Passing networks: An examination of the positions that are more prevalent in positional attack in handball

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Abstract
This study aimed to examine the player positions that are more dominant in positional attack. A total of six international matches were selected, all matches involving MOL-Pick Szeged handball club. For the 12 graphs obtained from social network analysis of MOL-Pick Szeged and each of their six opponents, a set of network metrics were computed. Data were calculated using Gephi software. There were an average of 745 (SD = 68) passes for each game constituting a total of 4,472 passes between players with an average of 373 (SD = 78) passes coded per team. Computations involved micro level of analysis related to player position centralities across the team, and macro levels of analysis related to the network of the team as a whole. The results showed that the backcourt players are the key players in the attack against the most used defences. Interestingly, a comparison of total passes per match against 6:0 defences and against 5:1 defences, for Pick and the opponent teams, showed that the total passes for Pick were only higher than their opponents in the match that Pick lost. The total passes against 6:0 formation were only higher for Pick in one match, and the total passes against 5:1 formations were higher for Pick in the matches that the team drew and lost. These results may indicate that passing network metrics can identify weaknesses of a team to particular defensive formations used by their opponents.

Keywords: social network theory, graph theory, passing networks, handball, centrality.

Introduction
The interactions between players in team sports can be recorded as a matrix of passes and visualised as a network diagram (Korte & Lames, 2018). In this network, the players are nodes, that symbolise individuals playing in a particular position; and the passes are edges that represent the interactions between the positions (Ribeiro, Silva, Duarte, Davids & Garganta, 2017). The analysis of these networks can identify the interactions between players and has significance in visualisation of patterns in the network. The diagram provides semi-quantitative insight into the operation of the team as a whole and the importance of individual positions for team effort. Also, in-depth quantitative analysis of patterns of team passing using network mathematics techniques has given insight into team dynamics (Clemente, Martins & Mendes, 2016) and some network parameters are correlated with team performance (Clemente, Martins, Kalamaras, Wong & Mendes, 2015a; Grund, 2012; Peña & Touchette, 2012). The analysis of passing networks in handball is scarce (an exception is Korte & Lames, 2019) and further work is required to understand how the prevalence of a position in positional attack may vary according to the opponent's defensive formations and match outcomes.

Passing networks in team sports have been examined using the social network analysis (SNA) approach. This approach allows identification of interactions of players by pairs (micro level of analysis) and the passes that occur for the team overall (macro level of analysis). Centrality measures operate at micro levels of analysis and are used to interpret the activity of each player or the set of players with a common positional role (Clemente, Martins, Kalamaras, Wong & Mendes, 2015a). These measures can identify a player who is connected to more teammates via passing (higher centrality), compared to others who are less connected (lower centrality). The more connected players could be considered more influential for the team structure. In football studies, authors conducting micro level analysis have found that the midfielders are the most prominent players in a team (Clemente et al., 2015a; Clemente, Martins & Mendes, 2016). For instance, Clemente and colleagues (2015) examined the degree centrality and degree prestige of Switzerland national team players for the FIFA World Cup 2014 and found that key players receiving the ball were the midfielders. These results suggest the use of a specific attacking style of play (attack building) used by this national team. Macro level analysis studies in football suggest that the more successful teams are those that have more homogeneous interactions amongst players (Clemente, Couceiro, Martins & Mendes, 2015c; Grund, 2012). In basketball, the point guard has been identified as the principal player on a team (Fewell, Armbruster, Ingraham, Petersen & Waters, 2012; Clemente, Martins, Kalamaras & Mendes, 2015b). Studying a variety of team sports, Korte and Lames (2018) applied centrality measures to find that the point guard in basketball, the defensive midfielder in football, and the centre back in handball are the key tactical positions (Korte & Lames, 2018).

In handball, the importance of the centre back position has been emphasised and the relevance of the left and right backs has been found recently (Korte & Lames, 2019). The authors also found that passing sequences were longest in attack formations without a goalkeeper and shortest in the 6v5 formation. In the 7v6 formation the players in the back positions assume more importance and in the 5+1v6 formation the wing players interact more frequently. Interestingly, the interactions of the wing players were found to be higher in the 6v5 formations. Some advances have been made using passing networks in handball through examining the relevance of players according to different attacking formations. However, for the present, no studies have investigated how the relevance of a player's position relates to different defensive formations. The lack of studies regarding defensive formations has been highlighted in recent work, and caused the authors to call for further studies in this area (Korte & Lames, 2019)

Therefore the present study aims to characterise the interactions of players by examining the positional attacks across different defensive formations. Macro and micro levels of analysis will be used to assess the involvements of playing positions, the cohesion between players and their interactions. The aim is to identify: a) the positions that are more prevalent in attacks according to different defensive formations and b) the positions that are more prevalent in attacks according to match outcomes.

Methods

Sample

A total of six international matches of the EHF Champions League Men 2019-2020 Group A were selected for this study. All matches were from MOL-Pick Szeged (Pick) handball club. Three matches were played at home (Pick vs Celje, Pick vs Elverum, and Pick vs Flensburg) and three were played away (Zagreb vs Pick, Paris vs Pick, and Alborg vs Pick). Of the six matches, Pick won four (3 matches by 7 goals difference and 1 match by 5 goals difference), drew one, and lost one (5 goals difference). Hence the selected matches covered a range of team success for Pick. There was an average of 745 (SD = 68) passes for each game, constituting a total of 4,472 passes between players. An average of 373 (SD = 78) passes were coded for each team (max = 496, Celje; min = 300, Paris). The passes (edges) and the players (nodes) were represented in 12 network graphs (6 for MOL-Pick Szeged and 6 for each of their opponents).

Procedure

As with previous studies (Korte & Lames, 2019), only positional attacks were counted (counter-attacks were not annotated), meaning that both offensive and defensive players were in their playing positions. Considering the tactical formations, the following number of offensive and defensive players were used: 7v6, 6v6, 6v5, 6v4, 5v6, 5v5, 5v4, 6v6 without/goalkeeper (w/GK), 6v5 w/GK and 5v5 w/GK. 6v6 was the base formation and the others indicate two-minute disadvantage or goalkeeper substitution (7v6 and w/GK). For this study, the offensive playing positions were outlined as follows: centre back (C); left back (LB); left wing (LW); pivot (P); right back (RB); right wing (RW); and additionally pivot in 7v6 (P7). Considering that the GK is not involved in positional attacks, this node was not included in the analysis. The defensive systems considered for the analyses were the following: 6:0 and 5:1. Other defensive systems as 4:2, 3:3, 5+1, or 5+2 were not analysed because they were marginal or not used during the six matches by any of the teams. The annotation of the matches was performed using XPS Network software for video analysis. First and second data collections were performed with a 20-day interval (Clemente et al., 2015; Robinson & O'Donoghue, 2007). To ensure reliability of the data the percentage disagreement [(d = (100 x |difference between A and B|) / (average of A and B)] was calculated. A 10% of the overall data was assessed for reliability purposes. The percentage disagreement was 3%, thus meeting the requirements for observer agreement (Robinson & O'Donoghue, 2007).

Network analysis

For the 12 data sets obtained from the social network analysis of MOL-Pick Szeged and their six opponents a set of network metrics was computed using Gephi software (version 0.9.2). This software was also used for visual representation of the passing networks. Account was taken of completed passes by players of the focus team and the context of passing in terms of opposition defensive formation. Micro levels of analysis were used to measure players' centralities in the team. *Degree centrality* was taken to measure the activity of each player: "players with higher centrality are connected to more teammates than those with lower centrality. Thus, such nodes are believed to be more important for the overall network structure" (Clemente et al., 2016). Players with larger centrality scores are the ones that contributed more to their team's attack, using passes to interact with other players from their team. Macro levels of analysis were used to identify the network of the team. *Network diameter* is related to the distance between players of a passing graph as number of links (Clemente et al., 2016). According to the authors, in graph theory, two players are connected if a sequence of players exists and their connections are adjacent. Our database is of a fair size in relation to numbers of passes but small in relation to numbers of matches. We have therefore chosen to take a descriptive/semi-quantitative approach to reporting the results.

Results

Micro level of analysis

The passing networks in Figure 1 show the importance of players in back positions (centre, left, and right) in passes performed in attack formations of the teams. Regarding Pick attack, the centre back was the most prominent player in the majority of the matches, apart from match number 2 (against Celje), for which the left back was the most prominent. Regarding Pick's opponents, the left back is the post prominent player for three matches (Alborg, Celje and Flensburg), the centre back for two matches (Elverum and Zagreb), and the right back for one match (Paris).

Figure 2 shows the weighted degree centrality of Pick players and opponent team players in total and for the 6:0 and 5:1 defensive formations. Regarding the total values, it is possible to identify that Pick centrality was higher in match number 2 (140% vs average of 6 matches; against Celje) and lower in match number 4 (65%; against Flensburg); and the opponents' centrality was higher for Celje (118%) and lower for Paris (72%). Regarding 6:0 defence values, Pick (weighted degree) centrality was higher in match number 1 (173%; against

Alborg) and lower in match number 4 (31%; against Flensburg); and opponents' centrality was higher for Flensburg (152%) and lower for Alborg (52%). Regarding 5:1 defence values, Pick centrality was higher in match number 2 (165%; against Celje) and lower in match number 3 (5%; against Elverum); and opponents' centrality was higher for Zagreb (142%) and negligibly low for Flensburg and Paris.

Macro level of analysis
Figure 3 shows the comparison between Pick and the opponent teams of total passes for matches as a whole and against 6:0 and 5:1 defences. The total passes for Pick were only higher than their opponents in match number 5 (by 21%; against Paris; Pick lost this match). The passes against 6:0 formation were higher for Pick than opponents in match number 1 (by 270%; against Alborg; Pick won this match). The passes against 5:1 formation were higher for Pick than opponents in matches number 4 (294 : 0; against Flensburg; Pick drew this match) and number 5 (380 : 8; against Paris; Pick lost this match).

Table 3 shows network diameters and average path lengths for Pick and opponent teams. For Pick, both network diameter (ND = 3) and the average path length (APL = 1.4) were higher in match number 6 (against Zagreb). For the opponent teams, the network diameter and the average path length were higher for Alborg (ND = 3; APL = 1.4), Elverum (ND = 3; APL = 1.4) and Paris (ND = 3; APL = 1.4). The network diameter and the average path length against 6:0 formation were higher for Pick in match number 4 (against Flensburg, ND = 3; APL = 1.6); and against 5:1 formation were higher in match number 4 (against Alborg, ND = 3; APL = 1.6). The network diameter and the average path length against 6:0 and 5:1 formations were higher for for Alborg (ND = 3; APL = 1.6). For Pick, network diameter increased or remained constant for 6:0 and 5:1 comparisons for matches they won and average path length decreased 6:0 to 5:1 or remained constant for the matches they drew and lost. For opponents, network diameter increased, remained constant and decreased for 5:1 to 6:0 comparisons. For Pick, average path length increased or remained constant for 6:0 and 5:1 comparisons for matches they won and average path length decreased 6:0 to 5:1 for the matches they drew (Flensburg) and lost (Paris). For opponents, average path length was less for 5:1 than 6:0 with the exception of Elverum. For this limited sample, average path length provided somewhat better discrimination.

Discussion
This study aimed to identify the player positions that were more prevalent in positional attacks for different defensive formations and to find out about player positions in such attacks according to (a limited number of) match outcomes. Results indicated that the backcourt players are key players to attacks against the most frequently used defences. The importance of centre positions has been emphasised in previous studies in team sports (Korte & Lames, 2018), particularly the point guard in basketball (Clemente, Martins, Kalamaras & Mendes, 2015b; Fewell, Armbruster, Ingraham, Petersen & Waters, 2012;), the defensive midfielder in football and the centre back in handball (Korte & Lames, 2018). The relevance of the left and right backs has also been identified recently (Korte & Lames, 2019). Interestingly, a comparison of total passes per match between Pick and the opponent teams, and against 6:0 defences and 5:1 defences, showed that the total passes for Pick were only higher than their opponents in the match that Pick lost. The total passes against 6:0 formation were only higher for Pick in match number 1, and the total passes against 5:1 formations were higher for Pick in the matches that the team drew and lost. These results may indicate that passing network metrics can identify weaknesses of a team to particular defensive formations used by their opponents.

There are limitations to this research study, principally related to the nature and size of the sample and the unbalanced defensive formations identified. Using a bigger sample would increase the number of positional attacks against different defensive formations and enable statistical assessment of the tentative perspectives given for this work. Also, differences in numbers of attacking players were not considered. Future studies should take into account how temporary suspensions of players affect the passing networks of a team. Another aspect that was not included was the sequencing of passes, their relation to shots on goal and the performance outcomes. It is important to identify how passing network data for a team can relate to their shooting performance and to understanding of strengths and weaknesses in positional attack.

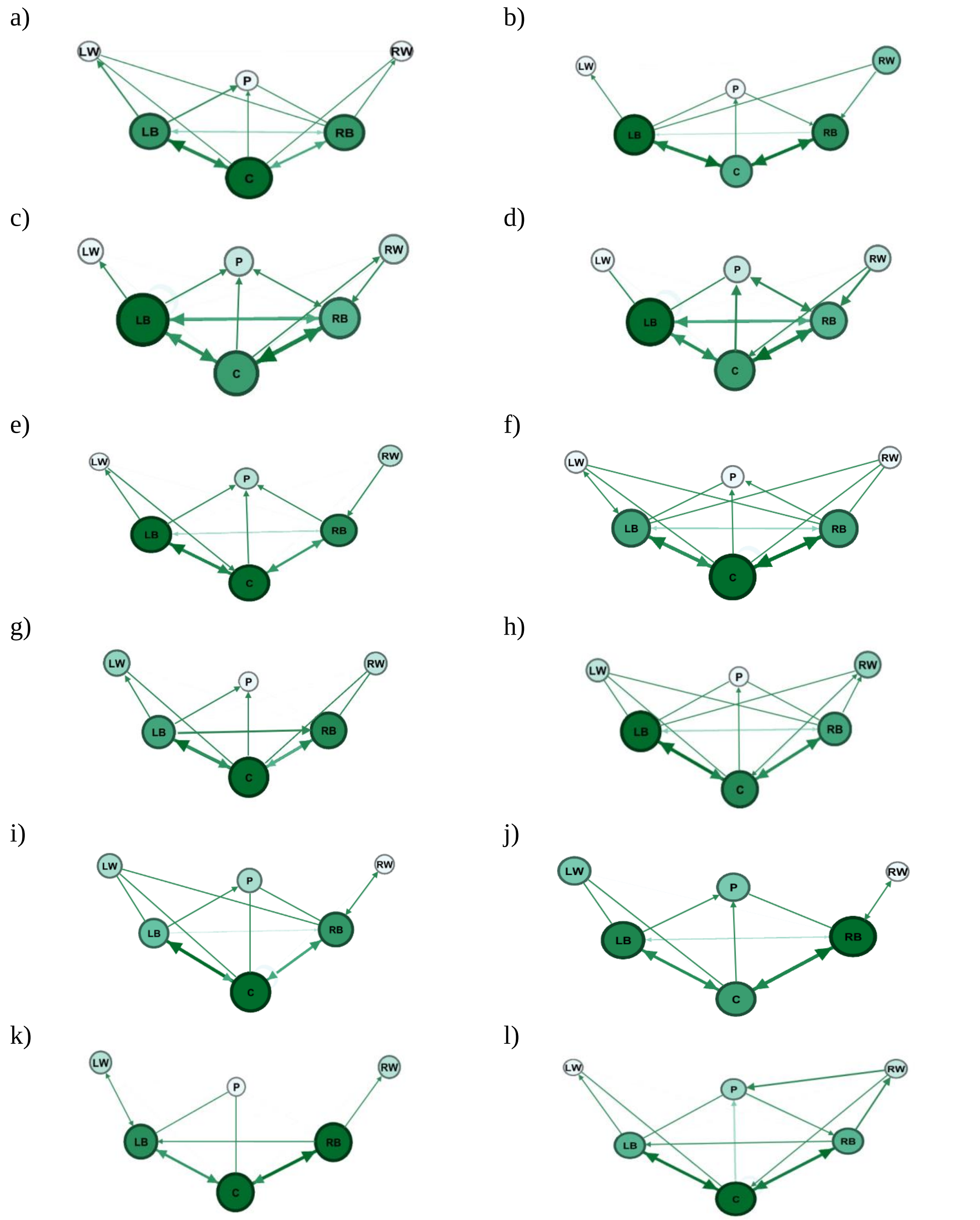

Figure 1. Network representation for the six MOL-Pick Szeged matches: a) Pick 1; b) Alborg; c) Pick 2; d) Celje; e) Pick 3; f) Elverum; g) Pick 4; h) Flensburg; i) Pick 5; j) Paris; k) Pick 6; and l) Zabreb.

Figure 2. Weighted degree centrality of MOL-Pick Szeged players and opponent team players: a) Pick total values per position; b) opponents' total values per position c) Pick values per position against 6:0 defence; d) opponents' values per position against 6:0 defence; e) Pick values per position against 5:1 defence; and f) opponents' values per position against 5:1 defence.

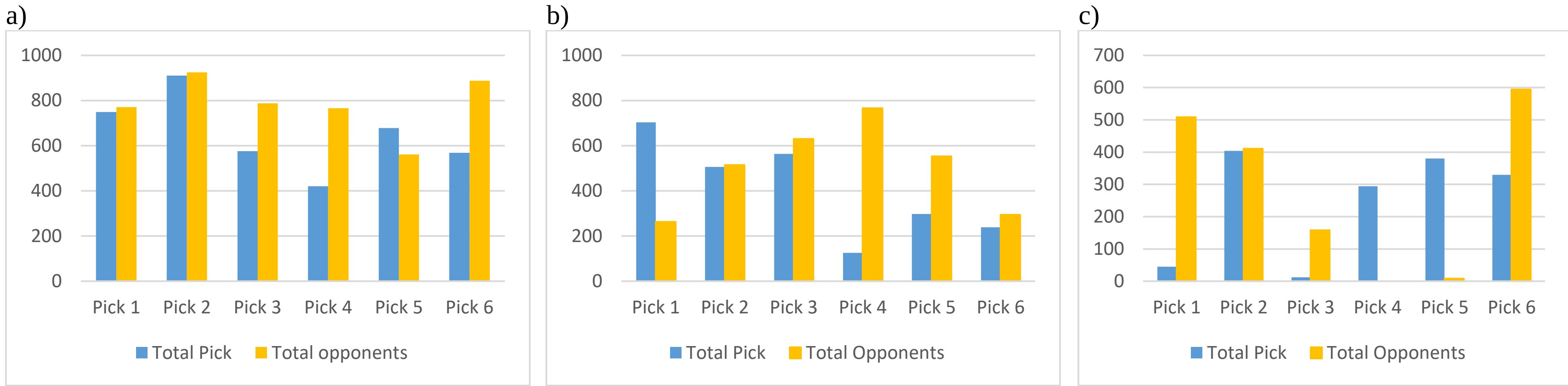

Figure 3. Comparison between the total passes of MOL-Pick Szeged and opponent teams: a) total passes per match; b) total passes against 6:0 defence; and c) total passes against 5:1 defence.

Table 3. Network diameter and average path length of MOL-Pick Szeged and opponent teams.

	Pick 1			Pick 2			Pick 3			Pick 4			Pick 5			Pick 6			Average			SD		
	6:0	5:1	T	6:0	5:1	T	6:0	5:1	T	6:0	5:1	T	6:0	5:1	T	6:0	5:1	T	6:0	5:1	T	6:0	5:1	T
Network diameter (ND)	2	3	2	3	3	2	2	3	2	3	2	2	2	2	2	3	3	3	2.5	2.7	2.2	0.5	0.5	0.4
Average path length (APL)	1.3	1.6	1.2	1.5	1.5	1.2	1.2	1.5	1.2	1.6	1.3	1.3	1.4	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.3	0.1	0.1	0.1
	Alborg			Celje			Elverum			Flensburg			Paris			Zagreb			Average			SD		
	6:0	5:1	T	6:0	5:1	T	6:0	5:1	T	6:0	5:1	T	6:0	5:1	T	6:0	5:1	T	6:0	5:1	T	6:0	5:1	T
Network diameter (ND)	3	3	3	2	2	2	2	3	2	2	0	2	3	2	3	3	2	2	2.5	2.0	2.3	0.5	1.1	0.5
Average path length (APL)	1.6	1.5	1.4	1.3	1.2	1.2	1.2	1.4	1.2	1.3	0	1.3	1.4	1.2	1.4	1.5	1.2	1.2	1.4	1.1	1.3	0.1	0.5	0.1

Conclusion

The present study indicated that passing network metrics may be relevant for the analysis of handball matches in identifying the most prominent player positions (and subsequently players) for the offensive process. In this work, micro and macro network metrics were presented in a semi-quantitative way as a proposal for improvement of the analysis of the attacking processes in handball. Six international matches of the EHF Champions League Men (2019-2020 Group A) were analysed for the MOL-Pick Szeged handball club. This investigation allowed us to identify the more prevalent player positions in positional attacks according to different defensive formations, and the more prevalent positions in the attacks according to match outcomes. This is the first handball study to consider positions in attack taking into account defensive formations. Backcourt players were the key players in attack against common defence formations and total passes for the Pick team were only higher than their opponents in matches that they drew and lost. These results may indicate review of passing networks can identify weaknesses of a team to particular defensive formations. Apart from expanding the scale of studies, future investigations should consider how temporary suspensions of players may influence attacks and relate passing networks to shooting performance.

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