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Research Article

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China men's national basketball team previous Olympic Games performance and technical indicator correlation research based on AHP and GST

Liwu Xu

Institute of Sport, Shenyang Sport University, Shenyang, China

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ABSTRACT

To easier statistical analysis and get precise reasonable structure, take dimensionless treatment to all basketball technical indicators. Then through grey theory system analyze previous Chinese team technical indicator data in Olympic Games, get correlation degree between each technical indicator and competition performance, further achieve competition performance judgment matrix. By consistency testing on judgment matrix, input each technical indicator data and judgment matrix into analytic hierarchy process model, get each technical indicator weight on competition performance. Result shows that higher weight technical indicators are respectively steal, fault, foul and rebound, it indicates that basketball player first should guarantee steal in training so that can directly break opponent attack; the next is defend rebound, fight for initiative, finally is reduce error rate. Through establishing grey prediction model, utilize Matlab software predicting Chinese team next competition performance with its competition performance in previous world championship, get prediction value 67 scores. Carry out feasibility test by residual testing and correlation degree testing, obtain that the model correlation degree is first grade, which indicates the model is scientific and reasonable.

Key words: Nondimensionalize, Analytic Hierarchy Process, Grey System Theory, basketball performance, China men's national basketball team

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INTRODUCTION

Nowadays basketball becomes more and more fashionable, people is attaching more and more importance to basketball competition. How to analyze team's situation as well as competition performance have already been current relative hot topics. Research directions in this paper are analyzing teams' strength and make prediction of competition results. Players technical performance in competition process is one of the major factors that decide competition performance, while basketball competition spot technical statistics data is quantitative indicator to measure players' technical level and also the objective criterion to judge team competition performance.

The problem as problems in basketball competition had ever been discussed by Neijiang normal college mathematics department Zhang Shuang, Zhou Cui and others in their article "About some problems analysis in basketball competition" through stepwise regression model, data statistical analysis [1, 2]. However, due to problem complexity, the model is still in the trial stage and need to be further improved. Besides, the problem also is researched by Gong Jian from Wuhan physical education institute in his article "China men's national basketball team performance experimental research on 2008 Olympic Games based on neural network", through establishing 3 layers forward back-propagation neural network model, using rolling prediction method to predict China men's national basketball team major technical statistical indicators in 2008 Olympic Games [3, 4]. But the model requires huge amounts of data, it is difficult to collect information and the results have great errors. Zhou Bing-Yu from capital physical education institute through observation, analysis of world high level basketball competition and videos as well as combining with system theory thoughts, he put forward that take basketball competition as a completed system to analysis and research, exploring its internal factors and mutual relations among each factor and process, which is applying system theory holistic view idea into competitive basketball competition research [5]. But the article completely deny cell analysis research method not possess perspective scientificity, little adapted to each field.

Team's technical indicator refers to attack and defense ability that presented by player fully utilizing each technique in actual competition, it mainly reflected by two-point shot percentage, three-point percentage, free throw percentage, rebound, assist, fault, steal, foul such 8 technical indicators. Basketball competition is a team competition, which not only requires every player has superb techniques, but also require team-work spirits. It cannot judge teams technical indicator singularly from one competition but should take integral analysis with multiple competitions results, from which technical indicator got is objective criterion [6].

Due to model research's model research's entire technical indicators unit is not unified, in order to easier statistical analysis and make precise reasonable structure, carry out dimensionless treatment to all technical indicators. Then according to previous Chinese team technical indicator data in Olympic Games, through grey theory system get correlation degree between each technical indicator and competition performance, and further get competition performance judgment matrix. By consistency testing on judgment matrix, get each technical indicator weight on competition performance. Through establishing grey prediction model, predict Chinese team next competition performance with their competition performance in previous world championship. After getting prediction value, carry out feasibility testing by residual testing and correlation testing on it.

GREY CORRELATION DEGREE ANALYSIS

According to data (refer to Table1), first find out China men's national basketball team correlation between each indicator and competition performance.

Table 1: Each indicator and competition performance

2-pointer %	3-pointer%	Free throw%	Rebound	Assist	Foul	Fault	Steal	Total scores
41.2	45.5	90	32	17	20	19	8	76
59	32	76.5	38	23	23	19	8	96
48.5	40	81.8	31	19	21	16	3	65
50	44.4	73.1	21	15	23	20	3	71
61.9	21.7	75	20	9	18	17	2	68
67.9	48	93.3	26	21	19	21	6	88
86.3	25	81.8	30	16	22	12	6	84

Due to each data as well as statistical data and final performance have no significant correlations, draw these data to see whether can find some laws, get scatter figure 1 as following.

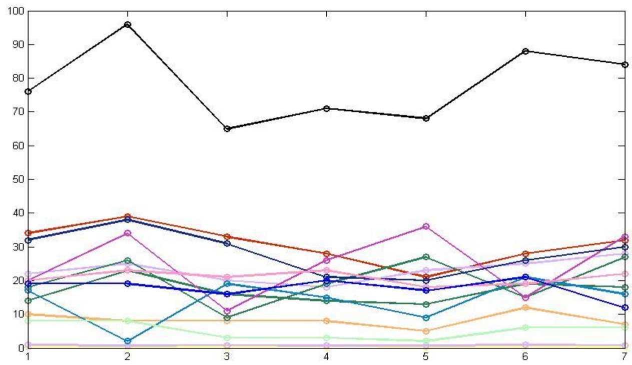

Figure 1: scatter figure

Grey correlation degree concrete analysis steps are like following:

(1) Define comparison objects (evaluation objects) and reference series(evaluation criterion). Give m pieces of evaluation objects, n pieces of evaluation indicators, reference series to be $x_n = \{x_n(k) | k = 1,2,...,n\}$,comparison series to be: $x_i = \{x_i(k) | k = 1,2,...,n\}, i = 1,2,...,m$.

(2) Define each indicator value corresponding weight. It can use analytic hierarchy process and others to define each

indicator weight $w=[w_1,w_2,...,w_n]$, from which $w_k(k=1,2,...,n)$ is the k indicator corresponding weight.

(3) Calculate grey correlation coefficient:

$$\xi_\alpha(k)=\frac{\min\limits_{\alpha}\min\limits_{k}|x_0(k)-x_\alpha(k)|+\rho\max\limits_{\alpha}\max\limits_{k}|x_0(k)-x_\alpha(k)|}{|x_0(k)-x_\alpha(k)|+\rho\max\limits_{\alpha}\max\limits_{k}|x_0(k)-x_\alpha(k)|}$$

Among them, $\xi_\alpha(k)$ represents correlation coefficient between technical statistics and comparison criterion, $\rho\in[0,1]$ is called resolution ratio, $\min\limits_{\alpha}\min\limits_{k}|x_0(k)-x_\alpha(k)|$ 和 $\max\limits_{\alpha}\max\limits_{k}|x_0(k)-x_\alpha(k)|$ are respectively called two levels minimum difference and two levels maximum difference. Generally speaking, the bigger the coefficient ρ is, the bigger resolution ratio would be；The smaller ρ is, the smaller the resolution ratio would be.

(4) Calculate grey weighting correlation degree. Computation formula of grey weighting correlation degree is $r_i=\sum_{k=1}^{n}w_i\xi_i(k)$, from which r_i is the i evaluation objects grey weighting correlation degree to ideal objects.
(5) Evaluation analysis. According to size of grey correlation degree, sort each evaluation objects can establish evaluation objects correlation sequence .The bigger the correlation sequence is, the better its evaluation result would be.

Due to data dimensions are different, while in hypothesis process requires consistence of dimensions, this paper initialize these data, which mainly take dimensionless treatment to all data and meanwhile enable all sequence has a common intersection point so as to easier comparing.

Due to data in Table 1 has different dimensions, while the calculation process requires keeping the consistence dimensions, we initialize these data, which mainly take dimensionless treatment to all data and meanwhile enable all sequence has a common intersection point so as to easier comparing. We adopt below methods to covert.

Given original series to be $X=(x(1),x(2),\cdots,x(n))$, then can construct it initialized series as $\overline{X}=(1,\frac{x(2)}{x(1)},\cdots,\frac{x(n)}{x(1)})$.So the initialized series obviously cannot meet the demand of dimensionless, and if all the original series should construct such initialized series, then it surely would have common intersection point 1,refer to Table 2.

Table 2: Original series construct initialized series

Session	1	2	3	4	5	6	7
2-pointer	0.010	1.432	1.177	1.214	1.502	1.648	1.367
Numbers of goals	1.000	1.643	1.143	1.000	0.929	1.357	1.286
Numbers of pitches	1.000	1.147	0.971	0.824	0.618	0.824	0.941
3-pointer	0.010	0.703	0.879	0.976	0.477	1.055	0.549
Numbers of goals	1.000	0.800	0.800	0.800	0.500	1.200	0.700
Numbers of pitches	1.000	1.136	0.909	0.818	1.045	1.136	1.273
Free throw	0.010	0.850	0.909	0.812	0.833	1.037	0.909
Numbers of goals	1.000	1.444	0.500	1.056	1.500	0.833	1.500
Numbers of pitches	1.000	1.700	0.550	1.300	1.800	0.750	1.650
Rebound	1.000	1.188	0.969	0.656	0.625	0.813	0.938
Assist	1.000	0.118	1.118	0.882	0.529	1.235	0.941
Foul	1.000	1.150	1.050	1.150	0.900	0.950	1.100
Fault	1.000	1.000	0.842	1.053	0.895	1.105	0.632
Steal	1.000	1.000	0.375	0.375	0.250	0.750	0.750
Total score	1.000	1.263	0.855	0.934	0.895	1.158	1.105

During preliminary stage of model establishing, firstly carry out grey correlation degree analysis of 8 technical indicators that influence competition performance. Below is correlation degree formula.

$$\varepsilon_{0i} = \frac{1+|s_0|+|s_i|}{1+|s_0|+|s_i|+|s_i - s_0|} \quad |s_0| = \left|\sum_{k=2}^{n=1} x_0^0(k) + \frac{1}{2}x_0^0(n)\right| \quad |s_i| = \left|\sum_{k=2}^{n=1} x_i^0(k) + \frac{1}{2}x_i^0(n)\right|$$

$$|s_i - s_0| = \left|\sum_{k=2}^{n=1}\left(x_i^0(k) - x_0^0(k)\right) + \frac{1}{2}\left(x_i^0(n) - x_0^0(n)\right)\right|$$

By grey system theory software it gets Table 3.

Table 3: 8 technical indicators grey correlation degree analysis result

Indicator	2-pointer	3-pointer	Free throw	Rebound	Assist	Foul	Fault	Steal
Total score	0.599	0.6198	0.6138	0.745	0.58	0.72	0.74	0.82

ANALYTIC HIERARCHY ANALYSIS MODEL

Hierarchical structure establishment and features

When applies analytic hierarchy process to analyze decisive problems, firstly it should organize and layer the problems, construct a hierarchical structure model. In this model, complicated problems are dissolved into element compositions. These elements form into some hierarchies according to their nature and relations. Regard last hierarchical element as criteria that plays a dominate role in next hierarchical relative elements. These hierarchies can be divided into 3 types.

1)The top hierarchy: Only one element in this hierarchy, it normally is intended target or ideal result of analytic problems, therefore is also called target hierarchy.
2)Middle hierarchy: In this hierarchy, it including intermediate links that get involved to fulfill targets, which can be composed of some hierarchies that including criteria, sub-criteria that required to consider, therefore it also called criteria hierarchy.
3)The bottom hierarchy: This hierarchy includes optional each measure, decision scheme and so on to fulfill targets, therefore it also called measure hierarchy or scheme hierarchy.

Note: Hierarchy numbers in hierarchical structure has something to do with problem's complicated degree as well as required analysis elaborate degree, normally it not limited. Each element in every hierarchy governs less than 9 elements .Because too many elements governing would bring difficulty to paired judgment.

Establish judgment matrix

In this model, use hierarchical structure reflect scores variation tendency as well as 3 criterions factors that bring into this tendency. But a criterion hierarchy's every criteria weight in target measuring is not always the same; therefore weighting analysis should be made on 8 technical indicators.

When define each factor that influence scores proportion in the factor, main difficulties that come across is the proportion tends not to be quantified. Besides, when there are many factors and directly consider each factor influence degree on the factor, it tends to let decision maker put forward data inconsistent with his actual thoughts on importance degree due to inadequate consideration as well as catches one and loses another, even he may put forward a group of paradox implicit data. To clarify the point, it can make assumption as below: Smash one stones with 1kg weight into n patches, you can precise measure its weight, given it to be $w_1,\cdots w_n$ .Now, ask someone to estimate such n patches weights proportion of total weight (cannot let him know each patch of stone's weight), the person not only feels difficult to provide precise proportions, but also may entirely provide mutual contradicted data due to catch one and lose another.

Assume that now it should make comparison of n pieces of factors $X = \{x_1,\cdots,x_n\}$ influence on one factor Z, so how to compare can provide reliable data? Saaty and others suggest that it can adopt the method of carrying out comparison between two factors and establishing paired comparison matrix. That is every time take two factors x_i and x_j ,use a_{ij} represent proportion between x_j and Z, all comparison result use matrix $A = (a_{ij})_{n\times n}$ to represent, regard A as paired comparison judgment matrix between Z and A(it is called judgment matrix for short).

It is easily found that if the influence proportion of x_i and x_j to Z is a_{ij} ,then influence proportion of x_j and

x_i to Z is $a_{ji} = \frac{1}{a_{ij}}$ .Definition 1 if matrix $A = (a_{ij})_{n \times n}$ meets (i) $a_{ij} > 0,$ (ii) $a_{ji} = \frac{1}{a_{ij}}$ $(i, j = 1,2,\cdots,n)$, then it called positive and negative matrix(easier refer to $a_{ii} = 1, i = 1,\cdots,n$).

With regard to value a_{ij} defining, this paper takes number 1 to 9 and their reciprocal as scale by quoting Saaty's. Table 4 lists out definitions from 1 to 9 scales.

Table 4: Scale definitions

Scale	Definition
1	Indicates two factors have equal importance by comparing
3	Indicates the former is slightly more important than the later by comparing two factors
5	Indicates the former is obviously more important than the later by comparing two factors
7	Indicates the former is intensely more important than the later by comparing two factors
9	Indicates the former is extremely more important than the later by comparing two factors
2,4,6,8,	Indicates middle value of above adjacent judgment
Reciprocal	If importance ratio between element i and j is a_{ij} ; then importance ratio between j and i would be $a_{ij} = 1/a_{ji}$.

In the view of psychology, too many grades will go beyond people judgment ability, which increases difficulties in judging and also easily lead to false data providing. Saaty and others use experimental methods compare accuracy of people judgment result in different scales. The experimental result also shows that it is more proper for adopting 1to 9 scale.

Finally, it should to point out normally it is necessary to make paired judgment by $\frac{n(n-1)}{2}$ times. Some think it only needs to make $n-1$ times comparison of all elements with one element. Drawback of such method is every one judgment error all can generate unreasonable sequence, while individual judgment error is hard to avoid to system that hard to make quantification. Carry out $\frac{n(n-1)}{2}$ times comparing can provide more information, through repeatedly comparing from each different perspective then can output a reasonable sequence.

Judgment matrix consistency test

(i) Calculate consistency indicator CI : $CI = \frac{\lambda_{\max} - n}{n-1}$

(ii) Look up corresponding average random consistency indicator RI .To $n = 1,\cdots,9$, Saaty provides the value of RI , as Table 5 shows.

Table 5: RI value

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

RI value is got in this way that construct 500 sample matrix by random method, random select numbers from 1 to 9 as well as its reciprocals to construct positive reciprocal matrix, and determine average value of maximum feature root $\lambda'_{\max}$, and define $RI = \frac{\lambda'_{\max} - n}{n-1}$.

(iii) Calculate consistency proportion CR : $CR = \frac{CI}{RI}$ .When $CR < 0.10$, it is thought that judgment matrix consistency is acceptable, otherwise it should make proper correction to judgment matrix.

Model establishment

According to each technical indicator and competition performance correlation degree can get score judgment matrix as Table 6 shows.

Table 6: Score judgment matrix

	1	2	3	4	5	6	7	8
1	1	5	5	7	3	7	7	9
2	$\frac{1}{5}$	1	$\frac{1}{2}$	5	$\frac{1}{5}$	5	5	7
3	$\frac{1}{5}$	2	1	5	$\frac{1}{5}$	5	5	7
4	$\frac{1}{7}$	$\frac{1}{5}$	$\frac{1}{5}$	1	$\frac{1}{7}$	$\frac{1}{3}$	1	5
5	$\frac{1}{3}$	5	$\frac{1}{5}$	7	1	7	7	9
6	$\frac{1}{7}$	$\frac{1}{5}$	$\frac{1}{5}$	3	$\frac{1}{7}$	1	2	5
7	$\frac{1}{7}$	$\frac{1}{5}$	$\frac{1}{5}$	1	$\frac{1}{7}$	$\frac{1}{2}$	1	5
8	$\frac{1}{9}$	$\frac{1}{7}$	$\frac{1}{7}$	$\frac{1}{5}$	$\frac{1}{9}$	$\frac{1}{5}$	$\frac{1}{5}$	1

Establish hierarchical structure as Figure 2 shows:

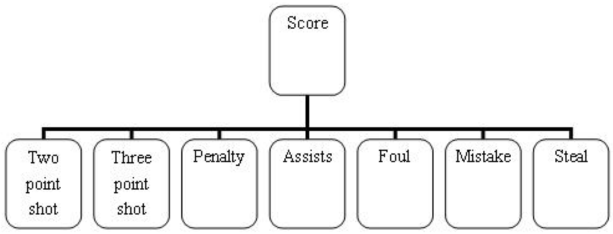

Figure 2: Score hierarchical analysis structure figure

Utilize Matlab software to handle data in Table 7, calculate each influence factor weight on score, and refer to Table 8.

Table 7: Competition data

2-pointer%	3-pointer%	Free throw%	Rebound	Assist	Foul	Fault	Steal	Total score
41.2	45.5	90	32	17	20	19	8	76
59	32	76.5	38	23	23	19	8	96
48.5	40	81.8	31	19	21	16	3	65
50	44.4	73.1	21	15	23	20	3	71
61.9	21.7	75	20	9	18	17	2	68
67.9	48	93.3	26	21	19	21	6	88
86.3	25	81.8	30	16	22	12	6	84

Table 8: weight result table

1	0.0186
2	0.0566
3	0.0566
4	0.1467
5	0.0263
6	0.1391
7	0.1596
8	0.3966

GREY MODEL

Given known reference data series to be $x^{(0)} = \left(x^{(0)}(1) + x^{(0)}(2) \ldots\ldots x^{(0)}(k)\right)$, series by one time accumulation is $\left(x^{(1)}(1), x^{(1)}(1) + x^{(0)}(2)\right), \ldots, x^{(1)}(n-1) + x^{(0)}(n)$.

Among them, $x^{(1)}(k)=\sum_{i=1}^{k}x^{(0)}(i)(k=1,2,...,n)$. Determine average value series: $z^{(1)}(k)=0.5x^{(1)}(k)+0.5x^{(1)}(k-1)(k=2,3,...,n)$, That is $z^{(1)}=(z^{(1)}(2),z^{(1)}(3),...,z^{(1)}(n))$.So establish grey differential equation as $x^{(0)}(k)+az^{(1)}(k)=b(k=2,3,...,n)$, Corresponding whitening differential equation is $\frac{dx^{(1)}}{dt}+ax^{(1)}(t)=b$. Record

$$u=(a,b)^T, Y_1=(x^{(0)}(2),x^{(0)}(3),...,x^{(0)}(n))^T, B=\begin{bmatrix}-z^{(1)}(2) & 1\\ -z^{(1)}(3) & 1\\ . & .\\ . & .\\ . & .\\ -z^{(1)}(n) & 1\end{bmatrix},$$

Then by least square method, determine let $J\left(\hat{u}\right)=\left(Y_1-B\bullet\hat{u}\right)^T\left(Y_1-B\bullet\hat{u}\right)$ arrives at minimums $\hat{u}=\left(\hat{a},\hat{b}\right)^T=(B^TB)^{-1}B^TY$.

So, solve whitening differential equation can get $x^{(1)}(k+1)=\left(x^{(0)}(1)-\frac{b}{a}\right)e^{-ak}+\frac{b}{a}(k=1,2,...,n-1)$.

To ensure model establishment feasibility, it needs to make necessary test on known data series. Use reference data calculate series grade proportion $\lambda(k)=\frac{x^{(0)}(k-1)}{x^{(0)}(k)}\ (k=2,3,\cdots,n)$. If all grade proportion $\lambda(k)$ drop in admissible coverage $X=(e^{-\frac{2}{n+1}},e^{\frac{2}{n+1}})$, then series $x^{(0)}$ takes necessary transformation, enable it drop in the range of admissible coverage. Which is take proper constant c to make translation transformation $y^{(0)}(k)=x^{(0)}(k)+c\ (k=1,2,\cdots n)$, then series grade proportion $\lambda_{(k)}=\frac{y^{(0)}(k-1)}{y^{(0)}(k)}\in X \quad (k=2,3,\cdots n)$.

Establish model GM(1,1):

$x^{(0)}=(75,68,84,66,88,69,97,70,78,87,70,55,61,75,85,72,75,70,66,85,64,58,69,57,52,67,75,76,70,75,85,59,77,68)$

Series by one time accumulation is

$$x^{(1)}=\begin{pmatrix}75,143,227,293,381,450,547,617,695,782,852,907,968,1043,1128,1203,1278,1348,1414,\\1499,1504,1648,1706,1775,1832,1884,1951,2026,2102,2172,2247,2332,2391,2468,2536\end{pmatrix}$$

Corresponding whitening differential equation is $\frac{dx^{(1)}}{dt}+ax^{(1)}(t)=b$, therefore $\left(\hat{a},\hat{b}\right)^T=(B^TB)^{-1}B^TY_1=\begin{bmatrix}0.0210\\0.0002\end{bmatrix}$.

According to China men's national basketball team 34 groups' data since 1992, score series got from MATLAB programming is:

75.0000	74.8100	74.6169	74.4208	74.2215	74.0192	73.8137	73.6050	73.3931	73.1780
72.9596	72.7379	72.5130	72.2846	72.0530	71.8179	71.5795	71.3376	71.0923	70.8435
70.5912	70.3354	70.0761	69.8133	69.5470	69.2771	69.0036	68.7266	68.4459	68.1617
67.8739	67.5825	67.2875	66.9888	66.6866					

From them can get the 35th and 36th data as 66.9、66.68.

Then this paper tests on model. Relative error test indicator test: original time series $x^0=(x^0(1),x^0(2),......x^0(i))$, Prediction model simulation series $x^0 = (x^0(1), x^0(2), ...x^0(i))$, residual series $\varepsilon^{(0)} = (\varepsilon(1), \varepsilon(2), ...\varepsilon(i))$, $x^{(0)}(1) - x^{(0)}(1), x^{(0)}(2) - x(2), x^{(0)}(i) - x^{(0)}(i)$.

Relative error series $\Delta = \left(\left| \frac{\varepsilon(1)}{x^{(0)}(1)} \right|, \left| \frac{\varepsilon(2)}{x^{(0)}(2)} \right|, ... \left| \frac{\varepsilon(i)}{x^{(0)}(i)} \right| \right)$, average relative error $\Delta = \frac{1}{10} \sum_{k=1}^{10} \Delta_k$, simulation error $\Delta_{10} = \left| \frac{\varepsilon(10)}{x^{(0)}(10)} \right|$. GM (1, 1) model average relative error is 0.03689.

Correlation degree test:
Calculate grey absolute correlation degree:

$$|s| = \left| \sum_{k=2}^{5} [x(k) - x(1)] + \frac{1}{2} [x(6) - x(1)] \right|$$

$$\left| \hat{s} \right| = \left| \sum_{k=2}^{5} \left[\hat{x}(k) - \hat{x}(1) \right] + \frac{1}{2} \left[\hat{x}(6) - \hat{x}(1) \right] \right|$$

$$\xi = \left(1 + |s| + \left| \hat{s} \right| \right) \Big/ \left(1 + |s| + \left| \hat{s} \right| + \left| \hat{s} - s \right| \right)$$

Absolute correlation degree:
$GM(1,1)$ model absolute correlation degree $\xi = 0.9408 > 0.90$, the model correlation degree is first grade.

CONCLUSION

From analytic hierarchy process result, it can be found that higher weight factors are respectively steal, fault, foul and rebound. That is to say, these aspects have great influence on score, basketball player first should guarantee steal in training that can directly break opponent attack; the next is defend rebound, fight for initiative, then is reduce error rate. Through grey theory data, it indicates that China men's national basketball team performance would stable develop, because grey system theory mode ling's main tasks is according to specific grey system behavior features data, using few data display information and hidden information, get mathematical relations among factors or factors themselves. What establishes in this paper is one model carrying out stage wise analysis according to time. While discrete model can only make short -term analysis on the development of objective systems. Therefore above result just explains one prediction result of China men's national basketball team in stable playing levels, and scores got only represents one level.

Combine with above results, this paper makes suggestions to China men's national basketball team as following: Suggest China men's national basketball team players individual attack ability, especially rear guard ball control and govern ability. Strengthen reserve talents cultivation. Increase defense dynamics in competitions, strengthen body antagonism so that effectively propel to player attack ability improvement. Suggest that China men's national basketball team learn other excellent team strategic style, focus on integral cooperation while meanwhile properly propel to players individual attack ability effectively playing. It should strengthen physical training, especially for ability quality and endurance quality training.

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