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Grey theory-based amateur tennis player technical evaluation system applied research

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ABSTRACT

The paper makes comprehensive analysis of tennis player technical levels, and focuses on hang techniques, tennis landing then backhand, landing then forehand, as well as service techniques and establishes comprehensive evaluation system. In research process, it mainly studies tennis player stroke techniques so as to comprehensive reflect amateur tennis players' levels.

KEYWORDS

Tennis player; AHP analysis; Grey theory; Comprehensive evaluation model; Biomechanics.

INTRODUCTION

In the 18th century, Britain emerged a kind of new sports event-tennis, after that it wasn't wide spread in the country but rapidly spread in France, which was well received by broad masses and so it was promoted, and then due to social rapidly development, tennis event also accordingly popularized in all countries in the world. Tennis event is of great help to physical health, so amateur enthusiasts accordingly increase.

Regarding tennis correlation research, relative scholars have got certain achievements, such as Lin Chu-Hui and others had made comprehensive evaluation on tennis player technical levels, these scholars carried on analysis of tennis players' technical levels and made quantization on them by applying fuzzy mathematics relative theories, and provided theoretical supports for nation selecting excellent athletes.

The paper just based on above ideas, takes amateur tennis players as research objects, applies analytic hierarchy process, grey model comprehensive evaluation system to make systematic analyses and applies concrete examples to state, it plays guiding roles in promoting tennis players' techniques and builds theoretical foundation for tennis development.

PLAYERS' TECHNICAL EVALUATION SYSTEM WEIGHTS STUDY

Tennis amateur players technical levels evaluation three grades indicators totally contain 12 ones, in order to more clearly and reasonable define the three mutual relationships, the paper adopts analytic hierarchy process, so we can apply the method to rank above three grades indicators, and makes further analysis by technical indicators practicability and popularity.

Analytic hierarchy process theoretical model

Any one system requires using a great deal of information as basis to make correlation analysis, the *AHP* is making comparison and judgment of any one layer indicators' weights and using numerical values to represent and so it can form into corresponding judgment matrix, from which maximum feature value is defined as λ_{MAX} to calculate correlation feature vector and feature value, if define w as weight allocation values, then for feature vector, we can define it as:

$$w=(w_1,w_2,\cdots w_n) \tag{1}$$

In order to judge whether the model evaluation weight judgment matrix is disordered or not, make consistency test on the model, its corresponding ratio formula is:

$$C\cdot R=\frac{C\cdot I}{R\cdot I} \tag{2}$$

$$C\cdot I=\frac{\lambda_{MAX}-n}{n-1}\ (n>1) \tag{3}$$

In above formula, $I\cdot R$ value is as following TABLE 1 show:

TABLE 1 : Random consistency indicator

Number of matrix orders	3	4	5	6	7	8	9	10	11	12	13	14	15
$R \cdot I$	0.49	0.91	1.21	1.25	1.32	4.38	1.47	1.54	1.56	1.57	1.59	1.60	1.61

When value of matrix orders go beyond three, meanwhile it has $C \cdot R < 0.1$,then it can be thought it is acceptable, otherwise it continues to make corresponding adjustment till it can be acceptable.
With TABLE 1 showed 1~9 scale table as evidence, it makes weight analysis that can refer to TABLE 2.

TABLE 2 : 1~9 scale table

Scale a_{ij}	Definition
1	factor i and factor j have equal importance
3	factor i is slightly more important than factor j
5	factor i is relative more important than factor j
7	factor i is very important than factor j
9	factor i is absolutely very important than factor j
2 ,4 ,6 ,8 ,	Indicates middle state corresponding scale value of above judgments
Reciprocal	If compare factor i with factor j, it gets judgment value as $a_{ji} = 1/\ a_{ij}$, $a_{ii} = 1$

Refer to Figure 1, it is 1~9 scale graph.

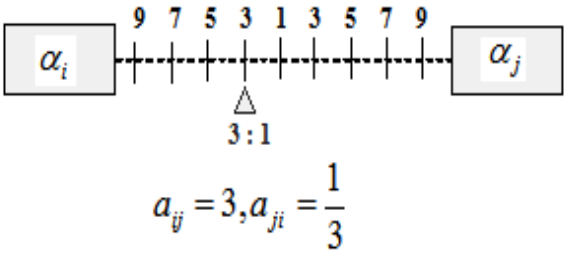

Figure 1 : Scale of 1 to 9

In above TABLE 2, 1-9 Values ratio selection requires to compare in two compared things between approximate order of magnitudes so that can have higher accuracy.

Apply analytic hierarchy process to study amateur tennis players' levels

To make evaluation on amateur players' technical levels, firstly it needs to define their corresponding evaluation indicators system model, establishes evaluation system as following TABLE 3 shows:

In above four pieces of second grade indicators system, apply *AHP* hierarchy to analysis and get the four pieces of second grade indicators importance order is tennis landing backhand, backhand, tennis service, hanging these four kind of relevant techniques, corresponding matrixes are as following 4 show:

TABLE 3 : Amateur tennis technical level evaluation indicator system

First grade technical level evaluation indicator	Second grade technical level evaluation indicator	Third grade technical level evaluation indicator
Tennis amateur player technical evaluation indicator	Tennis player's hanging	Forehand hang drive
		Backhand block
		Forehand block
		Smash
	Tennis player's backhand landing stroke	Backhand pivot attack
		Backhand topspin lob
		Backhand half-volley
		Backhand drop shot
		Slice backhand
		Backhand topspin
		Backhand flat
	Tennis players' forehand landing stroke	Forehand pivot attack
		Backhand flat
		Forehand full volley
		Forehand drop shot
		Slice forehand
		Forehand topspin
		Forehand topspin lob
	Service	Side spin
		Topspin
		Flat
		Side of topspin

TABLE 4: Second grade indicators judgment matrix

Item	Backhand landing	Service	Forehand landing	Hanging
Backhand landing	1	1	1	1/3
Service	1	1	1	1/2
Forehand landing	1	1	1	1/2
Hanging	3	2	2	1

By above TABLE 4,it can calculate its corresponding weight matrix is:

$$W=[0.1694\ 0.1814\ 0.2316\ 0.4023]$$

Carry on consistency test on above $CI=0.0756$,consistency ratio is $CR=0.0864<0.1$,thereupon it proves above judgment matrix conforms to requirements, it proves test is successful. In the following, respectively states on above four indicators.

Regarding backhand landing techniques indicators relative judgment matrix is as following TABLE 5 shows:

Regarding backhand landing techniques third grade indicators weights defining is calculating by Matlab software, its corresponding matrix is :

$$W_1=[0.0696\ 0.0512\ 0.2323\ 0.2412\ 0.1564\ 0.1331\ 0.1247]$$

TABLE 5 : Backhand landing technical indicator judgment matrix

Item	Backhand topspin	Backhand flat	Backhand drop shot	Slice backhand	Backhand half-volley	Backhand pivot attack	Backhand topspin lob
Backhand topspin	2	3	1/2	1/2	1/3	1/3	1/3
Backhand flat	1/3	2	1/3	1/3	1/4	1/4	1/4
Backhand drop shot	2	3	2	2	1	1	1
Slice backhand	2	3	2	2	1	1	1
Backhand half-volley	3	4	1/3	1/3	1	1	1
Backhand pivot attack	3	4	1/3	1/3	2	2	2
Backhand topspin lob	3	4	1/3	1/3	2	2	2

After consistency testing, it can get $CI = 0.0541$, corresponding ratio is $CR = 0.0362 < 0.1$,it proves the matrix conforms to requirements.

Regarding forehand tennis techniques indicators relative judgment matrix is as following TABLE 6 shows:

TABLE 6: Forehand landing technical indicators judgment matrix

Item	Forehand topspin	Forehand flat	Forehand drop shot	Slice forehand	Forehand full volley	Forehand pivot attack	Forehand topspin lob
Forehand topspin	1	1	1/2	1/2	1/2	1/3	1/3
Forehand flat	1/3	2	1/3	1/3	1/3	1/2	1/2
Forehand drop shot	2	3	2	2	2	3	3
Slice forehand	2	3	2	2	2	3	3
Forehand full volley	2	3	2	2	2	3	3
Forehand pivot attack	3	2	1/3	1/3	1/3	2	2
Forehand topspin lob	3	2	1/3	1/3	1/3	2	2

Regarding forehand tennis techniques third grade indicators weights defining is calculating by Matlab software, its corresponding matrix is :

$$W_2 = [0.0697\ 0.0451\ 0.2236\ 0.2213\ 0.2152\ 0.1191\ 0.1247]$$

After consistency testing, it can get $CI = 0.0069$, corresponding ratio is $CR = 0.0063 < 0.1$ it proves the matrix conforms to requirements.

Regarding hanging techniques indicators relative judgment matrix is as following TABLE 7 shows:

Regarding hanging techniques third grade indicators weights defining is calculating by Matlab software, its corresponding matrix is:

$$W_3 = [0.1289\ 0.1045\ 0.1132\ 0.3247\ 0.3247]$$

TABLE 7: Hanging technical indicator judgment matrix

Item	Backhand block	Backhand hang drive	Smash	Backhand hang drive	Backhand block
Backhand block	1	2	2	1/3	1/3
Backhand hang drive	2	1	2	1/2	1/2
Smash	2	2	1	1/2	1/2
Backhand hang drive	2	3	3	1	2
Backhand block	2	2	2	2	1

After consistency testing, it can get $CI = 0.0065$,corresponding ratio is $CR = 0.0058 < 0.1$ it proves the matrix conforms to requirements.

By above, we can know that four kinds of indicator systems smoothly pass testing, and meanwhile, second grade corresponding first grade indicator and third grade indicators corresponding second grade indicators weights are respectively solved, so it can apply them into comprehensive evaluation.

Regarding service technical indicators relative judgment matrix is as following TABLE 8 shows:

TABLE 8 : Service technical indicator judgment matrix

Item	Side spin service	Topspin service	Flat service	Side of topspin service
Side spin service	2	1	1/3	1/2
Topspin service	1/3	2	1/4	1/3
Flat service	1	4	2	1/2
Side of topspin service	2	3	11	1

Regarding service techniques third grade indicators weights defining is calculating by Matlab software, its corresponding matrix is:

$$W_4 = [0.1564\ 0.1023\ 0.1897\ 0.4563]$$

After consistency testing, it can get $CI = 0.0104$, corresponding ratio is $CR = 0.0137 < 0.1$, it proves the matrix conforms to requirements.

GREY MODEL APPLICATIONS

Firstly, set optimal indicator set, construct corresponding matrix, considering each indicator dimension is different, so it can do normalization processing, combine with above solved weights, it can calculate comprehensive evaluation result. We can let reference sequence to be $\{C^*\} = [C_1^*, C_2^*, \cdots, C_n^*]$, then corresponding comparison sequence is $\{C\} = [C_1^i, C_2^i, \cdots, C_n^i]$,then it can apply above correlation analysis method to solve the k indicator in the i sample optimal correlation coefficient :

$$\xi_i(k) = \frac{\min\limits_i \min\limits_k |C_K^* - C_K^i| + \rho \max\limits_i \max\limits_k |C_K^* - C_K^i|}{|C_K^* - C_K^i| + \rho \max\limits_i \max\limits_k |C_K^* - C_K^i|} \quad \textbf{(4)}$$

In above formula, $\rho \in [0,1]$, in general, we can get $\rho = 0.5$

By optimal correlation coefficient, we get each indicator evaluation matrix E,by, $r_i = \sum_{k=1}^{n} W(k) \times \xi_i(k)$,it can solve each indicator weight allocation quantity, then we can get comprehensive evaluation result R expression that :

$$R = E \times W \quad \textbf{(5)}$$

By above, we can get when $\{C\}$ gets closer to $\{C^*\}$,then correlation degree numeric value r_i will be bigger, and so it proves the i sample belongs to the optimal one, so it can make arrangement.

The paper tests at one gym's five amateur tennis players, the result is as following TABLE 9 shows:

TABLE 9 : Subjects performance percentage table

Three grades test indicator	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}
No.1	45	60	70	30	65	75	60	50	75	55	66	60
No.2	46	65	72	45	60	75	75	60	86	65	69	69
No.3	32	60	55	35	63	60	45	41	68	50	64	64
No.4	36	65	56	39	60	55	42	47	65	55	65	61
No.5	34	63	45	30	55	55	40	35	60	45	55	54

According to above grey comprehensive evaluation model, handle with above table collected data, list out three grade indicators and optimal indicator matrixes are respectively:

$$A = \begin{bmatrix} 43 & 64 & 70 & 43 \\ 41 & 62 & 65 & 33 \\ 45 & 63 & 72 & 45 \\ 32 & 65 & 55 & 36 \\ 34 & 60 & 56 & 35 \\ 35 & 61 & 45 & 30 \end{bmatrix}$$

$$B = \begin{bmatrix} 64 & 75 & 72 & 60 & 83 & 65 & 67 \\ 62 & 74 & 60 & 49 & 75 & 59 & 66 \\ 63 & 76 & 75 & 57 & 80 & 64 & 68 \\ 62 & 64 & 44 & 41 & 75 & 56 & 65 \\ 56 & 59 & 42 & 42 & 69 & 59 & 61 \\ 55 & 54 & 40 & 36 & 65 & 46 & 54 \end{bmatrix}$$

$$C = \begin{bmatrix} 66 & 62 & 68 & 45 & 73 & 48 & 66 \\ 63 & 55 & 67 & 43 & 59 & 47 & 55 \\ 67 & 61 & 65 & 40 & 74 & 56 & 64 \\ 65 & 52 & 60 & 42 & 65 & 43 & 47 \\ 60 & 56 & 67 & 37 & 66 & 47 & 56 \\ 56 & 45 & 61 & 22 & 62 & 41 & 53 \end{bmatrix}$$

$$D=\begin{bmatrix}75 & 64 & 64 & 68 & 71\\ 73 & 48 & 56 & 63 & 62\\ 85 & 65 & 64 & 74 & 72\\ 64 & 55 & 47 & 65 & 55\\ 75 & 50 & 53 & 62 & 54\\ 55 & 40 & 42 & 57 & 43\end{bmatrix}$$

Due to above four kinds of indicators dimensions are different, it can make normalization on them, and can get:

$$A=\begin{bmatrix}1.212 & 0.96 & 1.247 & 1.119\\ 1.106 & 0.976 & 1.112 & 0.964\\ 1.213 & 1.04 & 1.136 & 1.119\\ 0.669 & 0.897 & 0.917 & 0.946\\ 0.847 & 1.036 & 0.721 & 0.994\\ 0.934 & 1.011 & 0.724 & 0.784\end{bmatrix}$$

$$B=\begin{bmatrix}1.114 & 1.165 & 1.125 & 1.247 & 1.098 & 1.174 & 1.109\\ 1.023 & 1.055 & 1.032 & 1.032 & 1.004 & 0980 & 1.047\\ 1.114 & 1.165 & 1.125 & 1.247 & 1.098 & 1.174 & 1.109\\ 1.025 & 0.950 & 0.823 & 0.865 & 0.968 & 0.928 & 1.029\\ 0.959 & 0.874 & 0.762 & 0.914 & 0.947 & 0.978 & 0.956\\ 0.876 & 0.812 & 0.694 & 0.687 & 0.867 & 0.747 & 0.832\end{bmatrix}$$

$$C=\begin{bmatrix}1.112 & 1.106 & 1.236 & 1.147 & 1.099 & 1.124 & 1.109\\ 0.996 & 0.949 & 1.064 & 1.115 & 0.885 & 1.023 & 0.941\\ 1.112 & 1.106 & 1.236 & 1.147 & 1.099 & 1.124 & 1.109\\ 1.024 & 0.948 & 0.925 & 1.142 & 0.963 & 0.874 & 0.852\\ 0.98 & 1.047 & 1.046 & 0.987 & 1.214 & 0.965 & 0.964\\ 0.89 & 0.912 & 0.941 & 0.563 & 0.947 & 0.825 & 0.876\end{bmatrix}$$

$$D=\begin{bmatrix}1.021 & 1.243 & 1.201 & 1.134 & 1.234\\ 1.002 & 0.869 & 1.045 & 0.940 & 1.017\\ 1.119 & 1.246 & 1.203 & 1.134 & 1.121\\ 0.852 & 0.969 & 0.896 & 1.025 & 0.947\\ 0.997 & 0.936 & 0.967 & 0.941 & 0.973\\ 0.743 & 0.687 & 0.748 & 0.865 & 0.669\end{bmatrix}$$

According to above formula, it can solve four kinds of indicators corresponding grey correlation coefficient matrix E_i , then corresponding four kinds of indicators are :

$$E_1=\begin{bmatrix} 0.847 & 0.784 & 0.778 & 0.417 \\ 1.002 & 1.002 & 1.002 & 1.002 \\ 0.369 & 0.674 & 0.487 & 0.457 \\ 0.481 & 0.958 & 0.451 & 0.523 \\ 0.502 & 0.814 & 0.324 & 0.314 \end{bmatrix}$$

$$E_2=\begin{bmatrix} 0.847 & 0.754 & 0.555 & 0.571 & 0.746 & 0.639 & 0.854 \\ 1.002 & 1.000 & 1.002 & 1.002 & 1.002 & 1.001 & 1.000 \\ 0.852 & 0.603 & 0.369 & 0.425 & 0.664 & 0.564 & 0.843 \\ 0.734 & 0.529 & 0.347 & 0.467 & 0.626 & 0.628 & 0.598 \\ 0.614 & 0.478 & 0.336 & 0.378 & 0.564 & 0.417 & 0.534 \end{bmatrix}$$

$$E_3=\begin{bmatrix} 0.792 & 0.741 & 0.998 & 0.947 & 0.612 & 0.679 & 0.612 \\ 1.000 & 1.002 & 0.832 & 0.784 & 0.997 & 1.000 & 1.002 \\ 0.847 & 0.647 & 0.698 & 1.001 & 0.529 & 0.529 & 0.476 \\ 0.798 & 0.784 & 0.914 & 0.714 & 0.646 & 0.625 & 0.625 \\ 0.628 & 0.519 & 0.654 & 0.326 & 0.471 & 0.625 & 0.539 \end{bmatrix}$$

$$E_4=\begin{bmatrix} 0.914 & 0.471 & 0.654 & 0.612 & 0.547 \\ 0.625 & 1.001 & 1.000 & 1.002 & 1.001 \\ 0.753 & 0.478 & 0.492 & 0.698 & 0.439 \\ 1.000 & 0.446 & 0.556 & 0.565 & 0.498 \\ 0.531 & 0.369 & 0.397 & 0.526 & 0.334 \end{bmatrix}$$

According to above matrix, combine with grey prediction comprehensive evaluation method, it can get evaluation result about above five players four kinds of indicators, and handle with second grade to first grade indicators judgment matrix on the result, which are also five players' tennis technical level judgment values, that : $(0.6648 \quad 0.9546 \quad 0.5468 \quad 0.5942 \quad 0.4731)$ by above, we can get No.2 player performance is obviously higher than other players.

CONCLUSION

To make comprehensive evaluation on amateur tennis players technical levels, the paper adopts analytic hierarchy process, grey model comprehensive evaluation and other methods to do correlation research, and combines with concrete examples to analyze, finally it gets that in selected five players, the weakest tennis technical level is No. 5, the strongest is No.2 player, by the research, it is beneficial to amateur players technical levels improvements, which has certain guiding effects on the field development in future.

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