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Network Centrality and Core-periphery Analysis to Clarify the Tactics for Try in Rugby World Cup 2019

Koh Sasaki[1, *], Takumi Yamamoto[2], Ichiro Watanabe[3], Mitsuyuki Nakayama[4], Kensuke Iwabuchi[4], Takashi Katsuta[5], Ichiro Kono[6]

[1]Research Center of Health, Physical Fitness and Sports, Nagoya University, Nagoya, Japan
[2]Department of Physical Education, National Defense Academy, Yokoasuka, Japan
[3]Department of Physical Education, Tokyo City University, Tokyo, Japan
[4]High Performance Committee, Japan Rugby football Union, Tokyo, Japan
[5]High Performance Sport Centre, Japan Sport Council, Tokyo, Japan
[6]Governing Board, The Tokyo Organizing Committee of the Olympic and Paralympic Games, Tokyo, Japan

Email address:
sasakikoh@htc.nagoya-u.ac.jp (K. Sasaki), takumi@nda.ac.jp (T. Yamamoto), ichirojukucho@gmail.com (I. Watanabe), nakayama@rugby-japan.or.jp (M. Nakayama), kensuke.iwabuchi@gmail.com (K. Iwabuchi), t-katsuta@nifty.com (T. Katsuta), ichiro.kono@j-fairness.org (I. Kono)
[*]Corresponding author

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Abstract: After the first World Cup 1987, rugby undergoes rule revisions aimed at more dynamic games. There have been some analyses of the KPIs (Key Performance Indicators) so far, but not many ones as detailed dynamic network structure of tactics concerned with selected attack and defense areas, plays, and human resources. In current study, the tactics for try in Rugby World Cup 2019 was investigated by network centrality, core-periphery analysis and correspondence analysis. Bootstrap test and ROC analysis were used to validate the data of try contribution structure. The average score of try balance of final 8 teams was "3.94" and that of "not win" teams was "-2.23". We categorized these indices into team performance, and tested Monte Carlo methods with bootstrap hypothesis testing to assess the standardized values. Furthermore, to test the precision of sensitivity and specificity of standardized try balance values, the Area Under the Curve (AUC) of the receiver–operator curve (ROC) analysis was executed. In final 8 stage, the feature of tactics for try in first 20 minutes and last 20 minutes were analyzed. The results suggested the tactics of "attack channel diversity" in first 20 minutes and tactics of "defense and substitute diversity" in last 20 minutes. In addition, network correspondence analysis of the top 4 teams' performance in the tournament yielded interesting results regarding tactics of the attack and defense methods, and of the transition of human resources.

Keywords: Network Centrality, Core-periphery, AUC Curve of ROC, Correspondence Analysis, Rugby World Cup 2019, Performance Analysis

1. Introduction

After the first World Cup 1987, rugby undergoes rule revisions aimed at more dynamic games. In 1992, the try score increased from 4 to 5 points. In 1994, the "use it or lose it" rule was created. If the ball cannot be moved from the maul formed by the attacking side, it becomes the oppose' scrum. These would be modifications for the importance of the try increase and the ball moving for the try dynamically. In 2014, the number of substitutes increased from seven to eight in order to further expands human resources.

We have conducted some analyses which contribute to the win or not win in rugby games, especially defense performance [1, 2]. Organized and robust defenses would be required to win in the knockout tournaments such as the Rugby World Cup final 8 stage. Of course, the attacking ability to break the oppose' defense would be also required in the game. There have been some analyses of KPIs (Key Performance Indicators) [3-5] so far, but not many ones as detailed dynamic network structure of tactics concerned with selected attack and defense areas, plays, and human resources. Here, we would like to focus on the tactical network structure related to try which would greatly contribute to the win or not win in the rugby union game. Our last study of attack and defense analysis of rugby sevens revealed that they formed world ranking clusters with the ability to get own tries and the ability to defend oppose' tries [6]. In rugby union (15 players' rugby), total 30 players fight with complex attack and defense tactics. It would be effective to use recent data statistical approaches for the analysis.

Network analysis could elucidate the cooperative structure among the factors of the organization. This approach has been developed in many practical science areas to understand the behavior and tactics. Network analysis has been started in the field of communication network studies [7, 8]. Some traditional approaches focusing on network relationships were introduced from 1960 to 1970, including the "small world phenomenon", "the strength of weak ties", and "scale free network". Specification of the "cluster community" or "sub-group network" were also developed to determine with core-periphery structure [9]. Sociological predictive models are widely used in the field of information technology [10] and cerebral functions in biology [8, 11, 12].

Network analysis has been applied in sociological and biological approaches in sport sciences. As the sociological approaches, there are socio-psychological investigations on how sports support the cooperation values within a specific society [13, 14]. In addition, political and economic studies have been reported that declining the sports, exercise, and health promotion activities have negative impacts on the civil society [15-17]. Biological approaches include discussions on the causes of sports injuries [15, 18, 19]. Some core factors in physiological parameters during exercise-induced fatigue were clarified and discussed with the risk management for human health [15]. Various performance indicators in sports had also been investigated which involves some competitive dimensions [20-22, 2]. One study suggested that soccer team has core players, so-called hub, in the passing behavior study of game. The core players' transition was discussed on a power law model. The hub role switched dynamically throughout the game [22]. The difference between dynamic networks and static networks could be understood that the former focuses on diverse and tactical players' transition occurring in sports games.

A key role of network analysis would be to identify the decisive and practical core structures, and to achieve a particular goal across complex networks. The centrality is currently discussed with the methods for elucidating the boundary between core and peripherality [9, 23]. Furthermore, network centrality-core approach might clarify the temporal transition and multi-layered structure of the organization. It helps to understand the driving force of network dynamism [24-26]. This study focuses on the selection of game space, the method of attack and defense, and the transition of human resources for try in rugby union. Applying recent data statistical approaches could clarify the contribution structure.

2. Materials and Methods

Selected play channel and tactics for analysis were defined as shown in the figure 1. The play space was divided by the relative distance from the set piece or breakdown position before the start of the play by channel. The tactics were extracted from the play performed on the channel.

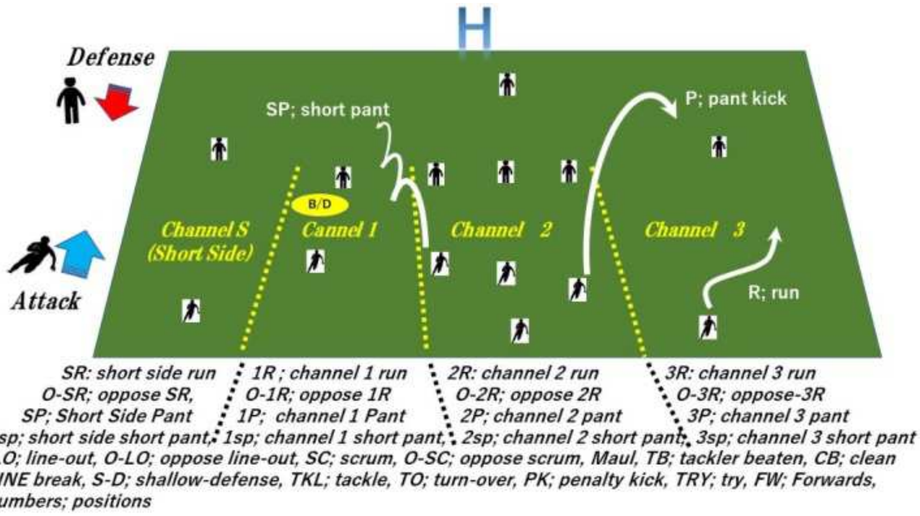

Figure 1. *Definition of attack / defense channels and analyzed tactics classification (channels are supposed to be between people, and in reality, no line is drawn on the ground. BD is the starting point for attacks such as Scrum and Breakdown. If this is near the center, channel S disappears and becomes channels 1, 2, or 3. Channel 3 is operationally defined as a single outer space. Channels 1 and 2 are often used for gain-line fights as near the starting break-down area, and channel 3 is used more dynamic open-running situations).*

Firstly, we verified that the try contributes to win in rugby union game or not. Bootstrap test and ROC analysis were used with reference to previous studies to validate the data of try contribution structure [20, 2]. Subjects were 38 games in the qualifying pool games and 8 games in the final 8 stage of Rugby World Cup 2019. On the pool stage, two cancelled games were excluded from the analysis, resulting in 38 games from 40. Try balance data were standardized in game of all 20 teams on the pool qualifying stage and final 8 teams. We use ROC (Receiver–Operator Curve) analysis [27, 22, 2] about whether got out of the pool stage or not (1 or 0).

Dynamic transition of tactics can be analyzed from the different try structure charts between the first 20 minutes and the last 20 minutes in a game. Correspondence analysis is used to find out which tactics and position are central function in a game. Correspondence Analysis, a method of Centering Resonance Analysis, could evaluate the similarity and uniqueness between the first 20 minutes and the last 20 minutes try by the axis contribution rate peculiar to graph analysis.

A try in rugby is allowed when the attacking player touches the ball into the opponent's in-goal area. A complex attack and defense will be developed by total 30 players. We tracked every play from the starting point (set pieces and breakdowns) to the try. From the network structure of the play and position, the centrality, core-periphery structure would be clarified. We can understand the network centrality tendency by degree centrality, betweenness centrality, and eigenvector centrality.

The network does not always have a complete core-periphery structure. We then use a genetic algorithm to find the optimal core-periphery division. It maximizes the correlation coefficient between the network under analysis and the complete pattern matrix. From the maximized “fitness function values”, we can solve the core vertices position. Furthermore, we analyze that each of the top four teams has what kind of the network centrality, the contribution play and the position for try.

The graphing placement algorithm could be easy to grasp by the Force-Directed model. In the model, an attractive force acts between the vertices connected by the edges, and a repulsive force acts between the vertices that are not connected. The coordinates of the points are determined so that the arrangement is as mechanically balanced as possible. In this study, we use the Fruchterman-reingold model, which is a Force-Directed model with such characteristics [28].

3. Results

3.1. Try Balance Value

We calculated the inter-team performance of try balance.

δ_n; try balance in a game

The average score of try balance of final 8 unions was 3.94 and that of not win unions was -2.23. We hypothesized these to be the indices of win. To validate this hypothesis, we categorized these indices into team performance that resulted in actual match win or not win. This helped us determine the distribution of conditional probabilities of the results.

P (δ_n |outcome)

Here, the outcomes are ∈{“Win,” “ Not win”}. Figure 2 shows the cumulative distribution of δ_2 for these two outcomes. Figure 2 shows that teams with higher δ_2 evidently contributed to wins. (Figure 2, Upper, pool stage: Lower, final 8)

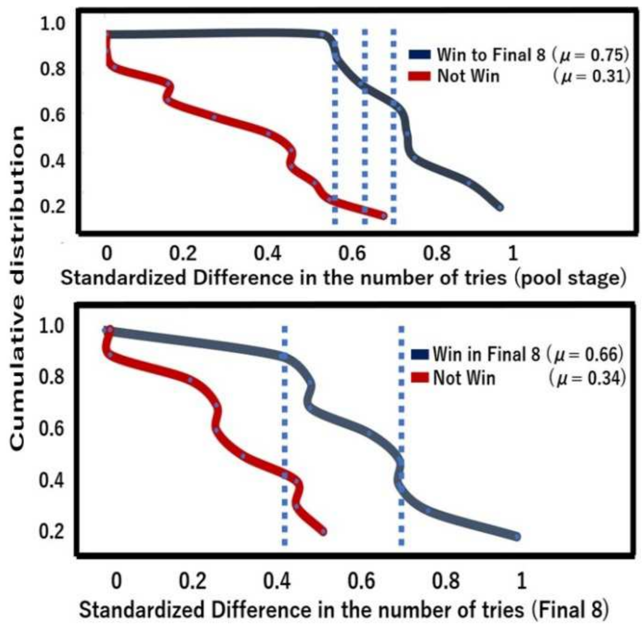

Figure 2. *Cumulative distribution of δ_2 for matches where the team with higher performance wins in the pool stage (Upper) and final 8 stage (Lower) in Rugby World Cup 2019.*

We set the following to assess the significance of the results.

$$\Delta_n^{outcome1,outcome2} \equiv \int_0^{\infty} d\delta_n \delta_n (P(\delta_n|outcome_1) - P(\delta_n|outcome_2)).$$

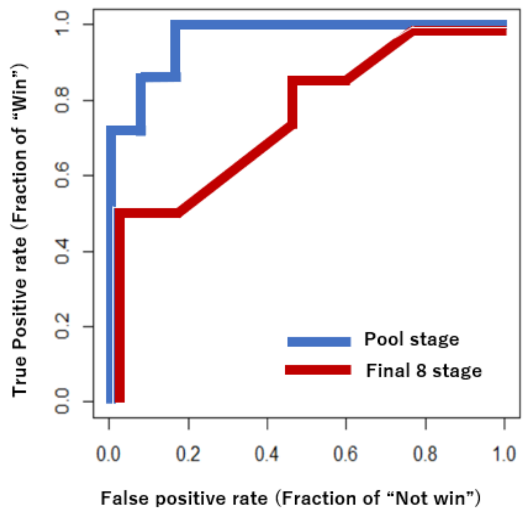

Figure 3. *Sensitivity and specificity of try balance value by AUC.*

Monte Carlo methods with bootstrap hypothesis testing to assess $\Delta_2^{outcome1,\ outcome2}$ were used [20, 29, 2]. We pooled the values of δ_2 from the 20 teams (total 38 pool games) in Rugby World Cup 2019, and drew surrogate random samples from the pooled data, with replacement. “Win” and “Not win” samples were drawn with 8 and 12 data points, respectively. The difference in means of the two surrogate samples was then determined. This procedure was repeated 50,000 times to determine the significance of the observed

$\Delta_2^{Win,\ Not\ win}$. A strongly significant difference in mean δ_2 was found between the "Win" and "Not win" outcomes (bootstrapping p value <0.01, Figure 2, Upper). This procedure also used with final 8 stage, 8 matches. The average score of try balance of "Win" game was 2.25 and that of "Not win" game was -2.25. Results also shows strongly significant difference in mean δ_2 (bootstrapping p value <0.01, Figure 2, Lower). The value δ_2 was possibly valid as an objective index of performance. Furthermore, to test the precision of sensitivity and specificity of δ_2, we analyzed the area under the curve (AUC) of the receiver–operator curve (ROC) [27, 20, 2]. In relation to all the varying values of δ_2 that are quantified values of try balance, we calculated the fraction in the "Win" and "Not win" groups. The closer the value of AUC was to 1, the higher the sensitivity and specificity, i.e., accuracy (Figure 3). An AUC value was 0.96 which suggested very high accuracy (n = 20: Blue line in Figure 3).

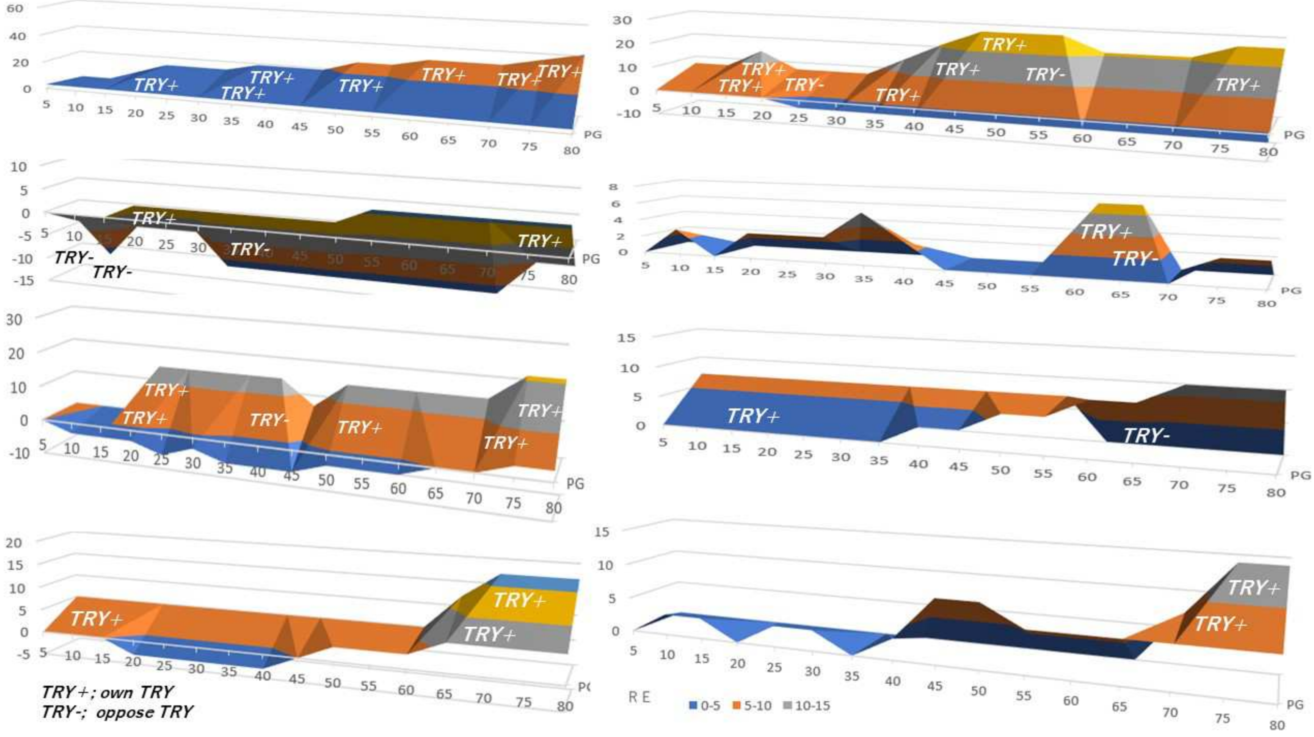

Figure 4. *Cumulative transition of points (TRY, PG) in the final 8 games in Rugby World Cup 2019.*

The highest score was obtained with three cut-off values of 0.75, 0.65, and 0.55 at three locations (value 0.75; "Sensitivity"; rate to evaluate the right thing correctly, True Positive rate=71%, "1-specificity" (False Positive rate; falsely evaluating negative as positive; The smaller the better)=0%, value 0.65; "Sensitivity"=86%, "1-specificity"=8%, value 0.55; "sensitivity"=100%, "1-specificity"=17% (Figure 2, Upper, blue bot lines). In each case, the highest value of 89% was obtained for the correct evaluation rate (qualifying pass rate). In this way, ROC curve was obtained that evaluated 89% that the team with larger try balance would break through the qualifying.

We also analyzed the ROC analysis whether the try balance contributed to "Win" or "Not win" in all matches of the final 8 tournament (Red line in Figure 3). The try balance for each game was also performed based on the outcome (1 or 0). The number of games of final stage had been reduced from 20 teams in qualifying. Therefore, the ROC curve was drawn with gentle curve. However, the AUC value was relatively positive (AUC=0.79) with two highly accurate cut-off values of 0.42 (sensitivity=88%, false positive rate=43%) and 0.71 (sensitivity=50%: False positive rate=0%). Maximum correct evaluating rate was 57% (Figure 2, Lower, blue dot lines). Here, the try balance (δ_2) in final 8 stage could also be suggested as a "Win" or "Not win" deciding indicator.

The figure 4 showed the scoring process in the final tournament 8 games. It was inferred that there would be a tactical transition in the second half. Therefore, the validity of the feature extraction was evaluated by calculating the unique axis contribution rate from the graph analysis approach in network analysis. That could reveal the tactical networking dynamism to the try changed over time.

3.2. Network Centrality, Core-periphery Values

The extracted centralities were shown in Table 1. As contribution play tactics to the try in first 20 minutes (0-20 minutes), "1R (1 channel Run)", "2R (2 channel Run)", "3R (3 channel Run)", "T-B (Tackler-Beaten)", "C-B (Clean-Break)", as contribution positions, "8 (Forward)", "9", "10" (Half-Backs) were extracted. In addition, as a contribution play tactics to the try in last 20 minutes (60-80 minutes), "1R", "T-B", "TKL (Tackle)", as contribution positions, "8", "9", "10", "16", "17", "18", "19" (16-19 were substitute players) was extracted.

Table 1. *Network centrality values of degree (Deg), betweenness (Bet), and eigenvectors (Eig) of contributors in groups (Tries in first 20 and last 20 minutes in pool stage games, top 4 teams at tries in last 20 minutes of final 8 games: The yellow fill means the top 10 items in each row).*

	Try in first 20 mins.			**Try in last 20 mins.**			**A**		**B**		**C**		**D**	
	Deg	**Bet**	**Eig**	**Deg**	**Bet**	**Eig**	**Deg**	**Eig**	**Deg**	**Eig**	**Deg**	**Eig**	**Deg**	**Eig**
PC	3	1	0	8	14	0.03	3	0.07	1	0.01	4	0.10	5	0.03
1R	84	70	0.65	69	140	0.57	6	0.28	11	0.40	36	0.61	8	0.8
2R	27	29	0.18	11	17	0.07	1	0.03	4	0.40	9	0.11	9	0.16
3R	27	34	0.16	12	13	0.05	1	0.04	2	0.28	5	0.01	6	0
3P	5	0	0	7	11	0.02	2	0.03	1	0.13	5	0.03	0	0
3sp	5	3	0.02	1	0	0.00	2	0.07	0	0.00	1	0.01	0	0
SR	3	2	0.02	8	13	0.03	1	0.05	0	0.00	11	0.20	5	0
Ssp	0	0	0	3	2	0.01	7	0.32	0	0.00	3	0.02	0	0
T-B	12	31	0.06	20	44	0.16	4	0.32	5	0.30	13	0.57	8	0.47
C-B	14	30	0.8	9	27	0.04	7	0.17	2	0.09	6	0.10	3	0
D-S	10	1	0.01	2	0	0.01	10	0.12	0	0.00	0	0.00	0	0
TKL	12	30	0.05	51	155	0.37	8	0.19	2	0.08	13	0.12	0	0
T-O	0	0	0	8	18	0.06	5	0.14	3	0.07	20	0.24	1	0
TRY	12	10	0.07	14	28	0.07	2	0.20	2	0.00	4	0.04	0	0
PI	0	0	0	1	0	0	5	0.00	1	0.00	0	0.00	0	0
SC	0	0	0	0	0	0	1	0.01	1	0.01	4	0.03	2	0.14
LO	0	0	0	0	0	0	0	0	1	0.08	4	0.08	2	0.02
FW	0	0	0	0	0	0	1	0	0	0	0	0	7	0.16
Maul	0	0	0	0	0	0	0	0	0	0	0	0	2	0.06
1	14	4	0.25	0	0	0	0	0.00	2	0.12	3	0.07	0	0
2	10	9	0.14	5	1	0.07	0	0.00	0	0.00	4	0.20	0	0
3	12	0	0.25	1	0	0.02	0	0.00	2	0.02	0	0.00	0	0
4	9	12	0.11	1	0	0.02	0	0.00	0	0.00	5	0.12	0	0
5	9	1	0.17	10	9	0.16	0	0.00	0	0.00	3	0.15	1	0
6	16	24	0.19	10	5	0.17	5	0.00	3	0.21	3	0.08	1	0.02
7	14	6	0.24	11	5	0.18	7	0.21	4	0.23	1	0.03	1	0
8	16	5	0.27	17	20	0.21	1	0.27	0	0.00	3	0.09	2	0
9	24	36	0.27	12	29	0.12	7	0.04	6	0.39	3	0.00	0	0
10	20	23	0.17	18	74	0.13	7	0.31	8	0.41	1	0.01	0	0
11	12	20	0.08	12	16	0.09	8	0.28	5	0.27	1	0.00	2	0.15
12	13	11	0.12	9	21	0.09	0	0.25	4	0.26	1	0.00	0	0
13	12	26	0.08	7	12	0.04	6	0.16	3	0.22	3	0.01	0	0
14	4	1	0.02	9	49	0.04	1	0.13	2	0.04	2	0.00	2	0
15	14	22	0.12	11	53	0.03	5	0.13	1	0.04	5	0.09	0	0
16	0	0	0	14	5	0.26	8	0.34	0	0	0	0.00	0	0
17	0	0	0	18	9	0.29	4	0.15	0	0	0	0.00	0	0
18	0	0	0	15	10	0.25	7	0.23	0	0	0	0.00	0	0
19	0	0	0	14	10	0.24	4	0.14	0	0	2	0.14	0	0
20	0	0	0	9	6	0.16	1	0.05	0	0	1	0.00	0	0
21	0	0	0	7	8	0.07	3	0.11	0	0	1	0.00	1	0
22	0	0	0	8	9	0.06	0	0	0	0	1	0.00	0	0
23	0	0	0	6	7	0.06	4	0.11	0	0	0	0.00	0	0

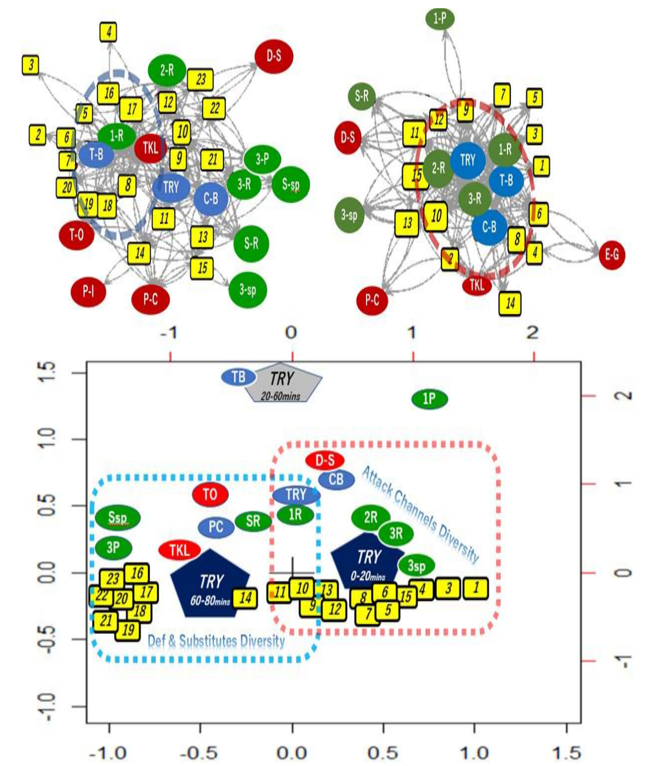

Figure 5. Correspondence analysis showing contributors' mapping of similarity or uniqueness between tries in first 20 and last 20 minutes in final 8 stage at Rugby World Cup 2019.

Network graph structure were shown in Figure 5 (Upper Right, tries in 0-20 minutes; Upper Left, try in 60-80 minutes: Lower, correspondence analysis). Each core border was drawn with a dotted circle line. Using a genetic algorithm, the optimum core-periphery dividing lines were obtained. The values of the coefficient maximize the correlation coefficient between the analyzed network and the pattern matrix. The coefficients were 0.47 for tries in 0-20 minutes and 0.43 for tries in 60-80 minutes. These showed medium high values. The core group could be extracted.

We conducted a correspondence analysis for a detailed view among "tries in 0-20 minutes", "tries in 60-80 minutes", and "tries in "20-60 minutes" as a dummy value [12, 2] (Suzuki, 2009: Sasaki et al., 2017). This centering resonance analysis could develop a relative comparison of the vertexes that were common among the multiple networks. In addition to the characteristics among the try groups, this analysis could allow us to grasp the similarities and uniqueness within a specific group. To maximize the relationship between row and column items, correspondence analysis sorts both the rows and columns to identify the relationships between them. In the axial contribution ratio, the accumulated ratio on the second axis was 100% (75.61%, 100.00%), suggesting that the data was adequately represented.

We also analyzed the same procedures of network centrality, core-periphery analysis and correspondence analysis among the top four teams in the final 8 stage for understanding the last 20 minutes battle characteristic (Table 1, Figure 6). Network core border coefficients were A=0.47, B=0.47, C=0.47, D=0.48. These suggested also medium high values like above-mentioned analysis. In the axial contribution ratio in correspondence analysis, the accumulated ratio on the third axis was 100% (47.82%, 78.00%, 100.00%), suggesting that the data was also adequately represented.

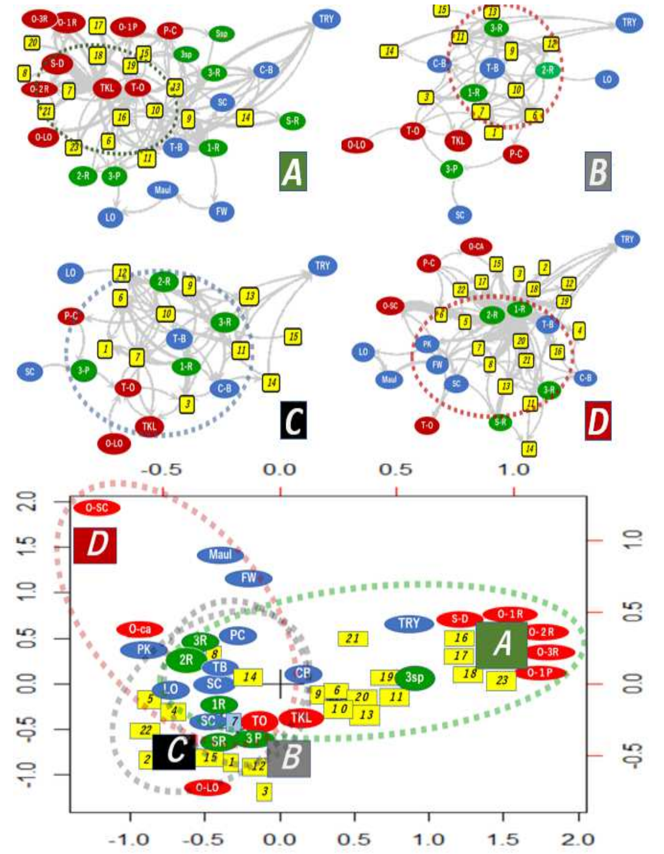

Figure 6. Correspondence analysis showing contributors' mapping of similarity and uniqueness between tries in last 20 minutes battle in final 4 union at Rugby World Cup 2019 (Upper left; A, Upper right; B, Second left; C, Second right; D, Low; Correspondence analysis).

4. Discussion

In both of the pool stage and the Final 8 stage, it was suggested that the try balance could contribute to the outcome. Teams which broke through the qualifying pool had an average value 3.94 try balances, and teams which could not break through had an average -2.23. Furthermore, the teams aiming for the top place tended to have an advantage of try balance values in the final stage. The effectiveness of boat strap test and ROC analysis by standardized try balance coefficients were shown [27, 20, 29, 2].

The feature of the try in the first 0-20 minutes was to move the ball in various channel areas with space tactics. Keeping power in breakdown fight in 1R (1 channel run attack) and 2R (2 channel run attack) would be showed. In particular, the number of fights in 1R sometimes exceeded 20 phases. A power skill called T-B (tackler beaten) would be required as a team. Therefore, by stopping the defense in 1, 2 channel areas, the 3R (3 channel run attack) space would expand greatly [30] (Greenwood, 2003). Here, the role of assembling the attack was depend on not only the number 10 (fly-half), but also on many FW (forward) players' contributions. Using only number 10 for the fight here would slow down the transition to subsequent attacks and increase the risk of excessive physical exhaustion for him [2].

The common feature, that is, the power fight and power skill of T-B located in the upper area at the lower of Figure 6, might be the feature of modern breakdown rugby. However, T-B could be played by premising of high physical ability of top-level rugby, and it might be cautious refer in youth rugby [31, 32, 19].

1P (1 channel pant) was also positioned as a common feature. 1P includes kicks from the number 9 position (scrum-half), which have been increasing in recent games. It would be interesting analysis of attack tactics distinguishing the kick in 1 channel by number 9 with the other positions to clarify its effectiveness (e.g.: destination, ball flight time). Kick tactics are systematic tactics which include not only punt types (i.e.: pant, short-pant) and channels (i.e.: 1, 2, 3, Short-Side), but also so-called air skills such as P-C (pant catch) skill with the competitive high-ball catching fights. Punt studies in other football codes might be also useful [33]. As mentioned above, the try feature in the first 0-20 minutes were formed by channel diversity which means the tactics of creative moving the ball quickly within the channels for C-B (clean break).

On the other hand, as the try feature in the last 20 minutes, the contribution of the substitute players, number 16 to 23, and the defense by TKL (tackle) also revealed the structures which lead to the try. Of course, basic tactics such as 1R and T-B are also necessary. Furthermore, whether or not the substitute could play positively in the attack and defense would be important factor after they come in the game. In this way, the total strength of 23 players rugby [34] instead of 15 players rugby would be a major feature of the second half tries. Substitution is a tactic utilization of human resources in team sports [35, 36]. Whether the team performance can be further enhanced at the timing of the substitute or not might be a clear turning point of the game.

Another feature of try in the last 20 minutes was that there have many tries by switching from defense to attack. Tackle study includes the issue of preventive medicine and refereeing concerned dangerous play [37-39]. There has detailed study which the tackle height by defense would relate to off-load success and clean break by attack [40].

In the international test match, it has been reported that a try becomes a turning point of the game occurs in the second half [41]. In this study, some suggestive results were obtained about the features of tries in the last 20 minutes among the top four teams (Figure 6). Team B had the feature of try tactics with attack channel diversity. The core channel plays ware 1R, 2R, 3R, TB. The core positions were FW (forward; 6, 7), half backs (9, 10), center (backs; 12, 13), wing (backs; 11) (figure 6, upper right). These were similar to above-mentioned features of try in the first 20 minutes. Team A had the feature of try tactics with defensive play. It was characterized by S-D (shallow defense) to oppose 2R, TKL (tackle) and (T-O) turnover. Recent rugby unions' attacking speed and power are increasing. Shallow defense would be a tactic to close the gap with opponents quickly. It would make opportunities for a quick effective tackle, blocking the attackers' pass course, inducing pass miss, slow forward, and turnover. Such defense tactics includes many more variations. For example, the basics of shallow defense is to align the defense lines in a straight, but there are also other cases where the outside defense player pops out and make defense line shape of an umbrella. Alternatively, after defense line made a pop to the front, it immediately shifts to the side to prevent an attack running to the outside, so-called drift defense. It would be also interesting to discuss such line attack and line defense. Team A have also the feature of try with many substitute contributions. These were similar to above-mentioned features of tries in the last 20 minutes. Team C had the feature of both of attack channel diversity and defensive plays. Team D's features ware described below.

The correspondence analysis of figure 6 showed the similarity and uniqueness of top 4 teams. Two teams of B and C were close to the center of the figure, which included the overall common channel plays tactics (SC; scrum, 1R, 2R, 3R, P-C, C-B, T-O). Team A, with its unique features of try in last 20 minutes, had the contribution of the defensive tactics which play against oppose' various channels run and punt attacks and the contribution of substitutes. Team D which is far away from A, had unique features of O-S (oppose scrum), O-CA (oppose counter-attack), PK (penalty kick), and FW's Maul connected to try.

Bootstrap test and ROC analysis which are data mining methods were carried out in order to identify the factors contributing to the attack and defense. In order to grasp the centrality, transformation, similarity and uniqueness of network structure, core-periphery analysis and correspondence analysis were carried out. The results clarified some concrete features of the present rugby union game.

A genetic algorithm was used for the network centrality and core-periphery analysis of the try structure, but the relationship coefficients were not sufficiently high. These results might be mainly due to the small data. The number of games in a particular tournament is limited, and how to expand the number of data would be a future task. However, it was suggested that understanding the features of the team's temporal, spatial, and human resources tactics by using not only the network central individual analysis but also the network core-periphery analysis would present some practical issues.

5. Conclusion

The first purpose of this study is to clarify the fact that try contributes to win in rugby union game. Bootstrap test and ROC analysis are used to validate the data of try contribution structure. The second purpose is to clarify the tactics of space selection with attack and defense methods, and tactics of transition of human resources. Network centrality, core-peripheral analysis and correspondence analysis are used to validate the core functional data of spatial tactics and the human resource allocation tactics. The average score of try balance of final 8 unions was "3.94" and that of not win unions was "-2.23". We hypothesized these to be the indices of win. To validate this hypothesis, we categorized these indices into team performance that resulted in actual match wins or losses, and tested Monte Carlo methods with bootstrap hypothesis testing to assess the standardized values. A strongly significant difference in mean try balance value was found between the "win" and "not win" outcomes (both of pool games and final stage games; bootstrapping p value <0.01). Furthermore, to test the precision of sensitivity and specificity of standardized try balance value, we executed the area under the curve (AUC) of the receiver–operator curve (ROC) analysis and had high AUC values (pool qualifying games; 0.96, Final stage games; 0.79) of ROC curve with high correct evaluation rate (89% for qualifying pass rate, 57% for win in final 8 stage). The try balance values could be positioned as a win / not win indicator.

In final 8 stage, the feature of contributing tactics for try in first 20 minutes and last 80 minutes of game were analyzed. The results by network centralities and core-periphery analysis and correspondence analysis suggested tactics of "attack channel diversity" in first 20 minutes and of "defense and substitute diversity in last 20 minutes. Using a genetic algorithm, the optimum core-peripheral coefficients (network core border coefficients) were obtained (0.47 for try in first 20 minutes: 0.43 for 60-80 minutes). Same procedures were executed among the top four teams in final 8 stage for understanding the last 20 minutes battle characteristics. Network core border coefficients showed medium high values (A: 0.47, B: 0.47, C: 0.47, D: 0.48). In the axial contribution ratio in correspondence analysis, the accumulated ratio on the third axis was 100% (47.82%, 78.00%, 100.00%), suggesting that the data was also adequately represented. The results showed the similarity and uniqueness of each teams' spatial attack and defense channel plays and human resources substitute tactics for try in last 20 minutes.

For understanding the game phase which would become more complicated, verification using data mining methods such as network analysis should be developed.

With faster attack and defense, higher strength, and an increasing number of large players [34], the spatial and human resource tactics and game performance will be transformed. It would include discussions on safety management or more dynamic game development. For understanding the game phase, which would become more complicated, data mining methods such as network analysis should be developed.

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