > ED. [f] CM > F. [g] EM > F. [h] EM > CM. [i] ED > CM. [j] F > CM. [k] ED > EM. [l] ED > F.

Table 4. Effects of match situational variables on individual and global metrics of network analysis in Brazilian professional soccer players [mean (standard deviation)].

Variables	**Competition Stage**		**Match Location**		**Quality of Oppositions**		**Match Outcome**		
	1st Stage	2nd Stage	Away	Home	Strong	Weak	Lost	Draw	Won
Individual Metrics									
In Degree	25.6 (9.9)	25.8 (10.7)	23.3 (7.4)	27.7 (11.6)^{*,a}	23.5 (9.6)	30.7 (9.7)^{**,b}	26.6 (11.8)	24.0 (7.8)	27.3 (11.5)
Out Degree	24.3 (12.1)	25.0 (11.6)	22.5 (10.4)	26.3 (12.8)^{*,a}	22.5 (11.7)	29.2 (11.1)^{**,b}	26.2 (13.7)	22.4 (9.6)	26.2 (12.9)
Closeness Centrality	0.8 (0.2)	0.8 (0.2)	0.8 (0.2)	0.8 (0.1)	0.8 (0.2)	0.8 (0.1)^{*,b}	0.8 (0.2)	0.8 (0.2)	0.8 (0.2)
Betweenness Centrality	3.0 (2.3)	2.7 (1.5)	3.0 (2.1)	2.8 (2.0)	3.0 (2.2)	2.6 (1.5)	2.8 (2.1)	3.0 (2.2)	2.8 (1.7)
Clustering	0.7 (0.1)	0.8 (0.1)	0.7 (0.1)	0.7 (0.1)^{*,a}	0.7 (0.1)	0.8 (0.1)^{**,b}	0.7 (0.1)	0.7 (0.1)	0.7 (0.1)
Eigenvector	0.8 (0.1)	0.9 (0.1)	0.8 (0.1)	0.9 (0.1)	0.8 (0.1)	0.9 (0.1)	0.8 (0.1)	0.9 (0.1)	0.8 (0.1)
Global Metrics									
Density	0.7 (0.1)	0.7 (0.05)	0.7 (0.1)	0.7 (0.1)	0.7 (0.1)	0.8 (0.02)^{*,b}	0.7 (0.1)	0.7 (0.1)	0.7 (0.1)
Clustering Coefficients	0.7 (0.1)	0.8 (0.1)	0.7 (0.05)	0.7 (0.1)	0.7 (0.1)	0.8 (0.02)^{*,b}	0.8 (0.1)	0.7 (0.05)	0.7 (0.1)

Note: * p-value < 0.05. ** p-value < 0.01. [a] = Home > Away. [b] = Weak > Strong.

Table 5. Effects of playing position on individual and global metrics of network analysis in Brazilian professional soccer players [mean (standard deviation)].

Variables	**Playing Position**				
	CD	ED	CM	EM	F
Individual Metrics					
In Degree	21.7 (6.9)	25.4 (10.4)	28.2 (11.3)	32.2 (9.5)^{**,d,e}	20 (7.5)
Out Degree	24.5 (9.6)^{*,a}	20.9 (11.0)	29.8 (11.4)^{**,b}	31.1 (12.6)^{*,e,f}	15.0 (7.1)
Closeness Centrality	0.8 (0.2)^{*,a}	0.7 (0.2)	0.9 (0.1)^{**,b,c}	0.8 (0.2)^{**,e}	0.7 (0.1)
Betweenness Centrality	3.7 (2.9)^{*,a}	2.4 (1.8)	3.5 (1.7)^{**,b}	3.1 (1.1)^{**,e}	1.4 (0.9)
Clustering	0.7 (0.1)	0.7 (0.1)	0.7 (0.1)	0.7 (0.1)	0.8 (0.1)
Eigenvector	0.8 (0.1)	0.8 (0.1)	0.9 (0.1)	0.9 (0.1)^{**,e,f}	0.8 (0.1)

Note: CD = Central Defenders. ED = External Defenders. CM = Central Midfielders. EM = External Midfielders. F = Forwards. * p-value < 0.05. ** p-value < 0.01. ^{a} = CD > F. ^{b} = CM > F. ^{c} = EM > ED. ^{d} = EM > F. ^{e} = EM > CD. ^{f} = CM > ED.

Supplemental file 1. Effects of opposition team formation (1-4-1-4-1 vs. 1-4-2-3-1 or 1-4-4-2) according to playing position on match running performance in Brazilian professional soccer players [mean (standard deviation)].

Position	Opposition Team Formation	TD (m)	Mean Speed (km·h^{-1})	MRS (km·h^{-1})	Jogging (m)	LIR (m)	MIR (m)	HIR (m)	SPR (m)	HIA (m)	NS (a.u.)
	1-4-1-4-1 vs.										
CD	1-4-2-3-1	6993.8 (1133.5)	4.6 (0.8)	29.5 (2.8)	2933.1 (719.8)	940.3 (354.9)	534.3 (207.9)	118.8 (62.8)	105.8 (66.7)	224.6 (66.6)	11.0 (5.3)
CD	1-4-4-2	7565.7 (1027.7)	4.7 (0.6)	31.4 (3.8)	3002.5 (739.2)	803.4 (213.0)	642.9 (237.2)	147.1 (95.9)	147.5 (200.1)	294.6 (275.7)	10.6 (10.2)
ED	1-4-2-3-1	9397.4 (1074.5)	5.8 (0.7)	32.0 (1.9)	3459.1 (213.8)	1346.5 (376.7)	1345.6 (483.6)	539.4 (223.5)	375.7 (179.3)	915 (392.4)	49.1 (27.6)
ED	1-4-4-2	9524.5 (791.9)	5.9 (0.4)	33.3 (2.8)	3492.4 (472.8)	1404.8 (250)	1432.5 (357.1)	452.9 (145.4)	312.9 (162.4)	765.8 (289.3)	48.0 (20.1)
CM	1-4-2-3-1	8789.8 (1020.8)	5.7 (0.8)	29.2 (3.7)	3841.4 (281.8)	1359.4 (393.3)	1097.3 (369.9)	212.5 (183.7)	84.1 (39.5)	296.6 (206.5)	9.5 (6.0)
CM	1-4-4-2	9255.4 (1639.0)	5.8 (1.0)	30.7 (1.9)	3874.6 (849.2)	1441.8 (496.3)	1127.2 (515.4)	332.2 (213.2)	192.0 (143.1)	524.2 (345.3)	26.4 (21.0)
EM	1-4-2-3-1	9692.3 (1425.6)	6.2 (0.6)	31.5 (4.2)	3718.0 (621.3)	1557.8 (507.2)	1440.4 (377.1)	496.3 (172.6)	278.3 (141.2)	774.5 (294.3)	33.9 (25.6)
EM	1-4-4-2	10449 (957.0)	7.0 (0.4)	29.5 (3.5)	4095.1 (523.6)	1951.1 (91.6)	1931.1 (216.2)	439.9 (199.3)	281.0 (184.5)	720.9 (349.0)	33.8 (23.6)
F	1-4-2-3-1	8636.5 (642.2)	5.7 (0.7)	33.8 (3.3)	3252.6 (189.3)	1217.2 (162.1)	1176.4 (64.8)	415.6 (54.4)	267.2 (30.7)	682.8 (48.3)	33.3 (11.0)
F	1-4-4-2	8448.4 (558.1)	5.6 (0.4)	29.4 (1.8)	3246.3 (317.3)	1178.8 (137.3)	1067.5 (159.3)	408.4 (50.7)	214.9 (70.9)	623.3 (113.3)	28.8 (11.1)
Mean All Positions	1-4-2-3-1	8762.5 (1434.8)	5.6 (0.9)	31.1 (3.4)	3463.2 (552.8)	1299.9 (422.7)	1326.3 (480.1)	363.3 (229.1)	226.2 (159.3)	589.5 (372.1)	27.9 (23.8)
Mean All Positions	1-4-4-2	9020.8 (1409.4)	5.8 (0.9)	31.1 (3.0)	3535.2 (713.6)	1334.7 (456.6)	1211.2 (523.9)	350.1 (187.4)	228.8 (163.2)	578.9 (325.7)	29.8 (21.4)

Note: CD = Central Defenders. ED = External Defenders. CM = Central Midfielders. EM = External Midfielders. F = Forwards. TD = Total Distance covered. MRS = Maximal Running Speed. LIR = Low-intensity Running (11.01-14 km·h^{-1}). MIR = Moderate-intensity Running (14.01-19 km·h^{-1}). HIR = High-intensity Running (19.01-23 km·h^{-1}). SPR = Sprinting (≥ 23.01 km·h^{-1}). HIA = High-intensity Activities (HIR + SPR). NS = Number of Sprints [a.u. (arbitrary units)], characterized by frequencies of efforts ≥ 23.01 km·h^{-1}.

Supplemental file 2. Effects of opposition team formation (1-4-4-2 vs. 1-4-2-3-1 or 1-4-4-2) according to playing position on individual and global metrics of network analysis in Brazilian professional soccer players [mean (standard deviation)].

Position	Opposition Team Formation	Individual Metrics						Global Metrics	
	1-4-4-2 vs.	In Degree	Out Degree	Closeness Centrality	Betweenness Centrality	Clustering	Eigenvector	Density	Clustering Coefficients
CD	1-4-2-3-1	24.7 (9.0)	24.6 (15.5)	0.8 (0.3)	4.4 (3.7)	0.7 (0.1)	0.8 (0.2)	-	-
CD	1-4-4-2	23.7 (3.5)	27.7 (3.2)	0.8 (0.1)	4.2 (2.5)	0.7 (0.1)	0.8 (0.1)	-	-
ED	1-4-2-3-1	25.1 (11.8)	21.9 (14.6)	0.7 (0.3)	1.5 (1.2)	0.8 (0.1)	0.8 (0.1)	-	-
ED	1-4-4-2	25.3 (6.7)	19.3 (3.2)	0.8 (0.1)	2.9 (2.3)	0.8 (0.1)	0.8 (0.1)	-	-
CM	1-4-2-3-1	27.9 (14.1)	31.6 (12.1)	0.9 (0.1)	4.0 (1.2)	0.7 (0.1)	0.8 (0.1)	-	-
CM	1-4-4-2	20.0 (4.2)	22.5 (7.8)	0.8 (0.1)	3.1 (1.1)	0.8 (0.1)	0.9 (0.1)	-	-
EM	1-4-2-3-1	31.7 (11.7)	32.7 (10.1)	0.8 (0.1)	3.6 (1.0)	0.7 (0.1)	0.9 (0.1)	-	-
EM	1-4-4-2	28.8 (5.6)	27.8 (11.7)	0.9 (0.1)	3.7 (0.5)	0.7 (0.1)	1.0 (0.1)	-	-
F	1-4-2-3-1	19.0 (3.7)	11.8 (1.7)	0.7 (0.1)	2.0 (1.1)	0.8 (0.1)	0.9 (0.1)	-	-
F	1-4-4-2	19.8 (7.9)	18.8 (10.6)	0.7 (0.1)	1.7 (0.8)	0.8 (0.1)	0.8 (0.1)	-	-
Mean All Positions	1-4-2-3-1	26.2 (11.2)	25.5 (13.7)	0.8 (0.2)	3.1 (2.2)	0.7 (0.1)	0.8 (0.1)	0.7 (0.1)	0.7 (0.1)
Mean All Positions	1-4-4-2	23.7 (6.6)	22.8 (8.7)	0.8 (0.1)	3.0 (1.7)	0.7 (0.1)	0.9 (0.1)	0.7 (0.01)	0.7 (0.02)

Note: CD = Central Defenders. ED = External Defenders. CM = Central Midfielders. EM = External Midfielders. F = Forwards.

Supplemental file 3. Effects of opposition team formation (1-4-1-4-1 vs. 1-4-2-3-1 or 1-4-4-2) according to playing position on individual and global metrics of network analysis and in Brazilian professional soccer players [mean (standard deviation)].

Position	Opposition Team Formation	Individual Metrics						Global Metrics	
	1-4-1-4-1 vs.	In Degree	Out Degree	Closeness Centrality	Betweenness Centrality	Clustering	Eigenvector	Density	Clustering Coefficients
CD	1-4-2-3-1	17.2 (7.7)	22.6 (9.0)	0.8 (0.1)	3.7 (3.8)	0.7 (0.2)	0.8 (0.1)	-	-
CD	1-4-4-2	21.1 (3.5)	24.6 (4.0)	0.8 (0.1)	2.9 (1.7)	0.7 (0.1)	0.8 (0.1)	-	-
ED	1-4-2-3-1	24.6 (14.7)	21.8 (13.4)	0.8 (0.1)	2.8 (1.7)	0.7 (0.1)	0.8 (0.2)	-	-
ED	1-4-4-2	26.4 (9.5)	20.1 (9.7)	0.7 (0.3)	2.9 (2.2)	0.7 (0.1)	0.8 (0.1)	-	-
CM	1-4-2-3-1	28.4 (12.9)	28.0 (8.9)	0.8 (0.1)	3.0 (1.4)	0.7 (0.1)	0.8 (0.1)	-	-
CM	1-4-4-2	30.1 (9.1)	30.8 (13.3)	0.9 (0.1)	3.4 (2.5)	0.7 (0.1)	0.9 (0.1)	-	-
EM	1-4-2-3-1	35.8 (11.6)	28.8 (16.6)	0.7 (0.4)	2.0 (1.4)	0.8 (0.1)	0.9 (0.1)	-	-
EM	1-4-4-2	32.0 (8.5)	34.0 (14.6)	0.8 (0.1)	2.9 (0.5)	0.8 (0.1)	1.0 (0.1)	-	-
F	1-4-2-3-1	19.0 (12.2)	15.7 (8.1)	0.7 (0.1)	0.9 (0.8)	0.7 (0.1)	0.6 (0.3)	-	-
F	1-4-4-2	21.6 (8.5)	13.4 (4.9)	0.7 (0.1)	1.0 (0.6)	0.8 (0.1)	0.9 (0.1)	-	-
Mean All Positions	1-4-2-3-1	25.5 (12.9)	24.0 (11.7)	0.8 (0.2)	2.6 (2.2)	0.7 (0.1)	0.8 (0.2)	0.7 (0.1)	0.7 (0.1)
Mean All Positions	1-4-4-2	26.4 (8.8)	24.9 (11.9)	0.8 (0.2)	2.8 (1.9)	0.7 (0.1)	0.9 (0.1)	0.7 (0.05)	0.7 (0.05)

Note: CD = Central Defenders. ED = External Defenders. CM = Central Midfielders. EM = External Midfielders. F = Forwards.