Nagoya J. Health, Physical Fitness, Sports Vol.44, No.1 (May 2021)
DOI: 10.18999/njhpfs.44.1.18

Network centrality analysis to clarify the systematic defence performance of rugby union international test matches in 2014

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Abstracts

Purpose of this study was to clarify who plays the decisive role at the defence competitive situations in rugby union matches. To raise the evidence for discussing the defence structure, the current study focused on the defensive turnover situations in match and applied the social network analysis to organizational strategy and management.

Key word; Rugby Union, match analysis, network analysis

Introduction

Purpose of this study was to clarify who plays the decisive role at the defence competitive situations in rugby union matches. The decreasing numbers of try scores per match in the Rugby World Cup (6.9 tries in 2003, 6.2 tries in 2007, and 5.5 tries in 2011) suggested that the defensive capabilities have improved. To raise the evidence for discussing the defence structure, the current study focused on the defensive turnover situations in match and applied the network analysis to organizational strategy and management. The network analysis suggests the players' relationship structures in the organized teams (Duch, *et al*, 2010; Sasaki, *et al*, 2013a). Team matches would be constructed by some cooperative plays by the team mate. In these days' ball matches have been developed in highly complex mechanism so that the network analysis might clarify the evidence of dynamic balance mechanism like a defensive co-operation of team activities.

Method

Network analysis has been developed in communication-network studies as a graph theory (Sasaki, et al, 2013a, 2013b). The network has structure of both the vertices (players' positions) and the edge line (co-operation between team-mates in match). It shows which position plays a central role of two (or more) men tackle turnover. Data were derived from 14 matches of close and balanced scores of the international test matches in autumn 2014.

To understand the multi (two or more) men positional relation structure, the frequencies of those multi men tackle turnover were plotted in the adjacent matrix (15×15). Calculating centrality was a major focus of social network because it indicates who occupies critical positions in the network. There some centrality measures those are derived from the adjacency matrix and constitute different mathematical computations on the same underlying data (Valente, *et al*, 2008). Our previous study used a degree centrality and an eigenvector centrality which were most commonly used by network analysts. Eigenvector (C_{ev}) centrality is directly dependent on the centrality values of its connected neighbours. A high centrality value of the neighbours should result in a high centrality for the vertex under consideration. (Junker and Schreiber, 2008) For a given graph $G := (V, E)$ with $|V|$ vertices and $|E|$ edges let $A = (a_{v,t})$ be the adjacency matrix, i.e. $a_{v,t} = 1$ if vertex v is linked to vertex t , and the numbers will increase depending on the number of connections. $a_{v,t} = 0$ if there is no connections between the vertices. λ is a scalar.

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$$C_{ev}(i) = \frac{1}{\lambda}\sum_{j=1}^{n} a_{ij}\, C_{ev}(j)$$
$$AC_{ev} = \lambda C_{ev}$$

In the present study, we used the Katz centrality as a variant of eigenvector centrality, and we include the potential intimacy relationship within the positional co-operations. We assume the "β = 0.07" which means a one fifteenth contributor's coefficient by a rugby union team player.

$$x(i) = \alpha \sum_{j=1}^{n} a_{ij}\,(x(j) + \beta)$$

Current study had the two original viewpoints. The first thing is that the graph drawing includes not only the tackle turnover but also the forward (number 1 to 8) unit play of scrum and lineout turnover. Scrum and lineout are the original unit playstyle of rugby union and the crucial match situation. This layout is called as a bipartite graph or an affiliation network which shows the personnel belonging to some unit organizations. The second thing is that we apply a unique statistical approach to understand and interpret the difference or similarity of the network centrality among the teams.

Results and Discussion

The map layout (figure 1-A and 1-B) was calculated by using the Fruchterman-Reingold Algorithm (1991), which is a force-directed layout algorithm for aesthetical graph drawing the centralization of the multi men tackle contributors' positioning. The purpose was to position the vertices of a graph in two- or three-dimensional space so that all the edges were of approximately equal length and with as few crossing edges as possible (Eade, 1984; Kamada and Kawai, 1989; Inoue, et al., 2012). The force-directed algorithms achieved this by assigning forces among the set of vertices and the set of edges. The forces were applied to the vertices, pulling them closer together or pushing them further apart. This was iteratively repeated until the system reached an equilibrium state. Results showed some contributors which mapped centrally in the graph by rugby positions.

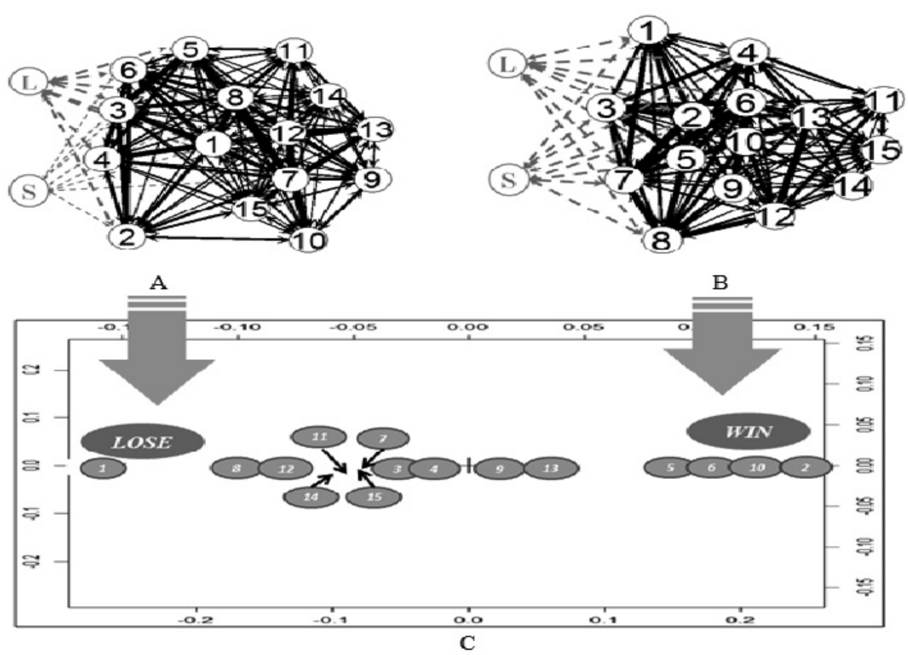

Figure 1. Multi men tackle turnover contributor's network mapping with added lineout and scrum turnover by force-directed placement (Katz centrality) at 2014 Rugby Autumn International matches (1-B; Right; winners, 1-A; left; losers, Comparatively bold black line showed more than frequencies of multi men tackle turnover partners: L: lineout turnover, S: scrum turnover, Comparatively bold grey dot line showed more than frequencies of lineout / scrum turnover, 1-C; Centering resonance analysis (correspondence analysis) between "win" and "Lose" by the multi men tackle turnover contributor's mapping).

3-1. Difference between win and not-win

Positive defence system would be performed by team-mates' cooperation of the successive pressure, cover and communication (Sasaki, 2013a). The effective defence is a key component to a platform for potential counter attacks (Fuller et al., 2007). In figure 1-A and 1-B, in the winning side, the positions of "2" (Hooker; centre of front row forward), "5" (lock; second row forward), "6", "7", (Back row Forwards), "10" (Fly-half backs) and "13" (centre three quarter backs) were mapped centrally. In the losing side, "1" (prop; front row forward), "8" (Back row Forwards), and "12" (centre three quarter backs) were mapped centrally. Those included almost multi positions like as the winning sides. However "10" was not mapped centrally. Does the Defence performance of "10" have some important role or not? Our previous study suggested the centre three quarter backs (position "12" and "13") in rugby union played the central and balanced role of the other backs positions and the back row forwards (position "6", "7" and "8") and hooker (position "2") played a linking role between forwards and backs to fill a gap, to deny the opposition the initiative, to harry them into confusions, and if possible to get turnover (Greenwood, 2003, p30). The current study suggests the number "10" fly half might have the tactical importance in these days' matches. This position has a great role for making decision and leading the strategy at the offensive situations. If he also has to make dedicated efforts in very tough defensive situations, the position player must have supreme physical performance for his accumulated roles.

Lineout turnover and scrum turnover were mapped on the both of the winning sides and the losing sides. However, the frequency of the scrum turnover of the winning sides was comparatively higher than the losing sides. In these days rugby union rules, the competitive advantage of scrum would be the important factors. This result may suggest that evidence.

Network graph analysis can verify the difference or similarity between some graphs. The correspondence analysis (Figure 1-C), which applies a technique known as a centering resonance analysis to the graphs, was examined to clarify the similarities and to compare the network centrality. To maximize the relationship between row and column items, correspondence analysis sort both rows and columns. As for the calculation result from the axial contribution ratio, the accumulated contribution ratio on the second axis is 100% (100%, 0.00%). It suggested this data information was represented enough. In the figure 1-C, the winning side were plotted the right side characterized "2", "10", "6", and "5", and the losing side were plotted the left side characterized "1", "8", and "12". This analysis might also suggest the number "10" fly-half has some effective role in the defence system as a midfield position.

3-2. Difference among the Unions

We next analysed the multi men tackle turnover on the each union. Fig 2 presented the World Rugby Top ranking teams (A; 1^{st}, B; 2^{nd}, C; 3^{rd}, D; 5^{th}, E; 6^{th}, F7^{th}; 4^{th} team was omitted because we had only one match data of that). Each union showed who carry out the central defensive role. As

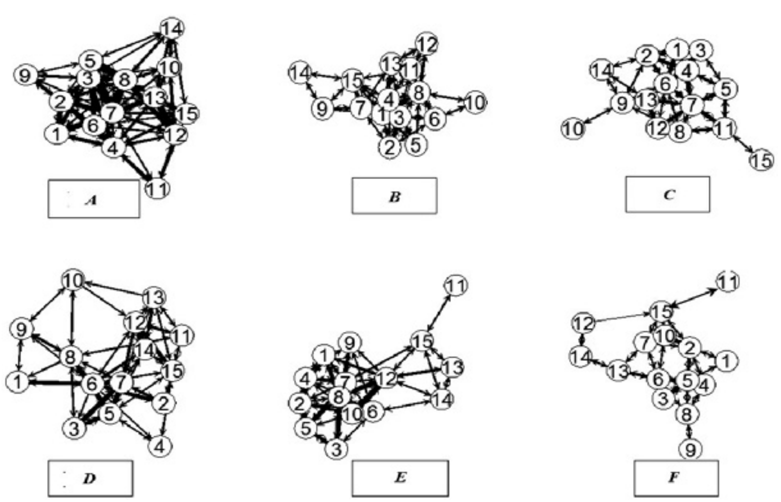

Figure 2. Multi men tackle turnover contributor's network mapping on the world rugby top ranking unions (A; 1^{st}, B; 2^{nd}, C; 3^{rd}, D; 5^{th}, E; 6^{th}, F; 7^{th}; the 4^{th} was omitted because we take only one games of that)

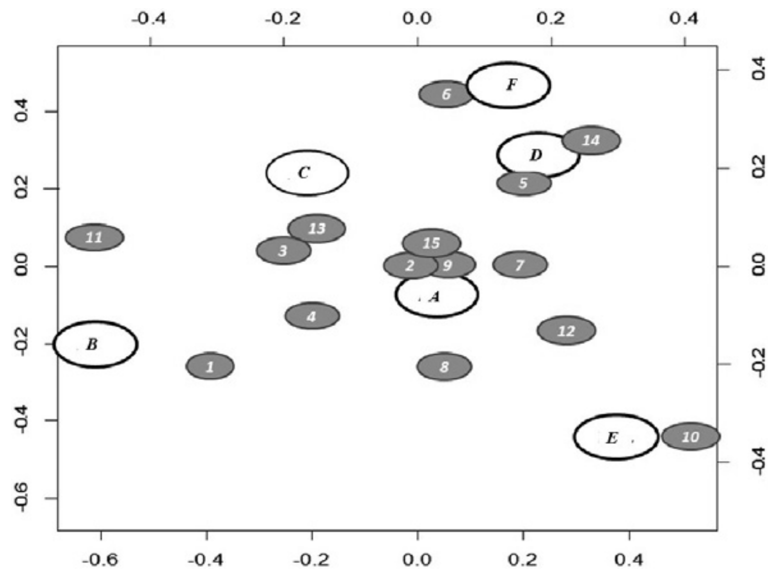

Figure 3. Centering resonance analysis among the top ranking unions in the world by the multi men tackle turnover contributor's mapping at 2014 Rugby Autumn International matches.

a different point of view, it showed who might perform the comparatively solitary defensive role.

Figure 3 presented the Centering resonance analysis (correspondence analysis). In figure 3, team A might be positioned centrally balanced team and the other unions positioned separately which has some characterized defensive contribution or not. It showed that the southern hemisphere unions were plotted in the left space and the northern hemisphere unions were plotted in right space. Team C and D were comparatively similar distance space from team A. On the other hand, team B, E, and F were some special characteristics comparing with team A, C and D or not? As the concerning with above mentioned discussion, the role of turnover contributing role of Fly half, number "10", characterized in team E. Is the number "10" a characteristic of Team E's defence system? Is the Number "6", the captain, a characteristic of team F's defence mechanism? For the detail and the objective interpretation of the complex team factors, we need to analyse more matches. However, the numbers of the international test matches among the unions are not so many times in one year. It would be our future tasks. The results would also suggest some strategic and tactical knowledge for planning in the game, practice, and the communication situation concerning team and/or match centrality.

In conclusion, the network Analysis would be one cruel for understanding the complex sport scenes. And the calculating centrality is one of major focus of social network because it indicates who occupies critical role in the network.

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