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A novel rugby team player selection method integrating the TOPSIS and IPA methods

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The selection of rugby players for any match will directly affect the team performance, and the final outcome of the match. Rugby team player selection involves many individual ability and technical performance criteria, making it a multiple criteria decision-making (MCDM) problem. Traditionally, a simple additive weighting method is used to select suitable team players. However, the traditional simple additive weighting method is only capable of unilaterally handling either individual ability criteria or technical performance criteria. In order to effectively solve the above issues, this study combines the order preference by similarity to ideal solution (TOPSIS) method and the importance-performance analysis (IPA) method for rugby team player selection. For numerical verification, this study applies the selection of Taiwanese Army rugby team players as an example to verify the effectiveness of the proposed novel rugby team player selection method. Simulation results show that the proposed method provides a more accurate and reasonable selection mechanism for selecting the best rugby team for a given match than the traditional simple additive weighting and TOPSIS methods. Moreover, the assessment results achieved using the proposed method can provide a reference for future training resource allocation.

KEY WORDS: Personnel selection. Rugby, TOPSIS Importance-performance analysis.

1. Introduction

Rugby is a high-teamwork, high-intensity sport, with each player on a team fulfilling a specific role in a specific position. Players, who tend to specialize in their team positions, must be in the top physical condition and have

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excellent technical skill. The intense and exciting game has grown rapidly in popularity in recent years, making it one of the most watched and played sports around the world, and its economic benefits and international influence cannot be underestimated.[1-2] Therefore, many studies follow and explore the related issues of rugby sports.[3-5]

The assessment criteria for selecting the best team players include many individual ability and technical performance criteria, which making selection become a multiple criteria decision-making (MCDM) problem. Many studies have thus explored rugby team player selection assessment criteria, such as Gabbett[6], who proposed a method for selecting players for semi-professional teams. He analyzed data which obtained from players' physiological tests of different grades to determine whether there are physiological differences between players in two grades. The physiological tests included body mass, muscular power, speed, agility, and estimated maximal aerobic power. The study found that muscular power, speed, agility, and estimated maximal aerobic power were not the main factors in player selection. Body mass, competitive experience and skills, however, were found to be high priority factors in player selection. Till et al.[7] used anthropometric and performance characteristics to predict player selection in junior UK rugby league players. Their study found that critical assessment criteria were the physical, technical, tactical and psychological variables. Gabbett and Seibold[8] demonstrated the relationship between physical qualities, team selection and physical match performance of semi-professional rugby league players. The rugby players performed different tests, including upper-body strength, upper-body strength endurance, lower-body power, prolonged high-intensity intermittent running ability, etc., and found that player selection was better than non-selection of players in all tests.

Many studies used various calculation methods to solve MCDM problems. For example, Wen et al.[9] combined the minimal variance order weighted averaging operator and importance-performance analysis (IPA) to solve complicated MCDM personnel selection problems. Chang[10] combined the intuitionistic fuzzy weighted averaging method and a soft set to solve the supplier selection problem of imprecise data. Turskis et al.[11] combined the Likert fuzzy rating method and the analytic hierarchy process (AHP) method to assess information security risks in critical infrastructures. Yang et al.[12] combined the AHP, entropy information method, and the technique for order preference by similarity to ideal solution (TOPSIS) method to solve the phase change material selection problem. The TOPSIS method is one of the most commonly used methods for solving MCDM problems. Hwang and Yoon[13] first proposed the TOPSIS method to deal with multiple attribute decision-making (MADM) and MCDM problems. The TOPSIS method is based on the criterion that the best alternative should simultaneously have the shortest distance from the positive ideal solution and the longest distance from the negative-ideal solution, and it then uses the relative closeness value to rank the preference order. The TOPSIS method has been widely used in many different fields, such as supplier selection,[14-15] determining the competitive advantages of shopping websites,[16] plant location selection,[17] and failure mode and effect analysis.[18]

Rugby team player selection has traditionally been carried out by using the simple additive weighting method to calculate the aggregated assessment criteria preference value. The traditional simple additive weighting method is a simple calculation, and is easy to understand. However, the method cannot simultaneously take individual ability and technical performance information into account. In order to address this problem, Martilla and James[19] proposed the IPA method for reviewing the performance of the automotive industry. They used importance degree and performance level to construct a two-dimensional grid, divided into four quadrants, labeled keep up the good work, concentrate here, low priority, and possible overkill, to provide a reference for future management decision-making. The IPA method has since been widely used in many different fields, such as the medicine,[20] tourism[21] and hospitality industries,[22] benefit evaluation of military simulation training systems,[23] and personnel selection.[9] In order to effectively address the issue of rugby team player selection, this paper combines the TOPSIS and IPA methods to rank the rugby players, and provide a reference for future training resource allocation.

The structure of this paper is arranged as follows. Section 2 reviews related works, including the TOPSIS and IPA methods. Section 3 describes the proposed a novel player selection method combining the TOPSIS and IPA methods for rugby team player selection problems. Section 4 applies the proposed method to select the best players for the Taiwanese Army rugby team as a numerical example, and compares the simulation results achieved using the proposed method with those achieved using the traditional simple additive weighting and TOPSIS methods to verify the rationality and correctness of the proposed method. Conclusions are presented in Section 5.

2. Methodology

2.1 Topsis Method

The TOPSIS method was developed by Hwang and Yoon[13] to handle the related issues of MADM and MCDM problems. The basic principle of the TOPSIS method for handling

MADM and MCDM problems is that the best alternative should have the shortest distance from the positive ideal solution, and the longest distance from the negative-ideal solution. The process for implementing the TOPSIS method is presented in six steps as follows:[13, 24-25]

Step 1: Calculate the normalized evaluation matrix.
The normalized value r_{ij} is calculated as:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \; j = 1,2,3 \dots, n; \;\; i = 1,2,3 \dots, m \tag{1}$$

Step 2: Calculate the weighted, normalized evaluation matrix.
The weighted, normalized value v_{ij} is calculated as:

$$v_{ij} = w_j * r_{ij}, \; j = 1,2,3, \dots, n; \; i = 1,2,3, \dots, m \tag{2}$$

where w_i is the weight of the i^{th} criterion, and $\sum_{i=1}^{n} w_i = 1$.

Step 3: Determine the positive ideal solution and the negative ideal solution.

$$A^+ = \{v_1^+, v_2^+, \dots, v_n^+\} = \{(\max_j v_{ij} \mid i \in J), (\min_j v_{ij} \mid i \in J')\},$$

$$A^- = \{v_1^-, v_2^-, \dots, v_n^-\} = \{(\min_j v_{ij} \mid i \in J), (\max_j v_{ij} \mid i \in J')\},$$

where J is associated with benefit criteria, and J' is associated with cost criteria.
Step 4: Calculate the separation measures.
The n-criteria Euclidean distance is used to calculate the separation measures. The separation of the positive ideal and the negative ideal solutions for each alternative are measured as D_i^+ and D_i^-, respectively:

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (V_{ij} - V_j^+)^2}, i = 1,2, \dots, m \tag{3}$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (V_{ij} - V_j^-)^2}, \; i = 1,2, \dots, m \tag{4}$$

Step 5: Calculate the relative closeness to the ideal solution of each alternative.
The relative closeness of the i^{th} alternative to positive ideal solution A^+ is defined as:

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{5}$$

where $0 \leq C_i \leq 1$, and $i = 1,2,\dots, m$.
Step 6: Rank the preference order.
Alternatives are preference ranked in decreasing order of C_i.

2.2 Ipa Method

Martilla and James[19] proposed the IPA method to measure service performance in the automobile industry. The IPA method uses the average importance degree and performance level values to construct a two-dimensional grid, as shown in Fig. 1.[19, 26] Four quadrants are formed by the x and y axes in the IPA diagram, where the x-axis represents the performance of an attribute, and the y-axis represents the importance of an attribute. The four quadrants of the IPA diagram have different meanings: Quadrant I (*keep up the good work*), indicates both high importance and high performance, and the project in question should continue to be maintained because it provides the competitiveness of the firm. Quadrant II (*concentrated here*), indicates high importance, but low performance, and is a critical factor for the future development of the firm, through investing more resources to prioritize improving the project. Quadrant III (*low priority*), indicates both low importance and low performance, hence the project does not require attention under limited resources. Quadrant IV (*possible overkill*), indicates low importance, but high performance, and the firm should not waste limited resources on these projects, but rather deploy the resources elsewhere.

3. The Proposed Novel Rugby Team Player Selection Method

Team player selection is a key factor to effectively improve any rugby team's win rate. Rugby is a very complicated sport, in which every player position has a different function. Selecting the best players for a match involves simultaneously considering individual ability and technical performance criteria, making it a complicated MCDM problem. Rugby players produce optimal match performances by combining their individual athletic

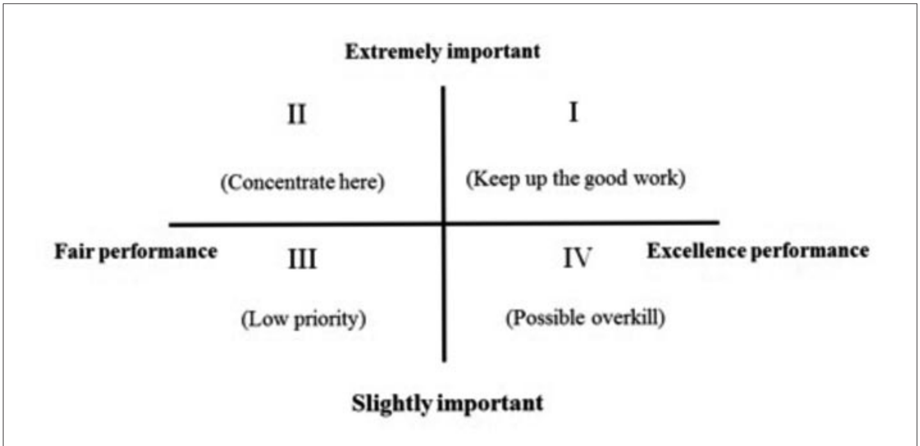

Fig. 1. - Four-quadrant IPA grid.

ability and technical skills, to devastating effect on-field. However, the traditional simple additive weighting method used to select team players only unilaterally handles individual ability criteria or technical performance criteria, but cannot handle both simultaneously. In order to effectively solve this shortcoming, this study combines the TOPSIS and IPA methods to improve the assessment process in rugby team player selection. This paper applies the TOPSIS method to handle the qualitative and quantitative data for the individual ability and technical performance criteria of rugby players. Moreover, the four quadrants of the IPA diagram provide a reference for future training resource allocation.

The implementation steps of the proposed method are as follows, and are shown in Fig. 2:

Step 1: Determine the individual ability and technical performance assessment indicators.

The individual ability and technical performance assessment indicators are determined through discussions with rugby experts.

Step 2: Collect individual ability test data for each player.

Physical testing was conducted to obtain the individual ability test data for each rugby player.

Step 3: Collect technical performance assessment score for each rugby player.

A technical performance assessment score for each rugby player was given by rugby experts.

Step 4: Calculate the normalized evaluation matrix.

Eq. (1) was used to calculate the normalized value r_{ij}.

Step 5: Calculate the weighted, normalized evaluation matrix.

Eq. (2) was used to calculate the weighted, normalized value v_{ij}.

Step 6: Determine the positive ideal solution and the negative ideal solution.

Step 7: Calculate the separation measures.

Eqs. (3) and (4) were used to calculate the separation measures.

Step 8: Calculate each alternative's relative closeness to the ideal solution.

Eq. (5) was used to calculate each alternative's relative closeness to the ideal solution.

Step 9: Construct the IPA grid.

The data obtained in Step 8 was used to construct the IPA grid, in which the x-axis was individual ability, and the y-axis was technical performance.

Step 10: Rank the rugby players, and establish a reference for future training resource allocation.

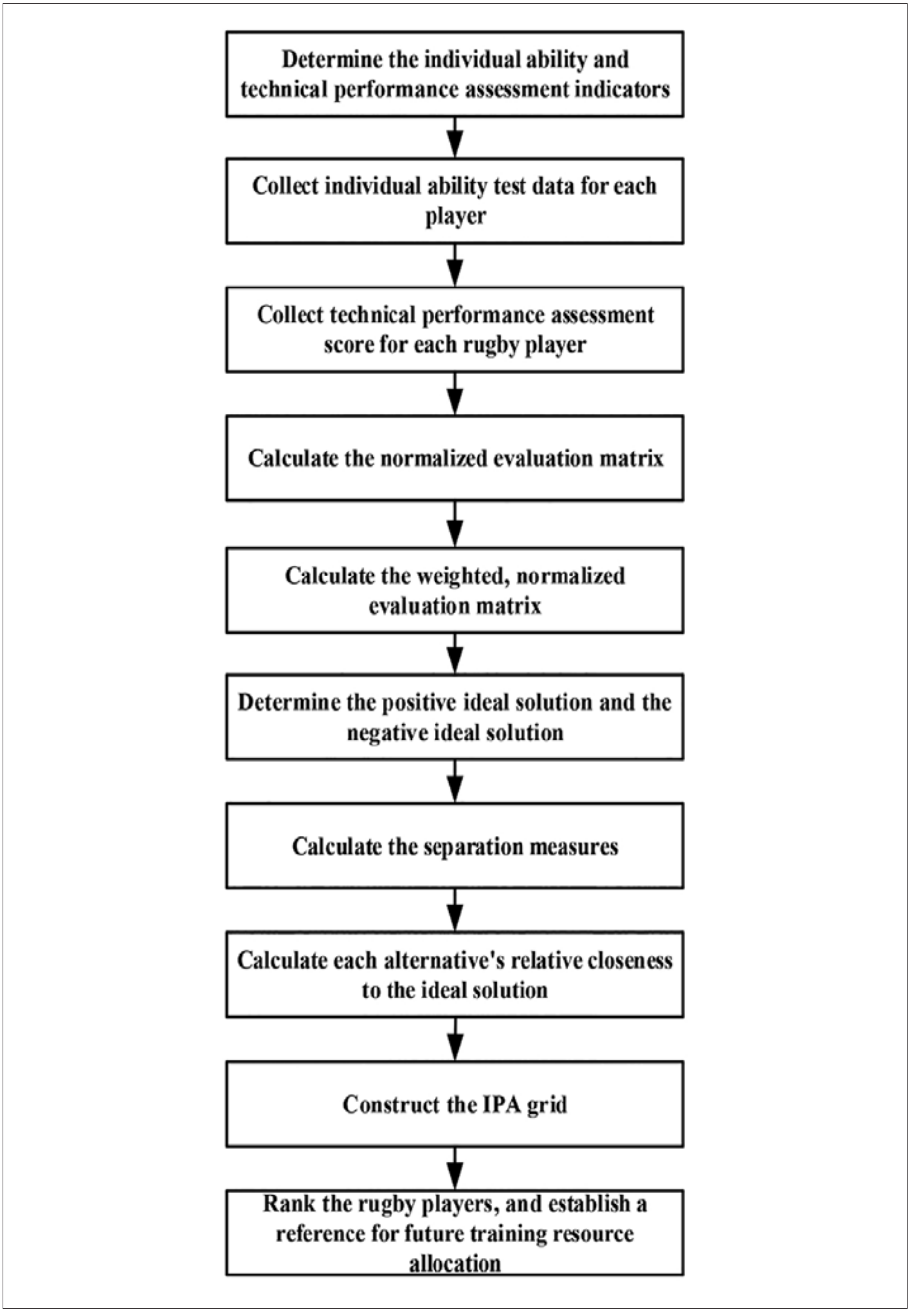

Fig. 2. - Flowchart for the proposed novel rugby team player selection method.

The results obtained in Step 9 were used to rank the rugby players, and establish a reference for future training resource allocation.

4. Case Study

4.1 Overview

In the example of rugby competition player selection used for this study, the R.O.C. Military Academy selected a squad of the best 28 rugby players from a pool of 40 players to compete in the rugby tournament at the National Intercollegiate Games. Rugby player selection involves many individual ability criteria and technical performance criteria, making it a complicated MCDM problem. Rugby experts from Taiwan agreed that in rugby team player selection, the individual ability evaluation indicators should include flat bench press (kg), shoulder press (kg), deadlift (kg), squat (kg), shuttle run (10 m, 20 m, and 30 m), 60 meter sprint, height (cm), and body weight (kg). The technical performance evaluation indicators were divided into two categories: response capability, and skill score. The technical performance linguistic assessment level is shown in Table I. Based on Table I, the technical performance of the 40 rugby players was evaluated by experts, and the results are shown in Table II. In terms of personal ability, actual tests were used to obtain the eight evaluation index values of the 40 rugby players, as shown in Table II.

4.2 Solution by the Simple Additive Weighting Method

The simple additive weighting method is simple, and easy to calculate, and it is widely used in different areas. The method requires that the decision matrix (X) be normalized, and the formula is as follows:[27-28]

Table I
Linguistic assessment level for technical performance

Level	Response capability	Skill score
$s1$	Almost never	Almost never
$s2$	Remote	Remote
$s3$	Very slight	Very slight
$s4$	Slight	Slight
$s5$	Low	Low
$s6$	Medium	Medium
$s7$	Moderately high	Moderately high
$s8$	high	high
$s9$	Very high	Very high
$s10$	Completely high	Completely high

TABLE II
The evaluation index values for 40 rugby players

Player	Individual ability								Technical performance	
	Flat bench press (kg)	Shoulder press (kg)	Deadlift (kg)	Squat (kg)	Shuttle run (10m, 20m, and 30m)	60 meter sprint	Height (cm)	Body weight (kg)	Response capability	Skill score
Player 1	70	50	100	110	24.97	8.67	177	73	*s*8	*s*7
Player 2	75	60	140	120	24.73	8.92	175	78	*s*8	*s*7
Player 3	80	55	110	150	24.99	8.88	180	67	*s*7	*s*7
Player 4	85	60	130	125	25.51	8.70	178	85	*s*8	*s*7
Player 5	95	45	70	110	25.14	8.65	164	58	*s*8	*s*5
Player 6	75	50	140	100	24.56	8.05	175	67	*s*7	*s*7
Player 7	85	50	90	80	25.69	9.02	178	68	*s*8	*s*7
Player 8	40	40	100	95	24.65	8.50	176	62	*s*9	*s*7
Player 9	115	80	120	100	26.45	8.78	168	80	*s*8	*s*6
Player 10	78	45	80	130	26.45	8.33	170	67	*s*7	*s*5
Player 11	80	50	120	100	24.63	8.81	173	69	*s*8	*s*7
Player 12	75	50	120	110	25.09	8.98	170	64	*s*6	*s*6
Player 13	55	45	100	120	25.45	8.05	180	70	*s*8	*s*7
Player 14	80	70	120	120	24.33	8.05	174	72	*s*7	*s*7
Player 15	75	55	120	100	24.77	8.50	170	65	*s*7	*s*7
Player 16	65	50	110	120	25.25	8.54	168	68	*s*6	*s*5
Player 17	65	35	110	100	25.62	8.95	161	55	*s*6	*s*6
Player 18	50	55	110	95	24.87	8.34	175	70	*s*6	*s*7
Player 19	45	40	110	90	24.56	8.19	173	63	*s*6	*s*6
Player 20	65	50	120	100	24.83	8.66	175	68	*s*6	*s*6
Player 21	50	40	110	95	24.86	8.85	178	73	*s*5	*s*5
Player 22	45	40	90	100	24.62	8.51	171	60	*s*6	*s*6
Player 23	50	45	85	90	23.53	8.39	171	59	*s*6	*s*6
Player 24	85	65	135	150	24.86	8.25	175	75	*s*6	*s*7
Player 25	65	45	130	105	24.50	8.45	164	67	*s*5	*s*6
Player 26	85	65	135	150	25.68	8.56	177	80	*s*5	*s*5
Player 27	50	40	90	95	24.48	8.70	180	63	*s*4	*s*4
Player 28	50	40	90	95	24.77	8.33	180	65	*s*5	*s*4
Player 29	85	40	90	110	25.05	8.44	175	68	*s*5	*s*5
Player 30	45	55	110	100	24.29	7.88	177	68	*s*5	*s*5
Player 31	60	45	135	160	25.59	8.81	172	83	*s*6	*s*6
Player 32	60	50	60	85	25.88	8.63	178	65	*s*5	*s*5
Player 33	75	55	130	90	24.86	8.70	171	68	*s*5	*s*5
Player 34	60	50	60	80	27.24	9.19	175	65	*s*6	*s*5
Player 35	75	40	130	80	25.69	8.42	178	70	*s*6	*s*5
Player 36	60	35	100	90	23.92	8.06	167	60	*s*6	*s*5
Player 37	60	40	100	90	24.35	8.35	163	60	*s*6	*s*5
Player 38	60	38	100	70	24.43	8.26	164	60	*s*6	*s*5
Player 39	60	35	100	90	24.18	8.78	173	73	*s*4	*s*4
Player 40	60	40	90	90	26.12	8.35	174	62	*s*4	*s*4

$$R_{ij} = \begin{cases} \dfrac{x_{ij}}{Max_i\, x_{ij}}, & if\ j = benefit \\ \dfrac{Min_i x_{ij}}{x_{ij}}, & if\ j = cost \end{cases} \tag{6}$$

The preference value for each alternative (V_i) is as follows:

$$V_i = \sum_{j=1}^{n} W_j R_{ij}\,, \quad i = 1,2,\ldots,m \tag{7}$$

where Wj is the preference weight of each criteria, and $\sum W_j = 1$.

According to Table II, Eqs. (6) and (7) were used to calculate the aggregate preference value of the simple additive weighting, and the results are shown in Table III.

4.3 Topsis Method

The TOPSIS method is one of the most popular methods for solving MCDM problems. The method finds a solution which is both the shortest distance from the positive ideal solution, and the longest distance from the negative-ideal solution. According to Table 2, Eq. (1) was used to calculate the normalized evaluation matrix, and the results are shown in Table IV.

According to Table 4, Eq. (2) was used to calculate the weighted, normalized evaluation matrix, and determine the positive ideal solution and the negative ideal solution. The results are shown in Table V.

According to the results of Table 5, Eqs. (3) and (4) were used to calculate the separation measures (D_i^+, D_i^-), and Eq. (5) was used to calculate the each alternative's relative closeness to the ideal solution of technical performance assessment scores for each r (Table VI).

4.4 The Proposed Method

In order to address the MCDM problem of rugby team player selection, this paper combines the TOPSIS method and IPA to correctly rank rugby players, and to provide a reference for future training resource allocation. In the rugby team player selection example, rugby experts first determined the individual ability and technical performance assessment indicators. Then, individual ability test data and ugby competition player were collected; the

TABLE III
Normalized Decision matrix

Player	Individual ability								Technical performance		
	Flat bench press (kg)	Shoulder press (kg)	Deadlift (kg)	Squat (kg)	Shuttle run (10m, 20m, and 30m)	60 meter sprint	Height (cm)	Body weight (kg)	Response capability	Skill score	Preference value
Player 1	0.609	0.625	0.714	0.688	0.942	0.909	0.983	0.859	0.889	1.000	0.822
Player 2	0.652	0.750	1.000	0.750	0.951	0.883	0.972	0.918	0.889	1.000	0.877
Player 3	0.696	0.688	0.786	0.938	0.942	0.887	1.000	0.788	0.778	1.000	0.850
Player 4	0.739	0.750	0.929	0.781	0.922	0.906	0.989	1.000	0.889	1.000	0.890
Player 5	0.826	0.563	0.500	0.688	0.936	0.911	0.911	0.682	0.667	0.714	0.740
Player 6	0.652	0.625	1.000	0.625	0.958	0.979	0.972	0.788	0.778	1.000	0.838
Player 7	0.739	0.625	0.643	0.500	0.916	0.874	0.989	0.800	0.889	1.000	0.797
Player 8	0.348	0.500	0.714	0.594	0.955	0.927	0.978	0.729	1.000	1.000	0.774
Player 9	1.000	1.000	0.857	0.625	0.890	0.897	0.933	0.941	0.889	0.857	0.889
Player 10	0.678	0.563	0.571	0.813	0.890	0.946	0.944	0.788	0.778	0.714	0.769
Player 11	0.696	0.625	0.857	0.625	0.955	0.894	0.961	0.812	0.889	1.000	0.831
Player 12	0.652	0.625	0.857	0.688	0.938	0.878	0.944	0.753	0.667	0.857	0.786
Player 13	0.478	0.563	0.714	0.750	0.925	0.979	1.000	0.824	0.889	1.000	0.812
Player 14	0.696	0.875	0.857	0.750	0.967	0.979	0.967	0.847	0.778	1.000	0.872
Player 15	0.652	0.688	0.857	0.625	0.950	0.927	0.944	0.765	0.778	1.000	0.819
Player 16	0.565	0.625	0.786	0.750	0.932	0.923	0.933	0.800	0.667	0.714	0.769
Player 17	0.565	0.438	0.786	0.625	0.918	0.880	0.894	0.647	0.667	0.857	0.728
Player 18	0.435	0.688	0.786	0.594	0.946	0.945	0.972	0.824	0.667	1.000	0.786
Player 19	0.391	0.500	0.786	0.563	0.958	0.962	0.961	0.741	0.667	0.857	0.739
Player 20	0.565	0.625	0.857	0.625	0.948	0.910	0.972	0.800	0.667	0.857	0.783
Player 21	0.435	0.500	0.786	0.594	0.947	0.890	0.989	0.859	0.556	0.714	0.727
Player 22	0.391	0.500	0.643	0.625	0.956	0.926	0.950	0.706	0.667	0.857	0.722
Player 23	0.435	0.563	0.607	0.563	1.000	0.939	0.950	0.694	0.667	0.857	0.727
Player 24	0.739	0.813	0.964	0.938	0.947	0.955	0.972	0.882	0.667	1.000	0.888
Player 25	0.565	0.563	0.929	0.656	0.960	0.933	0.911	0.788	0.556	0.857	0.772
Player 26	0.739	0.813	0.964	0.938	0.916	0.921	0.983	0.941	0.556	0.714	0.848
Player 27	0.435	0.500	0.643	0.594	0.961	0.906	1.000	0.741	0.444	0.571	0.680
Player 28	0.435	0.500	0.643	0.594	0.950	0.946	1.000	0.765	0.556	0.571	0.696
Player 29	0.739	0.500	0.643	0.688	0.939	0.934	0.972	0.800	0.556	0.714	0.748
Player 30	0.391	0.688	0.786	0.625	0.969	1.000	0.983	0.800	0.556	0.714	0.751
Player 31	0.522	0.563	0.964	1.000	0.919	0.894	0.956	0.976	0.667	0.857	0.832
Player 32	0.522	0.625	0.429	0.531	0.909	0.913	0.989	0.765	0.556	0.714	0.695
Player 33	0.652	0.688	0.929	0.563	0.947	0.906	0.950	0.800	0.556	0.714	0.770
Player 34	0.522	0.625	0.429	0.500	0.864	0.857	0.972	0.765	0.667	0.714	0.691
Player 35	0.652	0.500	0.929	0.500	0.916	0.936	0.989	0.824	0.667	0.714	0.763
Player 36	0.522	0.438	0.714	0.563	0.984	0.978	0.928	0.706	0.667	0.714	0.721
Player 37	0.522	0.500	0.714	0.563	0.966	0.944	0.906	0.706	0.667	0.714	0.720
Player 38	0.522	0.475	0.714	0.438	0.963	0.954	0.911	0.706	0.667	0.714	0.706
Player 39	0.522	0.438	0.714	0.563	0.973	0.897	0.961	0.859	0.444	0.571	0.694
Player 40	0.522	0.500	0.643	0.563	0.901	0.944	0.967	0.729	0.444	0.571	0.678

TABLE IV
The Normalized Evaluation Matrix Of 40 Rugby Players

Player	Individual ability								Technical performance	
	Flat bench press (kg)	Shoulder press (kg)	Deadlift (kg)	Squat (kg)	Shuttle run (10m, 20m, and 30m)	60 meter sprint	Height (cm)	Body weight (kg)	Response capability	Skill score
Player 1	0.160	0.160	0.145	0.163	0.158	0.160	0.162	0.169	0.198	0.189
Player 2	0.172	0.192	0.203	0.178	0.156	0.165	0.160	0.181	0.198	0.189
Player 3	0.183	0.176	0.159	0.222	0.158	0.164	0.164	0.155	0.174	0.189
Player 4	0.194	0.192	0.188	0.185	0.161	0.161	0.163	0.197	0.198	0.189
Player 5	0.217	0.144	0.101	0.163	0.159	0.160	0.150	0.135	0.198	0.135
Player 6	0.172	0.160	0.203	0.148	0.155	0.149	0.160	0.155	0.174	0.189
Player 7	0.194	0.160	0.130	0.118	0.162	0.167	0.163	0.158	0.198	0.189
Player 8	0.091	0.128	0.145	0.141	0.156	0.157	0.161	0.144	0.223	0.189
Player 9	0.263	0.256	0.174	0.148	0.167	0.163	0.153	0.186	0.198	0.162
Player 10	0.178	0.144	0.116	0.193	0.167	0.154	0.155	0.155	0.174	0.135
Player 11	0.183	0.160	0.174	0.148	0.155	0.163	0.158	0.160	0.198	0.189
Player 12	0.172	0.160	0.174	0.163	0.158	0.166	0.155	0.148	0.149	0.162
Player 13	0.126	0.144	0.145	0.178	0.161	0.149	0.164	0.162	0.198	0.189
Player 14	0.183	0.224	0.174	0.178	0.154	0.149	0.159	0.167	0.174	0.189
Player 15	0.172	0.176	0.174	0.148	0.156	0.157	0.155	0.151	0.174	0.189
Player 16	0.149	0.160	0.159	0.178	0.159	0.158	0.153	0.158	0.149	0.135
Player 17	0.149	0.112	0.159	0.148	0.162	0.166	0.147	0.128	0.149	0.162
Player 18	0.114	0.176	0.159	0.141	0.157	0.154	0.160	0.162	0.149	0.189
Player 19	0.103	0.128	0.159	0.133	0.155	0.152	0.158	0.146	0.149	0.162
Player 20	0.149	0.160	0.174	0.148	0.157	0.160	0.160	0.158	0.149	0.162
Player 21	0.114	0.128	0.159	0.141	0.157	0.164	0.163	0.169	0.124	0.135
Player 22	0.103	0.128	0.130	0.148	0.155	0.158	0.156	0.139	0.149	0.162
Player 23	0.114	0.144	0.123	0.133	0.149	0.155	0.156	0.137	0.149	0.162
Player 24	0.194	0.208	0.195	0.222	0.157	0.153	0.160	0.174	0.149	0.189
Player 25	0.149	0.144	0.188	0.156	0.155	0.156	0.150	0.155	0.124	0.162
Player 26	0.194	0.208	0.195	0.222	0.162	0.158	0.162	0.186	0.124	0.135
Player 27	0.114	0.128	0.130	0.141	0.155	0.161	0.164	0.146	0.099	0.108
Player 28	0.114	0.128	0.130	0.141	0.156	0.154	0.164	0.151	0.124	0.108
Player 29	0.194	0.128	0.130	0.163	0.158	0.156	0.160	0.158	0.124	0.135
Player 30	0.103	0.176	0.159	0.148	0.153	0.146	0.162	0.158	0.124	0.135
Player 31	0.137	0.144	0.195	0.237	0.162	0.163	0.157	0.193	0.149	0.162
Player 32	0.137	0.160	0.087	0.126	0.163	0.160	0.163	0.151	0.124	0.135
Player 33	0.172	0.176	0.188	0.133	0.157	0.161	0.156	0.158	0.124	0.135
Player 34	0.137	0.160	0.087	0.118	0.172	0.170	0.160	0.151	0.149	0.135
Player 35	0.172	0.128	0.188	0.118	0.162	0.156	0.163	0.162	0.149	0.135
Player 36	0.137	0.112	0.145	0.133	0.151	0.149	0.152	0.139	0.149	0.135
Player 37	0.137	0.128	0.145	0.133	0.154	0.155	0.149	0.139	0.149	0.135
Player 38	0.137	0.121	0.145	0.104	0.154	0.153	0.150	0.139	0.149	0.135
Player 39	0.137	0.112	0.145	0.133	0.153	0.163	0.158	0.169	0.099	0.108
Player 40	0.137	0.128	0.130	0.133	0.165	0.155	0.159	0.144	0.099	0.108

TABLE V
The Weighted, Normalized Evaluation Matrix Of 40 Rugby Players

Player	Individual ability								Technical performance	
	Flat bench press (kg)	Shoulder press (kg)	Deadlift (kg)	Squat (kg)	Shuttle run (10m, 20m, and 30m)	60 meter sprint	Height (cm)	Body weight (kg)	Response capability	Skill score
Player 1	0.016	0.016	0.014	0.016	0.016	0.016	0.016	0.017	0.020	0.019
Player 2	0.017	0.019	0.020	0.018	0.016	0.017	0.016	0.018	0.020	0.019
Player 3	0.018	0.018	0.016	0.022	0.016	0.016	0.016	0.016	0.017	0.019
Player 4	0.019	0.019	0.019	0.019	0.016	0.016	0.016	0.020	0.020	0.019
Player 5	0.022	0.014	0.010	0.016	0.016	0.016	0.015	0.013	0.020	0.013
Player 6	0.017	0.016	0.020	0.015	0.016	0.015	0.016	0.016	0.017	0.019
Player 7	0.019	0.016	0.013	0.012	0.016	0.017	0.016	0.016	0.020	0.019
Player 8	0.009	0.013	0.014	0.014	0.016	0.016	0.016	0.014	0.022	0.019
Player 9	0.026	0.026	0.017	0.015	0.017	0.016	0.015	0.019	0.020	0.016
Player 10	0.018	0.014	0.012	0.019	0.017	0.015	0.016	0.016	0.017	0.013
Player 11	0.018	0.016	0.017	0.015	0.016	0.016	0.016	0.016	0.020	0.019
Player 12	0.017	0.016	0.017	0.016	0.016	0.017	0.016	0.015	0.015	0.016
Player 13	0.013	0.014	0.014	0.018	0.016	0.015	0.016	0.016	0.020	0.019
Player 14	0.018	0.022	0.017	0.018	0.015	0.015	0.016	0.017	0.017	0.019
Player 15	0.017	0.018	0.017	0.015	0.016	0.016	0.016	0.015	0.017	0.019
Player 16	0.015	0.016	0.016	0.018	0.016	0.016	0.015	0.016	0.015	0.013
Player 17	0.015	0.011	0.016	0.015	0.016	0.017	0.015	0.013	0.015	0.016
Player 18	0.011	0.018	0.016	0.014	0.016	0.015	0.016	0.016	0.015	0.019
Player 19	0.010	0.013	0.016	0.013	0.016	0.015	0.016	0.015	0.015	0.016
Player 20	0.015	0.016	0.017	0.015	0.016	0.016	0.016	0.016	0.015	0.016
Player 21	0.011	0.013	0.016	0.014	0.016	0.016	0.016	0.017	0.012	0.013
Player 22	0.010	0.013	0.013	0.015	0.016	0.016	0.016	0.014	0.015	0.016
Player 23	0.011	0.014	0.012	0.013	0.015	0.016	0.016	0.014	0.015	0.016
Player 24	0.019	0.021	0.020	0.022	0.016	0.015	0.016	0.017	0.015	0.019
Player 25	0.015	0.014	0.019	0.016	0.015	0.016	0.015	0.016	0.012	0.016
Player 26	0.019	0.021	0.020	0.022	0.016	0.016	0.016	0.019	0.012	0.013
Player 27	0.011	0.013	0.013	0.014	0.015	0.016	0.016	0.015	0.010	0.011
Player 28	0.011	0.013	0.013	0.014	0.016	0.015	0.016	0.015	0.012	0.011
Player 29	0.019	0.013	0.013	0.016	0.016	0.016	0.016	0.016	0.012	0.013
Player 30	0.010	0.018	0.016	0.015	0.015	0.015	0.016	0.016	0.012	0.013
Player 31	0.014	0.014	0.020	0.024	0.016	0.016	0.016	0.019	0.015	0.016
Player 32	0.014	0.016	0.009	0.013	0.016	0.016	0.016	0.015	0.012	0.013
Player 33	0.017	0.018	0.019	0.013	0.016	0.016	0.016	0.016	0.012	0.013
Player 34	0.014	0.016	0.009	0.012	0.017	0.017	0.016	0.015	0.015	0.013
Player 35	0.017	0.013	0.019	0.012	0.016	0.016	0.016	0.016	0.015	0.013
Player 36	0.014	0.011	0.014	0.013	0.015	0.015	0.015	0.014	0.015	0.013
Player 37	0.014	0.013	0.014	0.013	0.015	0.015	0.015	0.014	0.015	0.013
Player 38	0.014	0.012	0.014	0.010	0.015	0.015	0.015	0.014	0.015	0.013
Player 39	0.014	0.011	0.014	0.013	0.015	0.016	0.016	0.017	0.010	0.011
Player 40	0.014	0.013	0.013	0.013	0.016	0.015	0.016	0.014	0.010	0.011
A^+	0.026	0.026	0.020	0.024	0.015	0.015	0.016	0.020	0.022	0.019
A^-	0.009	0.011	0.009	0.010	0.017	0.017	0.015	0.013	0.010	0.011

Table VI
The Separation Measures And The Relative Closeness To The Ideal Solution Of 40 Rugby Players

Player	D_i^+	D_i^-	C_i
Player 1	0.017	0.018	0.509
Player 2	0.013	0.023	0.633
Player 3	0.014	0.021	0.603
Player 4	0.011	0.024	0.677
Player 5	0.020	0.018	0.475
Player 6	0.017	0.019	0.530
Player 7	0.019	0.018	0.488
Player 8	0.025	0.017	0.402
Player 9	0.010	0.028	0.725
Player 10	0.019	0.016	0.450
Player 11	0.016	0.020	0.544
Player 12	0.018	0.016	0.469
Player 13	0.020	0.017	0.461
Player 14	0.012	0.022	0.641
Player 15	0.017	0.018	0.519
Player 16	0.020	0.014	0.425
Player 17	0.024	0.013	0.349
Player 18	0.022	0.015	0.408
Player 19	0.025	0.011	0.311
Player 20	0.020	0.015	0.428
Player 21	0.025	0.010	0.294
Player 22	0.025	0.010	0.284
Player 23	0.025	0.010	0.287
Player 24	0.012	0.024	0.674
Player 25	0.021	0.015	0.411
Player 26	0.014	0.023	0.611
Player 27	0.028	0.007	0.203
Player 28	0.027	0.008	0.224
Player 29	0.022	0.014	0.391
Player 30	0.024	0.012	0.340
Player 31	0.019	0.021	0.524
Player 32	0.026	0.008	0.248
Player 33	0.020	0.016	0.437
Player 34	0.025	0.009	0.267
Player 35	0.022	0.015	0.402
Player 36	0.025	0.010	0.291
Player 37	0.024	0.010	0.298
Player 38	0.026	0.010	0.273
Player 39	0.027	0.009	0.255
Player 40	0.027	0.008	0.220

results are shown in Table 2 (Steps 1-Step 3). The following procedure describes the remaining steps:

Step 4: Calculate the normalized evaluation matrix.

According to Table 2, Eq. (1) was used to calculate the normalized value r_{ij}, and the results are shown in Table 4.

Step 5: Calculate the weighted, normalized evaluation matrix.

Step 6: Determine the positive ideal solution and the negative ideal solution.

According to Table IV, Eq. (2) was used to calculate the weighted, normalized value v_{ij}, and further determine the positive ideal solution and the negative ideal solution; the results are shown in Table VII.

Step 7: Calculate the separation measures.

Step 8: Calculate each alternative's relative closeness to the ideal solution.

According to the results of Table 7, Eqs. (3) and (4) were used to calculate the separation measures, and Eq. (5) was used to calculate each alternative's relative closeness to the ideal solution; the results are shown in Table VIII.

Step 9: Construct the IPA grid.

The results of Table 8 were used to construct the IPA grid, with the x-axis as individual ability, and y-axis as technical performance; the results are shown in Fig. 3.

Step 10: Rank the rugby team players, and establish a reference for future training resource allocation.

The results of Table VIII and Fig. 3 were used to rank the rugby players (as shown in Table IX), and to establish a reference for future training resource allocation.

The four quadrant positions of the 40 rugby players are explained as follows.

(1) Quadrant I (*keep up the good work*): This quadrant position contained players 1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 14, 15, 20, 24 and 31. These 15 players have high individual ability and technical performance scores. Self-training and auxiliary coaching guidance are suggested for these players. There is no need to commit extra training resources under limited resources.

(2) Quadrant II (*concentrate here*): This quadrant position contained players 7, 8, 13 ,17 ,18 ,19, 22 and 23. These 8 players have poor individual ability, but good technical performance. The team should allocate increased training resources to these players to enhance their individual abilities, and effectively improve the team's competitiveness and win rate.

(3) Quadrant III (*low priority*): This quadrant position contained players 17, 19, 21, 22, 23, 27, 28, 30, 32, 34, 35, 36, 37, 38, 39 and 40. These 16 players have both poor individual ability and technical performance. If there are already a sufficient number of players for the team, then it is not necessary to allocate training resources to these players. If there are no enough players for the team, however, then resources can be allocated to improve both their individual ability and technical performance to effectively improve the team's competitiveness.

(4) Quadrant IV (*concentrate here*): This quadrant position contained players 12, 16, 20, 25, 26, 29, 31 and 33. These 8 players have good individid-

TABLE VII
The Weighted, Normalized Evaluation Matrix Of 40 Rugby Players By Proposed Method

Player	Individual ability (x-axis)								Technical performance (y-axis)	
	Flat bench press (kg)	Shoulder press (kg)	Deadlift (kg)	Squat (kg)	Shuttle run (10m, 20m, and 30m)	60 meter sprint	Height (cm)	Body weight (kg)	Response capability	Skill score
Player 1	0.020	0.020	0.018	0.020	0.020	0.020	0.020	0.021	0.099	0.094
Player 2	0.021	0.024	0.025	0.022	0.020	0.021	0.020	0.023	0.099	0.094
Player 3	0.023	0.022	0.020	0.028	0.020	0.021	0.021	0.019	0.087	0.094
Player 4	0.024	0.024	0.024	0.023	0.020	0.020	0.020	0.025	0.099	0.094
Player 5	0.027	0.018	0.013	0.020	0.020	0.020	0.019	0.017	0.099	0.067
Player 6	0.021	0.020	0.025	0.019	0.019	0.019	0.020	0.019	0.087	0.094
Player 7	0.024	0.020	0.016	0.015	0.020	0.021	0.020	0.020	0.099	0.094
Player 8	0.011	0.016	0.018	0.018	0.019	0.020	0.020	0.018	0.112	0.094
Player 9	0.033	0.032	0.022	0.019	0.021	0.020	0.019	0.023	0.099	0.081
Player 10	0.022	0.018	0.014	0.024	0.021	0.019	0.019	0.019	0.087	0.067
Player 11	0.023	0.020	0.022	0.019	0.019	0.020	0.020	0.020	0.099	0.094
Player 12	0.021	0.020	0.022	0.020	0.020	0.021	0.019	0.019	0.074	0.081
Player 13	0.016	0.018	0.018	0.022	0.020	0.019	0.021	0.020	0.099	0.094
Player 14	0.023	0.028	0.022	0.022	0.019	0.019	0.020	0.021	0.087	0.094
Player 15	0.021	0.022	0.022	0.019	0.020	0.020	0.019	0.019	0.087	0.094
Player 16	0.019	0.020	0.020	0.022	0.020	0.020	0.019	0.020	0.074	0.067
Player 17	0.019	0.014	0.020	0.019	0.020	0.021	0.018	0.016	0.074	0.081
Player 18	0.014	0.022	0.020	0.018	0.020	0.019	0.020	0.020	0.074	0.094
Player 19	0.013	0.016	0.020	0.017	0.019	0.019	0.020	0.018	0.074	0.081
Player 20	0.019	0.020	0.022	0.019	0.020	0.020	0.020	0.020	0.074	0.081
Player 21	0.014	0.016	0.020	0.018	0.020	0.020	0.020	0.021	0.062	0.067
Player 22	0.013	0.016	0.016	0.019	0.019	0.020	0.020	0.017	0.074	0.081
Player 23	0.014	0.018	0.015	0.017	0.019	0.019	0.020	0.017	0.074	0.081
Player 24	0.024	0.026	0.024	0.028	0.020	0.019	0.020	0.022	0.074	0.094
Player 25	0.019	0.018	0.024	0.019	0.019	0.020	0.019	0.019	0.062	0.081
Player 26	0.024	0.026	0.024	0.028	0.020	0.020	0.020	0.023	0.062	0.067
Player 27	0.014	0.016	0.016	0.018	0.019	0.020	0.021	0.018	0.050	0.054
Player 28	0.014	0.016	0.016	0.018	0.020	0.019	0.021	0.019	0.062	0.054
Player 29	0.024	0.016	0.016	0.020	0.020	0.020	0.020	0.020	0.062	0.067
Player 30	0.013	0.022	0.020	0.019	0.019	0.018	0.020	0.020	0.062	0.067
Player 31	0.017	0.018	0.024	0.030	0.020	0.020	0.020	0.024	0.074	0.081
Player 32	0.017	0.020	0.011	0.016	0.020	0.020	0.020	0.019	0.062	0.067
Player 33	0.021	0.022	0.024	0.017	0.020	0.020	0.020	0.020	0.062	0.067
Player 34	0.017	0.020	0.011	0.015	0.021	0.021	0.020	0.019	0.074	0.067
Player 35	0.021	0.016	0.024	0.015	0.020	0.019	0.020	0.020	0.074	0.067
Player 36	0.017	0.014	0.018	0.017	0.019	0.019	0.019	0.017	0.074	0.067
Player 37	0.017	0.016	0.018	0.017	0.019	0.019	0.019	0.017	0.074	0.067
Player 38	0.017	0.015	0.018	0.013	0.019	0.019	0.019	0.017	0.074	0.067
Player 39	0.017	0.014	0.018	0.017	0.019	0.020	0.020	0.021	0.050	0.054
Player 40	0.017	0.016	0.016	0.017	0.021	0.019	0.020	0.018	0.050	0.054
A^+	0.033	0.032	0.025	0.030	0.019	0.018	0.021	0.025	0.112	0.094
A^-	0.011	0.014	0.011	0.013	0.021	0.021	0.018	0.016	0.050	0.054

TABLE VIII
The Separation Measures And The Relative Closeness Values Of 40 Rugby Players By Proposed Method

Player	**Individual ability (*x*-axis)**			**Technical performance (*y*-axis)**		
	D_i^+	D_i^-	C_i	D_i^+	D_i^-	C_i
Player 1	0.022	0.016	0.424	0.012	0.064	0.838
Player 2	0.016	0.023	0.592	0.012	0.064	0.838
Player 3	0.016	0.023	0.582	0.025	0.055	0.689
Player 4	0.014	0.025	0.643	0.012	0.064	0.838
Player 5	0.023	0.018	0.437	0.030	0.051	0.634
Player 6	0.021	0.020	0.493	0.025	0.055	0.689
Player 7	0.024	0.016	0.404	0.012	0.064	0.838
Player 8	0.031	0.010	0.236	0.000	0.074	1.000
Player 9	0.012	0.031	0.719	0.018	0.056	0.755
Player10	0.022	0.017	0.434	0.037	0.040	0.519
Player 11	0.020	0.018	0.477	0.012	0.064	0.838
Player 12	0.020	0.018	0.466	0.040	0.037	0.481
Player 13	0.025	0.014	0.365	0.012	0.064	0.838
Player 14	0.014	0.024	0.628	0.025	0.055	0.689
Player 15	0.020	0.018	0.474	0.025	0.055	0.689
Player 16	0.022	0.017	0.435	0.046	0.028	0.381
Player 17	0.028	0.013	0.317	0.040	0.037	0.481
Player 18	0.025	0.014	0.361	0.037	0.047	0.561
Player 19	0.030	0.011	0.267	0.040	0.037	0.481
Player 20	0.023	0.016	0.415	0.040	0.037	0.481
Player 21	0.028	0.012	0.304	0.056	0.018	0.245
Player 22	0.030	0.009	0.224	0.040	0.037	0.481
Player 23	0.029	0.009	0.225	0.040	0.037	0.481
Player 24	0.011	0.028	0.712	0.037	0.047	0.561
Player 25	0.023	0.017	0.423	0.051	0.030	0.366
Player 26	0.011	0.028	0.716	0.056	0.018	0.245
Player 27	0.030	0.009	0.232	0.074	0.000	0.000
Player 28	0.029	0.009	0.238	0.064	0.012	0.162
Player 29	0.023	0.017	0.421	0.056	0.018	0.245
Player 30	0.026	0.015	0.358	0.056	0.018	0.245
Player 31	0.021	0.024	0.531	0.040	0.037	0.481
Player 32	0.029	0.010	0.249	0.056	0.018	0.245
Player 33	0.021	0.019	0.477	0.056	0.018	0.245
Player 34	0.030	0.009	0.236	0.046	0.028	0.381
Player 35	0.025	0.017	0.406	0.046	0.028	0.381
Player 36	0.029	0.011	0.269	0.046	0.028	0.381
Player 37	0.028	0.011	0.276	0.046	0.028	0.381
Player 38	0.030	0.010	0.247	0.046	0.028	0.381
Player 39	0.028	0.012	0.290	0.074	0.000	0.000
Player 40	0.028	0.010	0.252	0.074	0.000	0.000

ual ability, but poor technical performance. The team should increase available training resources to improve the technical performance of these players in order to effectively improve the team's competitiveness and strength.

4.5 COMPARISON AND DISCUSSION

In order to verify the reasonableness and effectiveness of the proposed method, Section 4 described the Taiwanese Army rugby team player selection simulation example. This paper also compares the simulation results

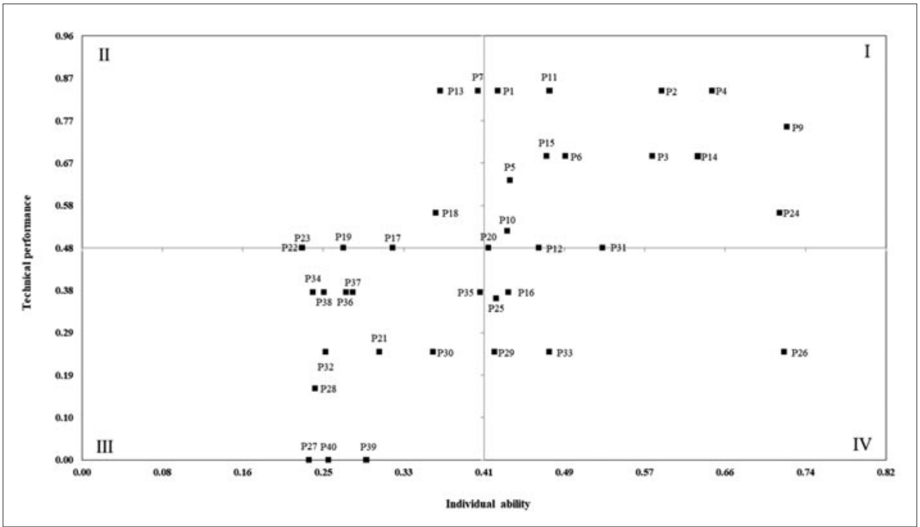

Fig. 3. - IPA grid.

achieved by the proposed method with those achieved using the traditional simple additive weighting and TOPSIS methods. All methods used the same input data, shown in Table 2, to calculate rugby team player selection results. A comparison of the player rankings by the three methods is shown in Table 10. Based on Table 2, Table 10, and Fig. 3, it is clear that the proposed integrated TOPSIS and IPA method has some advantages as follows.

First, the ranking repetition rate is reduced. Players 10 and 16, players 12 and 18 and players 21 and 23 are assigned the same ranks in the simple additive weighting method, a ranking repetition rate of 15%. In the calculation results of the TOPSIS method, the ranking repetition rate is 5% (players 8 and 35 are assigned the same rank). The ranking repetition rate of the proposed method, however, is 0%.

Second, the proposed method is capable of handling the two-dimensional information of individual ability and technical performance, using the weights of individual ability and technical performance to simultaneously calculate each alternative's average relative closeness to the ideal solution. Therefore, the calculation results are more accurate and reasonable. Conversely, the traditional simple additive weighting and TOPSIS methods can only process one-dimensional information, generating biased results.

Third, the proposed method uses different combinations of individual ability and technical performance to draw the four quadrants of the IPA dia-

Table IX
Rugby Player Rankings

Player	Individual ability (x-axis)	Technical performance (y-axis)	Quadrant	Average value	Ranking
Player 1	0.424	0.838	I	0.631	8
Player 2	0.592	0.838	I	0.715	3
Player 3	0.582	0.689	I	0.635	7
Player 4	0.643	0.838	I	0.740	1
Player 5	0.437	0.634	I	0.535	14
Player 6	0.493	0.689	I	0.591	12
Player 7	0.404	0.838	II	0.621	9
Player 8	0.236	1.000	II	0.618	10
Player 9	0.719	0.755	I	0.737	2
Player 10	0.434	0.519	I	0.476	17
Player 11	0.477	0.838	I	0.657	5
Player 12	0.466	0.481	I, IV	0.473	18
Player 13	0.365	0.838	II	0.602	11
Player 14	0.628	0.689	I	0.659	4
Player 15	0.474	0.689	I	0.581	13
Player 16	0.435	0.381	IV	0.408	21
Player 17	0.317	0.481	II, III	0.399	22
Player 18	0.361	0.561	II	0.461	19
Player 19	0.267	0.481	II, III	0.374	25
Player 20	0.415	0.481	I, IV	0.448	20
Player 21	0.304	0.245	III	0.274	35
Player 22	0.224	0.481	II, III	0.352	28
Player 23	0.225	0.481	II, III	0.353	27
Player 24	0.712	0.561	I	0.636	6
Player 25	0.423	0.366	IV	0.394	23
Player 26	0.716	0.245	IV	0.481	16
Player 27	0.232	0.000	III	0.116	40
Player 28	0.238	0.162	III	0.200	37
Player 29	0.421	0.245	IV	0.333	29
Player 30	0.358	0.245	III	0.302	34
Player 31	0.531	0.481	I, IV	0.506	15
Player 32	0.249	0.245	III	0.247	36
Player 33	0.477	0.245	IV	0.361	26
Player 34	0.236	0.381	III	0.308	33
Player 35	0.406	0.381	III	0.393	24
Player 36	0.269	0.381	III	0.325	31
Player 37	0.276	0.381	III	0.328	30
Player 38	0.247	0.381	III	0.314	32
Player 39	0.290	0.000	III	0.145	38
Player 40	0.252	0.000	III	0.126	39

gram. Players are allocated to different quadrants to provide training resource allocation suggestions. The traditional simple additive weighting and TOPSIS methods can only unilaterally handle individual ability criteria or technical performance criteria.

Finally, the proposed method considers the positive ideal solution and the negative-ideal solution, simultaneously. Although the simple additive weighting method is simple to calculate, it cannot simultaneously consider the positive ideal solution and the negative-ideal solution. The proposed method and the TOPSIS method can consider both the shortest distance from the positive ideal solution and the longest distance from the negative-ideal solution, simultaneously.

TABLE X
Comparison Of Rankings By The Three Methods

Player	**Simple additive weighting method**		**TOPSIS method**		**Proposed method**	
	Preference value	**Ranking**	C_i	**Ranking**	**Average value**	**Ranking**
Player 1	0.822	11	0.509	12	0.631	8
Player 2	0.877	4	0.633	5	0.715	3
Player 3	0.850	6	0.603	7	0.635	7
Player 4	0.890	1	0.677	2	0.740	1
Player 5	0.740	26	0.475	14	0.535	14
Player 6	0.838	8	0.530	9	0.591	12
Player 7	0.797	14	0.488	13	0.621	9
Player 8	0.774	18	0.402	23	0.618	10
Player 9	0.889	2	0.725	1	0.737	2
Player 10	0.769	21	0.450	17	0.476	17
Player 11	0.831	10	0.544	8	0.657	5
Player 12	0.786	15	0.469	15	0.473	18
Player 13	0.812	13	0.461	16	0.602	11
Player 14	0.872	5	0.641	4	0.659	4
Player 15	0.819	12	0.519	11	0.581	13
Player 16	0.769	21	0.425	20	0.408	21
Player 17	0.728	28	0.349	26	0.399	22
Player 18	0.786	15	0.408	22	0.461	19
Player 19	0.739	27	0.311	28	0.374	25
Player 20	0.783	17	0.428	19	0.448	20
Player 21	0.727	29	0.294	30	0.274	35
Player 22	0.722	31	0.284	33	0.352	28
Player 23	0.727	29	0.287	32	0.353	27
Player 24	0.888	3	0.674	3	0.636	6
Player 25	0.772	19	0.411	21	0.394	23
Player 26	0.848	7	0.611	6	0.481	16
Player 27	0.680	39	0.203	40	0.116	40
Player 28	0.696	35	0.224	38	0.200	37
Player 29	0.748	25	0.391	25	0.333	29
Player 30	0.751	24	0.340	27	0.302	34
Player 31	0.832	9	0.524	10	0.506	15
Player 32	0.695	36	0.248	37	0.247	36
Player 33	0.770	20	0.437	18	0.361	26
Player 34	0.691	38	0.267	35	0.308	33
Player 35	0.763	23	0.402	23	0.393	24
Player 36	0.721	32	0.291	31	0.325	31
Player 37	0.720	33	0.298	29	0.328	30
Player 38	0.706	34	0.273	34	0.314	32
Player 39	0.694	37	0.255	36	0.145	38
Player 40	0.678	40	0.220	39	0.126	39

5. Conclusions

Selecting the best players for a rugby team involves consideration of many different assessment criteria. During a rugby match, players require not only good responsiveness and skills, but must also be able to withstand a large number of collisions in receiving and making tackles, engaging in extreme physical activity like scrums an rucks, and must be able to consistently maintain the massive muscle power required for repeated sprints throughout an 80-minute game. Therefore, individual ability and technical performance are a critical index for player selection. However, the traditional simple additive weighting and TOPSIS methods for player selection cannot handle both individual ability and technical performance criteria simultaneously. This study therefore proposes a novel player selection method that combines the TOPSIS and IPA methods to solve this issue. The evaluation results of the four IPA diagram quadrants can provide a reference for future training resource allocation.

The advantages of the proposed method are as follows:

(1) The proposed method can simultaneously process qualitative and quantitative criteria in MCDM problems.

(2) The proposed method can reduce the player ranking repetition rate.

(3) The proposed method can consider two-dimensional information.

(4) The proposed method generates an IPA diagram to provide a reference for future training resource allocation.

(5) The proposed method considers each alternative solution's shortest distance from the positive ideal solution, and its longest distance from the negative-ideal solution, simultaneously.

Future researches can extend the concept of the proposed method to dealing with other athlete player selection problems of different sports. On the other hand, future researches can also explore the rugby team player selection problems in incomplete information.

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