Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(3):340-345

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

The correlation analysis and strategy between basketball scoring index and physical fitness based on principal component model

Jun Liu

Department of Physical Education, Dalian Polytechnic University, Dalian, China

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ABSTRACT

Based on methods of principal component analysis, this paper simplifies each indicator that affect basketball team integrated technical score, divides the 17 different indicators that reflect the integrated technology into five principle components, simply and accurately obtains the overall strength of the basketball team. According to the conclusions shooting percentage and the overall strength have great relevance, so according to the parabolic motion principles in physics this paper builds mathematical model of differential equation for basketball during throwing period, studies several cases when the hit rate is the highest, implements different training programs for different athletes, and improves the overall strength of the basketball team.

Key words: Comprehensive strength, principal component analysis, differential equations, physical fitness, scoring index, basketball

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INTRODUCTION

Principal component analysis theory has been widely applied to various fields; in sports, there have been many studies theory combined with principal component analysis, these studies has been applied in sports research and power quality of hammer thrower. And this article applies the principal component analysis for basketball, which is one of the most important sports project, combines theory with practice, and comes to useful conclusions for the athletes [1-3].

Basketball game takes confrontation as the basic law; there are many factors that determine the outcome of basketball games; due to the different competitive level of opponent, technical statistics of each game not necessarily takes the only antagonism as standard [4-6]. Through simple basketball statistics index, restore the true colors of the data; you need to use the system theory method to study the basketball game comprehensively, systematically and relatively; so that the winning factor of the basketball game can be found, and the objective laws of basketball development can be obtained [7-9].

This research will select a more comprehensive technical statistical indicators, sorts and classifies the technical statistical indicators, conducts necessary processing on the selected technical statistical data, and uses principal component analysis theory to sum up the overall strength of each basketball team, meanwhile obtains several factors that mainly affect the overall strength, and expands specific discussion on methods to improve it, proposes objective evaluation, and provides a theoretical reference for basketball training and competition.

PRINCIPAL COMPONENT ANALYSIS METHOD

Principal component analysis is one of a number of statistical indicators to simplify a few simple statistical principal component analyses. That is to reflect the original multiple statistical indicators with a relatively small number of integrated indicators, and these integrated statistical indicators must reflect the problem that original indicators can reaction as much as possible; meanwhile they are independent of each other. The calculation method is as follows:

(1)Calculate the correlation coefficient matrix

$$R=\begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mm} \end{pmatrix}$$

Where $r_{ij}(i,j=1,2,\cdots,m)$ is the correlation coefficient of variable x_i and x_j, which is calculated as:

$$r_{ij}=\frac{\sum_{k=1}^{n}(x_{ki}-\overline{x_i})(x_{kj}-\overline{x_j})}{\sqrt{\sum_{k=1}^{n}(x_{ki}-\overline{x_i})^2\sum_{k=1}^{n}(x_{kj}-\overline{x_j})^2}}$$

Since R is a real symmetric matrix (i.e. $r_{ij}=r_{ji}$), so we can just calculate the upper triangular elements or lower triangular elements.

(2)Calculate the eigenvalue and eigenvectors

First, solve the characteristic equation $|\lambda I-R|=0$, find the eigenvalue $\lambda_i(i=1,2,\cdots,p)$, and arrange it in order of size, namely $\lambda_1\geq\lambda_2\geq\cdots\geq\lambda_m\geq 0$; then calculate eigenvectors $e_i(i=1,2,\cdots,p)$ corresponding to eigenvalue λ_i.

(3)Calculate the principal component contribution rate and accumulative contribution rate

Principal component: $z_i/\sum_{k=1}^{p}\gamma_k(i=1,2,\cdots,p)$

Cumulative contribution rate: $\sum_{k=1}^{m}\gamma_k/\sum_{k=1}^{p}\gamma_k$

Generally, we take the first, second... $m(m\leq p)$ principal component that is corresponding to the eigenvalue $\lambda_1,\lambda_2,\cdots,\lambda_m$ when the cumulative contribution rate reaches 85-95% .

(4)Calculate the principal component load

$$p(z_k,x_i)=\sqrt{\gamma_k}e_{ki}(i,k=1,2,\cdots,p)$$

Thus we can further calculate the principal component scores: $Z=\begin{pmatrix} z_{11} & z_{12} & \cdots & z_{1m} \\ z_{21} & z_{22} & \cdots & z_{2m} \\ \vdots & \vdots & & \vdots \\ z_{n1} & z_{n2} & \cdots & z_{rm} \end{pmatrix}$

INDICATORS SELECTION

Technical statistical work is an important part of the basketball competition work; the selection of statistical indicators relates to whether it can accurately reflect the technical level of a team. According to expert assessment and a summary of the experience, the indicators that can react each team's composite technical score are divided into seventeen statistics indexes as shots, shooting average, two points shots, two-point shooting average, three-point shots, three-point shooting average, free throws, free throws shooting average, offensive rebounds, defensive rebounds, rebounds, assists, steals, blocked shots, turnovers, and fouls. Select the Lakers for research and see data in Table 1 and Table 2.

Table 1: The relative score for each item of Lakers' 23 games

opponent	session	shots	shooting average	two points shots	two-point shooting average	three points shots	three-point shooting average	free throws
Thunder	1	1.08	1.02	1.00	0.89	1.38	2.91	0.92
	2	1.19	0.96	1.20	0.94	1.16	1.04	0.97
	3	1.05	1.10	0.87	1.29	1.63	0.77	0.35
	4	1.08	1.02	1.03	1.16	1.22	0.55	0.58
	5	0.93	1.46	1.00	1.54	0.70	1.02	1.29
	6	0.93	1.28	0.83	1.15	1.26	1.90	0.45
	7	0.91	1.19	0.97	1.22	0.67	0.60	1.29
Jazz	8	0.82	1.28	0.81	1.49	0.89	0.56	1.29
	9	1.13	-0.98	1.05	0.98	1.32	0.99	0.61
	10	1.02	1.00	1.02	0.96	1.06	1.41	1.33
Suns	11	1.11	1.17	1.25	1.02	0.77	2.07	0.69
	12	0.94	1.17	1.05	1.11	0.67	1.35	1.31
	13	1.06	1.04	0.89	1.13	1.60	1.13	0.48
	14	1.08	1.01	1.17	1.03	0.93	0.88	0.41
	15	1.18	0.89	1.34	0.63	0.89	0.88	0.79
	16	1.11	1.01	1.20	0.93	0.92	1.20	0.97
	17	1.13	1.12	1.16	1.02	1.00	4.00	0.86
Celtics	18	0.85	0.95	0.72	1.33	1.38	0.33	1.58
	19	1.04	1.02	1.11	1.03	0.83	0.60	1.00
	20	0.86	0.90	0.72	1.02	1.67	1.40	0.96
	21	1.10	0.71	1.00	0.65	1.58	1.47	2.00
	22	0.94	1.26	0.98	1.19	0.83	1.46	1.90
	23	1.17	0.80	1.15	0.87	1.25	0.53	2.18

Table 2: The technical statistics for each item of Lakers' 23 games

session	free throws shooting average	offensive rebounds	defensive rebounds	rebounds	assists	steals	blocked shots	turnovers	fouls
1	0.86	1.33	1.07	1.14	1.00	1.00	2.67	1.00	1.29
2	0.82	2.71	1.00	1.32	1.54	1.00	0.18	0.94	0.87
3	1.05	0.50	0.82	0.74	1.38	1.33	1.33	0.89	1.37
4	0.69	0.77	0.89	0.86	1.27	0.50	0.57	1.38	1.30
5	0.95	0.71	1.25	1.07	1.50	1.67	3.33	0.81	0.76
6	0.74	0.77	1.14	1.02	1.10	0.57	2.00	2.50	1.11
7	0.86	0.91	1.22	1.13	0.75	1.00	3.50	1.27	0.77
8	1.11	0.95	1.90	1.45	0.96	0.60	3.25	2.00	0.75
9	1.00	1.08	0.86	0.93	0.78	1.25	1.25	0.64	1.19
10	1.21	1.00	0.91	0.93	0.88	1.75	0.63	0.46	0.75
11	1.09	1.20	1.25	1.24	1.04	1.33	1.00	0.82	0.91
12	0.96	1.33	1.08	1.15	1.10	1.57	1.00	0.82	0.88
13	0.91	0.90	1.07	1.03	1.05	0.40	3.00	2.43	1.33
14	0.78	0.72	0.70	0.71	1.09	1.33	2.33	0.86	1.92
15	1.26	1.58	1.07	1.23	1.47	1.00	1.25	0.67	1.14
16	0.99	1.75	1.17	1.32	0.95	1.50	0.50	0.82	1.21
17	0.93	1.50	1.30	1.35	0.95	1.20	1.40	0.92	0.93
18	0.98	0.77	0.94	0.89	0.64	1.33	4.67	1.15	1.00
19	1.31	1.38	1.19	1.23	0.65	0.50	3.50	0.80	0.74
20	0.99	0.50	1.04	0.83	0.87	0.50	1.50	1.25	1.10
21	0.95	2.29	0.64	0.97	0.57	1.13	0.14	0.81	0.96
22	1.49	1.09	1.43	1.33	1.00	1.50	2.00	0.93	0.81
23	0.77	2.88	0.94	1.33	0.61	1.17	0.43	0.79	0.76

The relative correlation coefficient matrix between the above data using SPSS is as follows:

$$R = \left[\begin{array}{ccccccccccccccccc}
1 & -0.362 & 0.802 & -0.716 & 0.094 & 0.214 & -0.196 & -0.149 & 0.627 & -0.449 & 0.138 & 0.182 & 0.100 & -0.629 & -0.416 & -0.260 & -0.095 \\
-0.362 & 1 & 0.103 & 0.364 & -0.327 & 0.111 & 0.099 & 0.033 & -0.142 & 0.407 & 0.228 & 0.301 & -0.023 & 0.243 & 0.277 & -0.185 & 0.272 \\
0.802 & -0.103 & 1 & -0.576 & -0.493 & 0.172 & -0.077 & 0.076 & 0.563 & -0.116 & 0.399 & 0.250 & 0.300 & -0.491 & -0.556 & 0.036 & 0.265 \\
-0.716 & 0.364 & -0.576 & 1 & -0.206 & -0.250 & -0.070 & -0.015 & -0.615 & 0.493 & -0.073 & 0.181 & 0.009 & 0.618 & 0.392 & -0.155 & 0.178 \\
0.094 & -0.327 & -0.493 & -0.206 & 1 & 0.019 & -0.137 & -0.292 & -0.026 & -0.511 & -0.516 & -0.162 & -0.367 & -0.146 & 0.266 & 0.376 & -0.637 \\
0.214 & 0.111 & 0.172 & -0.250 & 0.019 & 1 & -0.151 & -0.045 & -0.066 & 0.134 & 0.230 & 0.021 & 0.109 & -0.195 & -0.032 & 0.011 & 0.364 \\
-0.196 & 0.099 & -0.077 & -0.070 & -0.137 & -0.151 & 1 & 0.238 & 0.487 & 0.118 & 0.374 & -0.496 & 0.323 & -0.019 & -0.289 & -0.653 & 0.341 \\
-0.149 & 0.033 & 0.076 & -0.015 & -0.292 & -0.045 & 0.238 & 1 & -0.107 & 0.374 & 0.289 & -0.077 & 0.232 & 0.126 & -0.325 & -0.377 & 0.537 \\
0.627 & -0.142 & 0.563 & -0.615 & -0.026 & 0.066 & 0.487 & -0.107 & 1 & -0.135 & 0.561 & -0.145 & 0.101 & -0.528 & -0.324 & -0.322 & 0.093 \\
-0.449 & 0.407 & -0.116 & 0.493 & -0.511 & 0.134 & 0.118 & 0.374 & -0.135 & 1 & 0.716 & 0.068 & -0.161 & 0.375 & 0.344 & -0.505 & 0.564 \\
0.138 & 0.228 & 0.399 & -0.073 & -0.516 & 0.230 & 0.374 & 0.289 & 0.561 & 0.716 & 1 & -0.021 & 0.000 & -0.055 & -0.003 & -0.609 & 0.593 \\
0.182 & 0.301 & 0.250 & 0.181 & -0.162 & 0.021 & -0.496 & -0.077 & -0.145 & 0.068 & -0.021 & 1 & 0.068 & -0.171 & 0.044 & 0.239 & 0.094 \\
0.1 & -0.023 & 0.300 & 0.009 & -0.367 & 0.109 & 0.323 & 0.232 & 0.101 & -0.161 & 0.000 & 0.068 & 1 & -0.202 & -0.692 & -0.123 & 0.537 \\
-0.629 & 0.243 & -0.491 & 0.618 & -0.146 & -0.195 & -0.019 & 0.126 & -0.528 & 0.375 & -0.055 & -0.171 & -0.202 & 1 & 0.364 & -0.047 & 0.053 \\
-0.416 & 0.277 & -0.556 & 0.392 & 0.266 & -0.032 & -0.289 & -0.325 & -0.324 & 0.344 & -0.003 & 0.044 & -0.692 & 0.364 & 1 & 0.126 & -0.314 \\
0.260 & -0.185 & 0.036 & -0.155 & 0.376 & 0.011 & -0.653 & -0.377 & -0.322 & -0.505 & -0.609 & 0.239 & -0.123 & -0.047 & 0.126 & 1 & -0.575 \\
-0.095 & 0.272 & 0.265 & 0.178 & -0.637 & 0.364 & 0.341 & 0.537 & 0.093 & 0.564 & 0.593 & 0.094 & 0.537 & 0.053 & -0.314 & -0.575 & 1
\end{array}\right]$$

Table 3: The total explanatory variance

component	initial eigenvalue			Extracting square and load		
	total	variance %	accumulative %	total	variance %	accumulative %
1	4.329	25.465	25.465	4.329	25.465	25.465
2	4.219	24.815	50.280	4.219	24.815	50.280
3	2.085	12.264	62.544	2.085	12.264	62.544
4	1.811	10.652	73.196	1.811	10.652	73.196
5	1.100	6.469	79.665	1.100	6.469	79.665
6	1.000	5.881	85.547			
7	.706	4.152	89.699			
8	.591	3.476	93.175			
9	.361	2.126	95.301			
10	.281	1.653	96.953			
11	.164	.962	97.915			
12	.160	.942	98.857			
13	.091	.534	99.391			
14	.056	.328	99.719			
15	.036	.210	99.929			
16	.009	.050	99.979			
17	.004	.021	100.000			
Extraction Method: Principal Component Analysis.						

Table 4: Component matrix

Index	Components				
	1	2	3	4	5
shots	0.701	-0.571	0.232	0.172	-0.041
shooting average	-0.182	0.513	0.346	0.155	-0.133
two points shots	0.834	-0.142	0.396	0.031	-0.195
two-point shooting average	-0.651	0.546	0.150	-0.210	-0.169
three-point shots	-0.355	-0.645	-0.353	0.172	0.285
three-point shooting average	0.264	0.037	0.319	0.221	0.826
free throws	0.354	0.431	-0.719	-0.016	-0.121
free throws shooting average	.238	.508	-.097	-.313	.192
offensive rebounds	.770	-.118	-.277	.438	-.219
defensive rebounds	-.103	.850	.198	.338	.062
rebounds	.519	.619	.056	.532	-.045
assists	-.005	-.041	.812	-.068	-.268
steals	.493	.183	.028	-.718	.063
blocked shots	-.621	.452	-.064	-.105	-.019
turnovers	-.714	.077	.106	.596	.011
fouls	-.301	-.713	.388	-.160	.059
score	.454	.758	.183	-.187	.256
Extraction Method: Principal Component Analysis.					
a. Five components have been extracted.					

From the "total explanatory variance" Table 3 we can draw that the eigenvalue of correlation matrix that is greater than 1 include, $\lambda_1 = 4.329$, $\lambda_2 = 4.219$, $\lambda_3 = 2.085$, $\lambda_4 = 1.811$, $\lambda_5 = 1.110$; And the cumulative contribution rate is 79.665%, so select the top five factors as the principal component to evaluate the technical scores of a basketball team.

According to the matrix component of Table 4 and the total explanatory variance in Table 3, we can obtain the corresponding eigenvector to each eigenvalue, thus obtain the expression of the five principle components:

$$F_1 = 0.337x_1 - 0.088x_2 + 0.578x_3 - 0.483x_4 - 0.338x_5 + 0.264x_6 + 0.442x_7 + 0.310x_8$$
$$+1.280x_9 - 0.194x_{10} + 1.283x_{11} - 0.013x_{12} + 1.637x_{13} - 2.631x_{14} - 3.779x_{15} - 3.254x_{16} + 7.556x_{17}$$

$$F_2 = -0.274x_1 + 0.250x_2 - 0.099x_3 + 0.406x_4 - 0.616x_5 + 0.037x_6 + 0.513x_7 6 + 0.661x_8$$
$$-0.196x_9 + 1.604x_{10} + 1.531x_{11} - 0.103x_{12} + 0.609x_{13} + 1.914x_{14} + 0.407x_{15} - 7.722x_{16} + 12.621x_{17}$$

$$F_3 = 0.111x_1 + 0.168x_2 + 0.275x_3 + 0.111x_4 - 0.336x_5 + 0.319x_6 - 0.856x_7 - 0.126x_8$$
$$-0.461x_9 0.373x_{10} + 0.139x_{11} + 2.030x_{12} + 0.093x_{13} - 0.272x_{14} + 0.563x_{15} + 4.204x_{16} + 3.051x_{17}$$

$$F_4 = 0.083x_1 + 0.075x_2 + 0.022x_3 - 0.156x_4 + 0.164x_5 + 0.221x_6 - 0.020x_7 - 0.407x_8$$
$$+0.728x_9 + 0.638x_{10} + 1.316x_{11} - 0.170x_{12} - 2.383x_{13} - 0.446x_{14} + 3.153x_{15} - 1.734x_{16} - 3.118x_{17}$$

$$F_5 = -0.020x_1 - 0.065x_2 - 0.135x_3 - 0.125x_4 + 0.272x_5 + 0.826x_6 - 0.144x_7 + 0.249x_8$$
$$-0.365x_9 + 0.116x_{10} - 0.111x_{11} - 0.671x_{12} + 0.211x_{13} - 0.082x_{14} + 0.056x_{15} + 0.635x_{16} + 4.269x_{17}$$

Wherein, $F_1, \cdots, F_5$ respectively represents the principal component of the basketball team's composite technical score, $x_1, x_2, \cdots, x_{17}$ respectively represents 17 different indicators.

If Y is set as the team's comprehensive technical score, the coefficient of F_i $(i = 1,2,\cdots,5)$ is the information contribution rate of each factor (the ratio of the variance contribution rate of each factor and the cumulative contribution rate of five main components), the team's overall score is:

$$Y = 0.3197F_1 + 0.3115F_2 + 0.1539F_3 + 0.1337F_4 + 0.0812F_5$$

MECHANICAL MODEL OF BASKETBALL WHEN THROWING OUT

Based on the above analysis we can conclude: basketball team's integrated technological scoring and shooting percentage have great relevance. So the corresponding training for athletes on the problem of basketball hit rate will better improve the team's integrated technological score.

The position of the basketball when leaving hand is the coordinate origin, the horizontal thrown direction is the x-axis direction, the positive up direction is the positive y-axis direction, establish the coordinate system when throwing out basketball as shown in Figure 1:

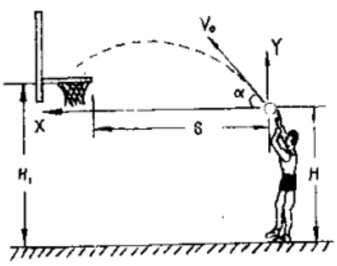

Figure 1: Schematic of basketball throwing out

In Figure 1, H_1 is the ring height, which is stipulated as 3.05 meters, H_2 is the shooting height of the basketball, S is the shooting distance.

According to the parabola principle of the physical model we can draw that, the motion equation of the ball at any time in the air is: $\begin{cases} X = V_0 \cos\alpha \cdot t \\ Y = V_0 \sin\alpha \cdot t - \frac{1}{2} g t^2 \end{cases}$

Trajectory equation is: $Y = \tan\alpha \cdot X - \frac{g}{2V_0^2 \cos^2\alpha} \cdot X^2$

Wherein, V_0 is the initial velocity of the shooting basketball, α is the angle between the horizontal direction at the shooting time, t is the flight time of the ball from throwing out to the goal.

ⅰ、the initial velocity equation of sinking a shot is:

$$V_0 = \sqrt{\frac{gs^2}{2\cos^2\alpha[\tan\alpha \cdot S - (H_1 - H_2)]}}$$

Through analysis when the throwing angle α is about 50°, the value of V_0 is minimum, and then it is most likely for shooting.

ⅱ、according to the conditions of sinking a shot the shooting distance equation is:

$$S = \frac{V_0^2}{g}\left[\frac{\sin 2\alpha}{2} + \cos\alpha\sqrt{\sin^2\alpha - \frac{2g(H_1 - H_2)}{V_0^2}}\right]$$

When the throwing angle α changes into $\alpha + 1$, the generated shooting error is: $\Delta S = S(\alpha + 1) - S(\alpha)$

Based on the above analysis the following can be drawn: (1), the best shots angle is around 50°, and in this range the shooting error rate is the minimum. (2), when basketball is thrown at a certain height, the best shooting angle should be reduced with the increasing of shooting distance, but it takes more effort. (3), when the shooting distance is constant, the best shooting angle should be reduced with an increase of the basketball throwing height, and the strength is also reduced. Based on the above mathematical model, different training programs were developed for basketball player with different conditions, which has achieved the best results.

CONCLUSION

Through the scientific selection of indicators that can reflect the basketball team's overall strength, it extracts five principle components to react the comprehensive scoring strength using principal component analysis method, and solves the linear equations of the overall strength score. The conclusion is that the shooting average has a greater impact on the composite score, so it establishes the differential equations based on the physical model of shots, and obtains the conditions that hit rate increases of athletes under different physiological conditions. Players lower in height should conduct training mainly on shooting angle and appropriately increase intensity, athletes with smaller strength mainly carry through close-up shot training; depending on the specific height, arm power, the distance from the ring, calculate and come to accurate data in order to facilitate the implementation of corresponding training for athletes.

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