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McLean, Scott, Salmon, Paul M., Gorman, Adam D., Dodd, Karl, & Solomon, Colin
(2021)
The Communication and Passing Contributions of Playing Positions in a Professional Soccer Team.
Journal of Human Kinetics, *77*(1), pp. 223-234.

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https://doi.org/10.2478/hukin-2020-0052

Journal of Human Kinetics volume 77/2021, 223-234 DOI: 10.2478/hukin-2020-0052
Section III – Sports Training

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The Communication and Passing Contributions of Playing Positions in a Professional Soccer Team

by

Scott McLean[1], Paul M Salmon[1], Adam D Gorman[2], Karl Dodd[1], Colin Solomon[1]

Determining the connectivity of team members in sport provides important information on team functioning. In soccer, teams that are highly connected via passing have been shown to be more successful compared to teams less connected via passing. In addition to passing connectivity, players are connected with each other via intra-team communication (ITC) through verbal instruction, and nonverbal cues. Despite ITC being a known component of effective teamwork to enhance strategy, efficiency, motivation and concentration, ITC of individual playing positions has not previously been measured during soccer games, nor has it been associated with passing connections in a performance context. In this study, the received ITC that was perceived to be beneficial to performance during 22 competitive professional soccer matches was measured, in conjunction with the passing connections between team members. In total, 526 ITC ratings were collected and analysed, and a total of 7,693 passes were analysed. From the ITC and passing measures, a player connectivity index (PCI) representing the coupling of ITC and passing, was developed to determine the overall connectivity of the individual playing positions. Social network analysis (SNA) centrality metrics were used to determine the connectivity of the playing positions. There were significant ($p < .05$) main effects between playing positions for beneficial ITC, passing, and the PCI for centrality metrics, indicating that different playing positions interact with other team members differently. Pairwise comparisons indicated significant differences between individual playing positions for ITC, passing and the PCI. The two central defenders and the two central defensive midfielders had the highest mean values for ITC, passing, and the PCI compared to the other playing positions. The current findings suggest that central defenders and central defensive midfielders are positioned tactically to be highly involved in the build-up of passing moves, and to deliver beneficial task related information to team members. These findings have implications for performance analysis, coaches, and for talent identification.

Key words: *intra-team communication, social network analysis, coaching, performance analysis.*

Introduction

Within the past decade, the acknowledgement of soccer as a dynamic and complex system has brought about a rapid progression of new methods aimed at improving match performance analysis (Low et al., 2019; McLean et al., 2019a; Sarmento et al., 2017). As such, there has been a shift away from analysis of isolated components of soccer performance to a focus on group behaviours that explores the collective movements and cooperative actions of team members and opposition players (Low et al., 2019; Sarmento et al., 2017). Methods such as spatiotemporal analysis and social network analysis (SNA) are now providing a detailed understanding of team functioning and performance in soccer (Low et al., 2019; Sarmento et al., 2017; Wäsche et al., 2017). For instance, analysing group tactical variables, via player tracking technology, such as team dispersion, effective playing areas, synchronisation, and numerical advantages and disadvantages has enabled detailed tactical insights for coaches (Low et al., 2019). In addition, the use of social network analysis (SNA) in soccer match analysis has demonstrated how players interact via their

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Authors submitted their contribution to the article to the editorial board.
Accepted for printing in the Journal of Human Kinetics vol. 77/2021 in January 2021.

passing connections, which reveals patterns of passing behaviour and identifies prominent players within the passing networks (Wäsche et al., 2017). When using SNA to analyse passing connectivity in soccer, players are seen as a network of nodes that are connected by passes (Grund, 2012). Recent applications of SNA in soccer have analysed entire match passing networks (Clemente et al., 2015; Grund, 2012), goal scoring passing networks (GSPN) (McLean et al., 2017a, 2018a), unsuccessful passing networks (Mclean and Salmon, 2019b), and different playing formations (Clemente et al., 2015; McLean et al., 2018b). Together, these applications of SNA to passing in soccer have enabled a detailed understanding of the relational and interdependent perspectives to understand team coordination and connectivity.

Connectivity between team members in soccer does not, however, only relate to passing, players are also connected via verbal and non-verbal communication (Mclean et al., 2018c). Team members use intra-team communication (ITC) for information exchange during matches in order to optimise performance (Sullivan and Feltz, 2003). In a study modelling soccer performance as a complex system, former professional soccer players with a combined 1190 professional matches in top European leagues and 134 international appearances considered ITC to be an important function of performance in soccer (McLean et al., 2017b). Furthermore, effective ITC influences various team processes including motivation, concentration, strategy, skill acquisition, attitudes, and behaviour (Yukelson, 1993), and better performing teams communicate more, they also use more task related messages (Lausic et al., 2009).

Previous methods of measuring ITC in sporting teams have recorded the verbal communication of players (Lausic et al., 2009; LeCouteur and Feo, 2011). For instance, in tennis doubles matches, situations of verbal communications were recorded during breaks between points, and in netball, verbal ITC was recorded from the side of the court for the four defensive positions (Lausic et al., 2009; LeCouteur and Feo, 2011). A limitation related to recording verbal ITC is that it does not measure the non-verbal communication exchanged between team members or how beneficial the received communication was to playing performance. Even though ITC is an important function of performance in soccer (McLean et al., 2017b), no research exists on how the ITC received in a match directly relates to perceived individual performances during competitive professional soccer matches.

One method that has been used to measure ITC during a match is for players to subjectively rate, post-match, verbal and nonverbal communication they received during a match, and how this was perceived by players to benefit their individual performance (Mclean et al., 2018c). It is now common practice for professional athletes to complete subjective assessments including sleep diaries, perceived effort, and wellness scales in both training and matches (Bishop et al., 2008; Gallo et al., 2017). As such, a subjective rating scale to assess the perceived benefit of ITC to performance is an appropriate method to capture the verbal and nonverbal communication players receive in matches (Mclean et al., 2018c; Salmon et al., 2017). This approach of subjectively rating perceived ITC has been used to assess the communication exchanged by members of an elite women's cycling team during two National Road Series races (Salmon et al., 2017). In addition, ITC examined for a professional soccer team showed that the team was a highly connected network for ITC, but less connected for passing (Mclean et al., 2018c). Furthermore, ITC was increased in matches won and drawn compared to matches lost, and there was a negative relationship between ITC and passing (Mclean et al., 2018c). The above-mentioned study was designed to investigate verbal and nonverbal ITC networks at a team level, but further investigation is required to determine contributions of individual playing positions to ITC. This would allow coaches to identify which players are the most connected playing positions for beneficial ITC and passing, and how this relates to team functioning.

Therefore, the aims of the current study were to (1) determine using SNA, the playing positions of a professional soccer team that are perceived to contribute the most to beneficial ITC compared to other team members, and (2) analyse passing contributions of the individual playing positions from a professional soccer team in competitive matches. A further investigative aim

was to combine the beneficial ITC and passing data to develop a player connectivity index (PCI) to represent the contributions of playing positions to overall connectivity to the team.

Methods

Participants

Twenty-five professional soccer players from the same club competing in the Australian A league (the top professional soccer league in Australia) participated in the current study. The team were highly experienced and included 10 players from four different countries, who had played more than 250 combined games at an international level. Data from substitutes were collected for all variables. For positions in which substitutes were used, ITC data were the mean of the two players, and passing data were the sum of passes of the two players who played in the specific position. Substitute data were not included if the substitution was made after 80 minutes of play, as it was not considered to represent a meaningful contribution to the ITC for the match. There was an average of 1.9 substitutes per match, and the mean times in the match for substitutes were 63 ± 6.6 min (n = 21) for substitute 1, 71 ± 7.5 min (n = 17) for substitute 2, and 74 ± 2.1 min (n = 5) for substitute 3.

Study Design and Procedures

The current study received institutional ethical approval from the Human Research Ethics Committee (S/16/913). This study was part of a larger data set, and a previous use of this data set aggregated the data for a team level analysis (Mclean et al., 2018c). The current study analysed the individual playing positions and used different SNA metrics to describe individual performances. The study was designed to investigate the perceived beneficial ITC, and passing contributions of playing positions in a professional soccer team across a competitive season from a network perspective. Players were informed of the study design, and all players in the squad provided informed consent to participate in the study. For the ITC data, each player completed a subjective ITC rating scale (A1 Appendix) following each match (Mclean et al., 2018c). The rating scale required each player to rate the perceived amount of ITC received, and the perceived benefit of the received ITC to their match performances, from each of the other playing positions. Having more communication does not necessarily ensure effective team coordination (LeCouteur and Feo, 2011), therefore, the beneficial communication data were used in the current analysis as it represented the verbal and nonverbal communication that was perceived to be meaningful to the players' performance in the matches. Match passing data were provided by Optasports, which is a reliable system for the analysis of match actions i.e. team events coded by independent analysts showed good agreement (Kappa 0.92 to 0.94) (Liu et al., 2013). SNA metrics of InDegree centrality (IDC) and OutDegree centrality (ODC) were calculated and used to determine the contributions of each playing position to the beneficial ITC, and the passing networks (refer to Procedure). The analysis was conducted for 22 matches of the 2016/2017 Australian A league season. The team used the same playing formation (1 4 2 2 2) in all matches (see Appendix 1 for classification of playing positions) (Mclean et al., 2018c).

The ITC rating scale was designed to measure the perceived benefit of the received verbal and nonverbal communication to individual performance (Mclean et al., 2018c). The ITC rating scale ranged from 0-4, with 0 representing no benefit to performance, and 4 representing a very high benefit to performance. The ITC rating scale was designed by sport scientists, soccer experts (soccer researchers and coaches), and a researcher experienced in the development of human factors methods (Stanton et al., 2013). The ITC rating scale was trialled with an amateur soccer team in three competitive matches and feedback was used to refine the tool. Participants in the current study were instructed and trained on how to complete the ITC rating scale by the research team, they were informed of the different types of communication (e.g. verbal, non-verbal), and that they were to consider and include these when completing the rating scale. Participants were instructed not to consider the match outcome as this could have influenced the responses provided. Prior to the commencement of the competitive season, the ITC rating scale was used in five pre-season matches as part of a familiarisation period. The layout of the ITC rating scale reflected the static playing formation of the team and therefore provided a visual representation to assist participants when

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entering their data post-match (A1 Appendix) (Mclean et al., 2018c). The ITC rating scale was completed individually and confidentially by each player in the team's dressing room within 60 min post-match. In total, 526 individual communication ratings were collected and analysed, and a total of 7,693 passes were analysed.

Social network matrices were produced for the level of perceived beneficial ITC, and passing data for each match (example in Table 2). The networks were directional (i.e. player A to player B) and indicated the strength of the connections between playing positions (i.e. the absolute values of the connections between players such as the total number of passes or the level of beneficial ITC from player A and player B). For the current analysis, the determination of the inward and outward-bound connections was deemed important to understand the individual contributions of a playing position to the beneficial ITC and passing. Therefore, the IDC and ODC were calculated for beneficial ITC, and for passing using the network analysis program Social Network Visualiser (SocNetV). The ODC represents the sum of connections (ITC or passes) from each player to all other players, and the IDC represents the sum of connections (ITC or passes) into each playing position from all other playing positions (Ribeiro et al., 2017). Only passes from members of the participating team were considered in the current DC metrics. For example, a regain of possession from a tackle or intercept was not considered as a contribution to IDC. To obtain a combined connectivity value for perceived beneficial ITC, and for passing, the IDC and ODC were summed, which represented the total connectivity of each player in terms of outward and inward bound connections for communication, and for passing. To represent the overall connectivity (passing and ITC) of the playing positions, a player connectivity index (PCI) was developed. The PCI represents the coupling of ITC and passing and was calculated by multiplying the combined perceived beneficial ITC and the combined passing connectivity scores and measured in arbitrary units (AU).

Statistical Analysis

To determine differences between the individual playing positions across the 22 matches, one-way analysis of variance (ANOVA) was performed for beneficial ITC, passing, and for the PCI, using the raw data. The level of significance was set at $p < .05$, and statistical power was reported (ß). Partial eta squared (η_p^2) was calculated as an indicator of effect size, and was defined as small (0.01), medium (0.06), and large (0.14) (Levine and Hullett, 2002). Pairwise comparisons were conducted, and due to the large number (110) of multiple comparisons, the Bonferonni correction was used with the level of significance set at $p < .0005$. The Levene's test for homogeneity was performed for ANOVA, and no results were significant ($p > .05$). Where significant differences were found between the playing positions in the pairwise comparisons, effect sizes (Cohen's d) were calculated to determine the magnitude of the difference. Effect size categories were defined as small (.2), medium (.5), and large (> .5) (Cohen, 1988).

Results

There was a significant ($p < .05$) main effect and large effect sizes for individual playing position for perceived beneficial communication ($p < .001$; η_p^2 .496; ß 1.000) (Figure. 1), passing ($p < .001$; η_p^2 .523; ß 1.000) (Figure. 2), and for the PCI ($p < .001$; η_p^2 .590; ß 1.000) (Figure. 3). Post hoc pairwise comparisons and effect sizes (Cohen's d) are presented in Table 3.

Discussion

The current study used SNA to determine the individual contributions of playing positions to a team's connectivity during 22 matches of a competitive professional soccer season. The primary and unique finding of this study was that the individual playing positions within the team contributed differently to team connectivity for the perceived beneficial ITC, and for the player connectivity index.

The passing analysis in this study supports previous analyses, whereby two central defenders and two central defensive midfielder positions provided the highest values for passing compared to the other playing positions within the team. Studies investigating passing networks in soccer have shown similar results to the current study (Clemente et al., 2015; Gama et al., 2014, 2015), whereby the centrally positioned midfield and defensive positions were found to be the most prominent contributors to passing networks

(Clemente et al., 2015; Gama et al., 2015). These results could be explained by the fact that, in the build-up of an offensive phase of play, defenders often initiate the attacking phase, and defensive midfielders are positioned to provide the link between defensive and attacking positions (Clemente et al., 2015; Gama et al., 2015). Furthermore, after re-gaining possession in their own defensive areas of the pitch, defensive players often have numerical superiority over the opposition allowing passes to be played with decreased opposition pressure, (e.g. teams may retreat to their own defensive area after losing possession to prepare their own defence, or pressure defenders using a limited number of players). In contrast with the high passing contributions of the RCD, LCD, RDMF, and LDMF were the lower passing contributions by the forward positions of RAMF, LAMF, RWFD, and CFWD. This result could be attributed to these forward playing positions not always being involved in offensive build-ups. For example, attacking players generally become involved in play higher up the pitch where there is a high presence of defenders, subsequently increasing the risk of intercepted or pressured passes in these areas (Clemente et al., 2015). Furthermore, offensive phases of play that commence at the back may not progress to attacking players, due to turnovers of possession in midfield locations (Clemente et al., 2015).

This study is the first to determine the perceived ratings of beneficial ITC to individual playing position performance. The playing positions RCD, LCD, RDMF, and LDMF achieved the highest values, compared to all other positions. This result indicates, that similar to the passing networks, these playing positions provide the majority of beneficial ITC to other team members. It has been suggested that increased ITC is optimal in defensive phases of play (LeCouteur and Feo, 2011; Mclean et al., 2018c), as such central defensive and central defensive midfielder positions may be ideally positioned tactically on the field to share information with the other players. A further explanation is that team members at an elite level share general team knowledge regarding the teams' playing philosophy and strategies, and team members who interact more regularly than others will share more specific knowledge about each other's tasks (Cannon-Bowers et al., 1995). The fact that passing interactions were higher for the RCD, LCD, RDMF, and LDMF compared to the rest of the team shows how these positions interact more often with other players, and potentially possess a knowledge of the roles of the other playing positions, which subsequently allows them to provide task relevant information.

Having four main contributors to communication (RCD, LCD, RDMF, LDMF) may be an effective method for optimal team functioning. Given that the demand for cognitive resources increases with team size (Eccles and Tenenbaum, 2004), reducing the number of major contributors to communication may reduce cognitive demand on the players. This could allow for more cognitive resources of individual players to be applied to primary task performance (Eccles and Tenenbaum, 2004). It is not known whether the team consciously decided for these players to be the main communicators or whether the results were driven by self-organisation and the demand of the playing positions (Silva et al., 2013). Nonetheless, this finding has implications for coaches, talent identification, player development, and future research. Players could be coached communication techniques, such as the use of cue words, which removes ambiguity within ITC (Eccles and Tran, 2012; Mclean et al., 2018c). The ITC scale itself could be used in talent identification to determine the players best suited to provide beneficial communication to the team members. To gain a more detailed understanding of ITC, future research could potentially remove all communication or communication from specific playing positions and investigate the effect on team functioning.

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Table 1

Matches played, and the percentage of matches in which players participated.

Player	Matches played in	Percent matches played in
1	21	95
2	20	91
3	20	91
4	20	91
5	19	86
6	19	86
7	18	82
8	18	82
9	18	82
10	17	77
11	14	64
12	12	55
13	11	50
14	9	41
15	7	32
16	5	23
17	4	18
18	2	9
19	2	9
20	2	9
21	2	9
22	1	5
23	1	5
24	1	5
25	1	5

Table 2

Example social network matrix using the raw match passing data.

	GK	RFB	RCD	LCD	LFB	RDMF	LDMF	RAMF	LAMF	RFWD	CFWD
GK	0	3	3	5	3	1	0	0	0	5	1
RFB	3	0	4	1	0	6	6	2	0	11	0
RCD	3	5	0	9	2	4	11	1	0	1	0
LCD	5	1	8	0	5	1	16	2	0	0	0
LFB	2	0	0	4	0	4	14	2	4	1	1
RDMF	0	8	2	5	0	0	10	7	1	3	2
LDMF	0	6	5	6	17	7	0	17	11	7	3
RAMF	0	6	1	1	1	6	5	0	2	10	3
LAMF	0	1	1	1	3	1	3	0	0	1	1
RFWD	0	9	2	0	1	8	4	11	2	0	3
CFWD	0	1	1	0	0	0	2	2	0	1	0

Values are the absolute number of passes between the intersecting positions during a match. For example, the GK passed the to the RFB on three occasions, the RCD on three occasions, the LCD on five occasions etc.

Table 3

Post hoc pairwise comparisons for total beneficial communication (Panel A), total passing (Panel B), and the Player Connectivity Index (Panel C).

A	GK	RFB	RCD	LCD	LFB	RDMF	LDMF	RAMF	LAMF	RFWD	CFWD
GK		-	↓3.4	↓2.9	-	↓2.6	↓2.5	-	-	-	-
RFB			↓1.7	-	-	-	↓1.2	↑1.2	-	-	-
RCD				-	-	-	-	↑3.2	↑1.7	↑2.2	↑1.9
LCD					-	-	-	↑2.3	-	↑1.3	-
LFB						-	-	↑1.6	-	-	-
RDMF							-	↑2.5	-	↑1.5	-
LDMF								↑2.5	-	↑1.6	↑1.4
RAMF									↓1.4	-	-
LAMF										-	-
RFWD											-
CFWD											

B	GK	RFB	RCD	LCD	LFB	RDMF	LDMF	RAMF	LAMF	RFWD	CFWD
GK		↓2.1	↓2.1	↓1.9	↓2.8	↓3.0	↓2.8	↓1.9	-	-	-
RFB			-	-	-	-	-	-	-	-	↑3.1
RCD				-	-	-	-	-	↑1.4	-	↑2.8
LCD					-	-	-	-	-	-	↑2.7
LFB						-	-	-	-	-	↑4.8
RDMF							-	-	↑1.8	-	↑4.2
LDMF								↑1.2	↑2.0	↑1.7	↑3.7
RAMF									-	-	↑3.1
LAMF										-	↑2.2
RFWD											↑3.1
CFWD											

C	GK	RFB	RCD	LCD	LFB	RDMF	LDMF	RAMF	LAMF	RFWD	CFWD
GK		↓2.7	↓2.5	↓2.5	↓3.4	↓3.4	↓3.1	-	-	-	-
RFB			-	-	-	-	↓1.3	-	-	-	-
RCD				-	↑1.1	-	-	↑1.5	↑1.6	↑1.6	↑2.9
LCD					-	-	-	-	↑1.3	-	↑3.1
LFB						-	↓1.6	-	-	-	↑4.6
RDMF							-	↑1.7	↑2.0	↑1.9	↑4.1
LDMF								↑1.9	↑2.1	↑2.0	↑3.6
RAMF									-	-	↑2.3
LAMF										-	-
RFWD											↑2.8
CFWD											

Arrows (↑ ↓) indicate a significant ($p < .0005$) difference and the direction of the differences, the value represents the magnitude of the difference (Cohen's d) (e.g. Panel A, Row 1: ↓3.4 indicates the GK had significantly lower values for communication compared to the RCD with a large ($d = 3.4$) effect size). Dashes (-) indicate no significant ($p > .0005$) difference.

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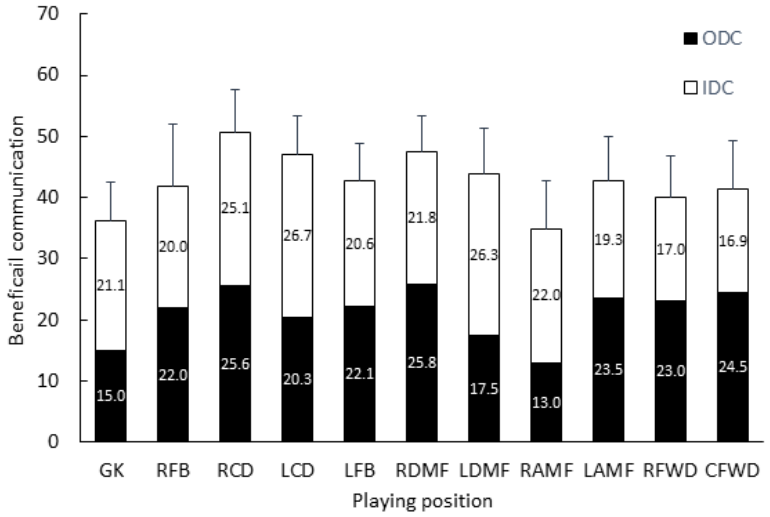


Figure 1

Combined OutDegree and InDegree centrality values for beneficial communication for the individual playing positions. Data are mean ± SD.

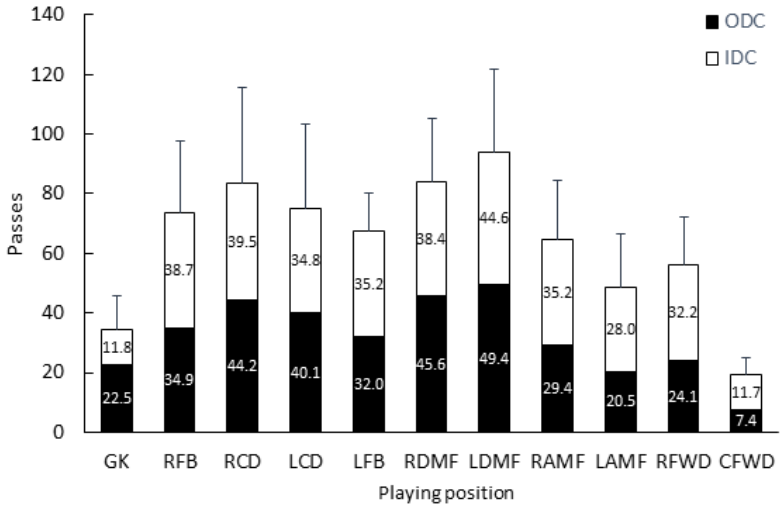


Figure 2

Combined OutDegree and InDegree centrality values for passing for the individual playing positions. Data are mean ± SD.

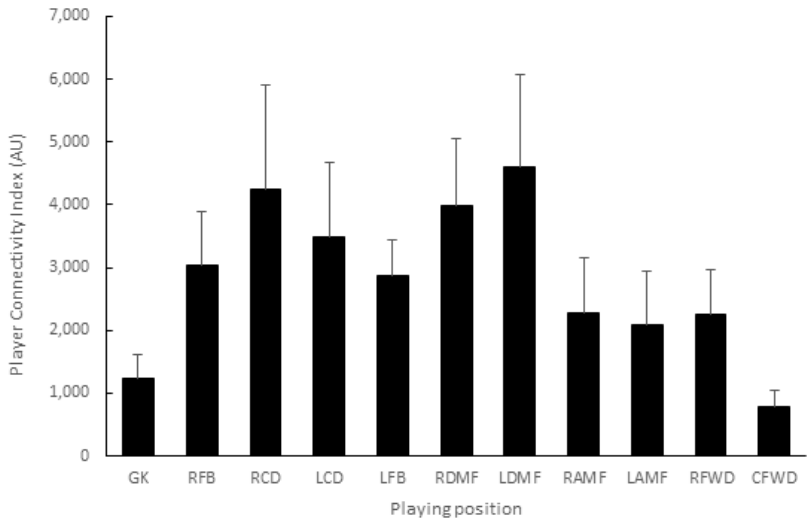
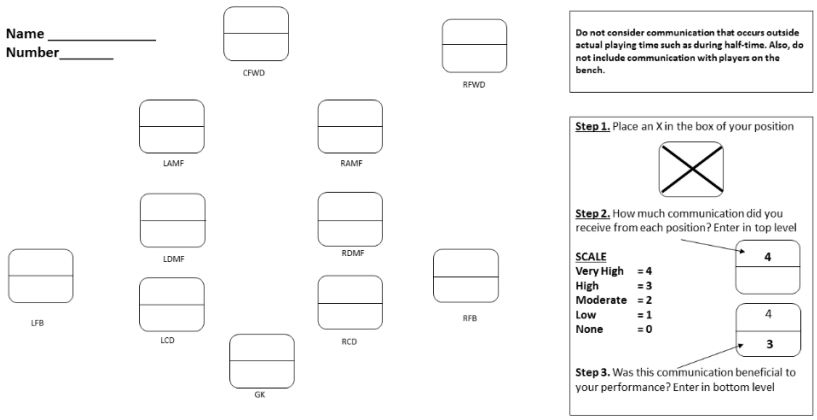


Figure 3

Player Connectivity Index (PCI) values for the individual playing positions. Data are mean ± SD.



Appendix 1

Intra-team communication tool (Mclean et al., 2018c).

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In the current study, beneficial ITC and passing were considered the variables that comprised team connectivity, and the PCI represented the coupling of passing and beneficial ITC. The results for the PCI indicated that the RCD, LCD, RDMF, and LDMF were the major contributors to team connectivity, compared to the other playing positions. This result is consistent with these positions also being identified as the prominent passers and beneficial communicators in the independent analysis of these variables. This finding has potential implications for match analysis and team strategy. Calculating the PCI for matches would allow coaches to determine whether changes occur for individual positions across different match outcomes, across a season, a tournament, and in matches of high or low possession, and how these changes relate to team functioning. One contribution of this research is the PCI, a novel metric designed to support assessment of player connectedness within their team during matches. The development of the PCI advances upon the typical independent analysis of passing by providing a metric that integrates two performance analysis metrics deemed important by coaches (McLean et al., 2017b). The PCI metric could be used in other team sports to understand team functioning and assist the coaching process.

Given that this is first-of-a-kind research in soccer, there are potential limitations to the current study including the subjectivity of the ITC rating scale. However, players were familiar with other subjective scales such as ratings of perceived exertion and wellness scales, and players were given instructions of how to complete the ITC rating scale. It was not possible to formally test the reliability of the ITC rating scale across matches, as performances in soccer are different from match to match, and player ratings would potentially change (Mclean et al., 2018c). Furthermore, the external factors influencing player's behaviour in soccer, including match status, different opposition, and playing home/away means that no two matches are identical. The ITC rating scale was developed by experienced researchers, soccer coaches, and sport scientists, and the progressive refinement prior to being used for data collection provides face validity (Mclean et al., 2018c). The findings also provide an indication of validity, as the ITC scale was sensitive enough to detect significant differences between playing positions across 22 matches when using a conservative pairwise comparison adjustment. A further potential limitation is the global rating of perceived beneficial ITC for the match, which does not measure single pieces of information which could have been crucial in deciding the match outcome. Lastly, instances where players switched positions during a match were not recorded, players were instructed to complete their ITC scales for the playing position in which they started the match.

In conclusion, the current study is the first to investigate, using SNA, the contributions of beneficial ITC and passing by the individual playing positions in competitive professional soccer. Central defensive and central defensive midfield positions were the most prominent contributors to beneficial ITC and passing, and subsequently achieved the highest PCI scores, compared to all other positions. The tactical strategy related to where these players are positioned may be optimal for information sharing, and for playing and receiving passes in the build-up of offensive phases, compared to all other positions. The findings of this study have implications for practice and for future research. For example, coaches could incorporate aspects of ITC in the design of training e.g. ensuring that players in the key positions for information exchange are aware of the match related tasks of other positions. The ITC scale is the first-of-its-kind to assess ITC in team sport and research could be extended to other sports to understand how players are connected via verbal and nonverbal communication.

Acknowledgements

Paul Salmon's contribution to this research was supported by his current ARC Future Fellowship (FT140100681).

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