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## The study of games and improvements in community square body-building activities based on the analytic hierarchy process

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### ABSTRACT

Community square body-building activities are the basic motivation of sports spreading in the whole country and an important part of gymnastic industry. With lots of sports fans being there, community squares are very convenient and the first choice of sporting activities for people. Meanwhile, the spreading of community square body-building activities also contributes to the dissemination of sports among people. This text has made the game analysis and improvement study in community square body-building activities through the angle of people groups involved in community square body-building activities and begins the paper by analyzing several common community activities. First, the Discriminant Analysis Method is used to analyze the degree of participation and satisfaction of people in different age groups in football, basketball, badminton, rope skipping, shuttlecock kicking, social dance, square dance and tai chi chuan. It also raises that teenagers have passion for the community square body-building activities like football, basketball, badminton, rope skipping and shuttlecock kicking, etc. Second, the Analytic Hierarchy is taken to study the square sporting activities that are suitable for teenagers and middle-aged people through comparing priorities. Then, the conclusion is: in order to raise teenagers' enthusiasm for sports and encourage more middle-aged and elderly people to do sports, sporting facilities should be improved. We also should build small football courts, basketball courts and put some new activities like rope skipping, shuttlecock kicking, etc. into the ranks of sports.

### KEYWORDS

Square body-building activity; Improvement study; The discriminant analysis method; The analytic hierarchy process; Sports spreading.



## INTRODUCTION

People is the best carrier of sports spreading and the most powerful strength for sporting development. As economy grows rapidly, there is an obvious improvement in people's living standard and the pursuit of life is not only the problem of food and clothing, but also the pursuit of spiritual life in higher level. In the background of great progress of people's living standard, nationwide body-building activity has become the slogan that everybody knows.

In the text of *The Establishment of Operation Patterns among Community Sporting Construction Clubs*, Yang Shoumin regarded the constructions of community sports as the carrier to analyze the construction and operation patterns of sporting clubs. The paper interviewed every local community, searched for statistics, analyzed the comment that the residents had raised on the sporting club construction and proposed that the construction of community sporting clubs conformed to the living needs of the residents and it enriched the life of community residents. Moreover, when the community sporting clubs are running, people should be viewed as the foundation, everything should be for people, everything should belong to people and the management pattern for people should be implemented. In the text of *The Current Operation Situation and Anticipation of National Community Sporting Clubs in the City of Taiyuan*, Deng Lixing took the example of Taiyuan to study the future of national community sporting clubs in Taiyuan. The paper researched the situation of local sports spreading and sporting club construction, searched and dealt with the statistics and in the end drew the conclusion that community sports development in Taiyuan was faster than past years but slower than those developed cities and if advanced technologies and sporting facilities were brought, its operation would step into a higher level. In the text of *The Study of Developing Current Situation and Strategy for Shanghai Zhabei District Community Sporting Body-building Facilities*, Zhang Yonghong took the example of Shanghai Zhabei district to study the construction problems of its community sporting facilities. The paper pointed out that community sporting construction in Shanghai developed quickly and all kinds of sporting facilities were comprehensive but shortcomings still remained and suggestions from community residents should be paid more attention to make community sporting construction in Shanghai better from the angle of meeting the needs of community residents.

This text regards community square sporting participators of different age groups as the carrier to study the games and improvements of community square sporting activities. Mathematical methods are used to make statistic quantitative analysis and conclusions are made in the end. It also provides the theoretical basics for the spreading and development among people of sports in our country.

## MODEL BUILDING

Communities are the most basic and common places for body-building activities. People is the carrier of sports. The fast spreading of community sporting activities not only puts great power into sporting development of our county but also give it a push and becomes the powerful basic of gymnastic industry spreading among people's life. Community square body-building activities are limited by the inner factors of places and facilities, etc. Given that people who do sports in community squares are concentrated, of high mobility and of different age groups, the main activities are badminton, square dance, social dance and tai chi chuan, etc. Moreover, rope skipping, shuttlecock kicking, football, basketball, etc are chosen in certain proportions.

### Participating groups in community square body-building activities

People of different ages have different choices for community sports. For teenager groups, most of teenagers like to choose football, basketball, badminton, rope skipping and shuttlecock kicking. For middle-aged and elderly groups, the main activities are those mild sports like square dance, social dance, tai chi chuan, badminton, etc. TABLE 1 and TABLE 2 are the proportions of participators in different sporting activities and of different ages. The data are from Internet statistics.

**TABLE 1 : The percentage of participators in different age groups**

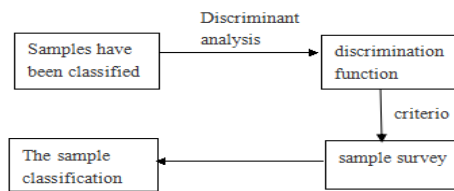
	Football	Basketball	Badminton	Rope skipping	Shuttlecock kicking	Square dance	Social dance	Tai chi chuan
《20	52.1%	69.8%	75.2%	48.3%	55.1%	10.4%	19.7%	1.8%
20~30	45.8%	50.2%	69.7%	47.1%	19.2%	27.5%	19.8%	2.0%
30~45	10.2%	15.3%	26.9%	22.1%	27.8%	49.1%	50.8%	12.9%
45~55	2.3%	5.7%	15.4%	21.6%	25.8%	50.1%	53.9%	40.7%
》 55	0.2%	1.1%	9.8%	3.7%	5.9%	49.7%	52.9%	58.4%

**TABLE 2 : The satisfaction degree of participators in different age groups**

	Football	Basketball	Badminton	Rope skipping	Shuttlecock kicking	Square dance	Social dance	Tai chi chuan
《20	49.2%	51.8%	73.1%	45.2%	49.8%	11.2%	15.3%	2.5%
20~30	39.1%	48.7%	61.3%	46.5%	20.0%	28.2%	21.7%	3.6%
30~45	9.6%	14.7%	25.4%	23.6%	25.6%	48.1%	51.9%	15.9%
45~55	2.9%	6.6%	11.5%	18.7%	19.9%	51.4%	55.2%	41.8%
》55	0.9%	2.1%	3.9%	5.8%	10.1%	58.3%	60.7%	60.4%

**The Discriminant analysis of the body-building activities participating situation of people in different age groups**

Discriminant Analysis is a diverse statistic analysis method. It aims at observing the known assessing standards and classifying the objects through the statistics. Figure 1 shows the general steps of Discriminant analysis:



**Figure 1 : Discriminant analysis step**

Discriminant Analysis means to make judgment analysis for historical statistics and build discriminant functions to observe the statistic classification. Here Bayes Discriminant Analysis is used to make standard study of sporting dancing teachers for their professional qualities.

TABLE 3 is the discriminant Analysis statistics from managing TABLE 1 and TABLE 2 statistically.

**TABLE 3 : The discriminant analysis statistics**

	Degree of satisfaction	Football	Basketball	Badminton	Rope skipping	Shuttlecock kicking	Square dance	Social dance	Tai chi chuan
《20	37.26%	52.1%	69.8%	75.2%	48.3%	55.1%	10.4%	19.7%	1.8%
20~30	33.63%	45.8%	50.2%	69.7%	47.1%	19.2%	27.5%	19.8%	2.0%
30~45	26.85%	10.2%	15.3%	26.9%	22.1%	27.8%	49.1%	50.8%	12.9%
45~55	26.0%	2.3%	5.7%	15.4%	21.6%	25.8%	50.1%	53.9%	40.7%
》55	24.79%	0.2%	1.1%	9.8%	3.7%	5.9%	49.7%	52.9%	58.4%

Bayes Discriminant Analysis is a method to analyze two or more kinds of statistics. Here, the sporting quality standards of teenage volleyball athletes need to be analyzed through the aging structure and gender. So, using Bayes Discriminant Analysis is suitable.

The classification function form conducted under the rules of the Bayes Discriminant Analysis is:

$$\begin{cases}
 y_1 = c_{01} + c_{11}x_1 + c_{21}x_2 + c_{31}x_3 + \dots + c_{p1}x_p \\
 y_2 = c_{02} + c_{12}x_1 + c_{22}x_2 + c_{32}x_3 + \dots + c_{p2}x_p \\
 y_3 = c_{03} + c_{13}x_1 + c_{23}x_2 + c_{33}x_3 + \dots + c_{p3}x_p \\
 \dots \\
 y_n = c_{0n} + c_{1n}x_1 + c_{2n}x_2 + c_{3n}x_3 + \dots + c_{pn}x_p
 \end{cases}$$

It means to build linear equations between the observing indexes and observing objects. Every equation corresponds to a kind of judging standard and  $c_{0j}, c_{1j}, \dots, c_{pj}, j = 1, 2, \dots, n$  are estimation parameters. After building the judgment functions, put each parameter of certain judging object into the discriminant functions above, then we can know which type the object belongs to.

According to the statistics above, we can manage the statistics and build the classification function groups of Bayes Discriminant Analysis in order to study the loving standards of different community square body-building activities among people in different ages.

**The statistic management and result of the discriminant analysis**

**Statistic management**

Taking advantage of SPSS to analyze the statistics above can get the classification functions about the loving degree of different community square body-building activities among people in different ages:

**TABLE 4 : The coefficient statistics**

Model	Non-standardized coefficient		Standardized coefficient
	B	Standard Deviation	Trialed version
(Constant)	38.106	.000	38.106
Football	.257	.000	.257
Basketball	.114	.000	.114
Badminton	.365	.000	.365
Rope skipping	-.024	.000	-.083
Shuttlecock kicking	.101	.000	.335
Square dance	.298	.000	.298
Social dance	-.268	.000	-.886
Tai chi chuan	.006	.000	.029

Based on the coefficient in TABLE 4, we can get classification about the loving degree of different community square sports among people in different age groups:

$$y = 0.257x_1 + 0.114x_2 + 0.365x_3 - 0.083x_4 + 0.335x_5 + 0.298x_6 - 0.886x_7 + 0.029x_8 + 38.106$$

y is the degree of satisfaction among people. x<sub>1</sub> is football. x<sub>2</sub> is basketball. x<sub>3</sub> is badminton. x<sub>4</sub> is rope skipping. x<sub>5</sub> is shuttlecock kicking. x<sub>6</sub> is square dance. x<sub>7</sub> is social dance. x<sub>8</sub> is tai chi chuan.

In order to enhance the accuracy of the judgments, prior probability is put in firstly to improve the classification functions of the Bayes Discriminant Analysis. Prior probability can raise the accuracy of judgments properly and the rule of it is study according to large amounts of documents or samples in the past.

Based on the prior probability, the classification functions of Bayes Discriminant Analysis change into another form as follow:

$$\begin{cases} y_1 = c_{01} + c_{11}x_1 + c_{21}x_2 + c_{31}x_3 + \dots + c_{p1}x_p + \ln(q(y_1)) \\ y_2 = c_{02} + c_{12}x_1 + c_{22}x_2 + c_{32}x_3 + \dots + c_{p2}x_p + \ln(q(y_2)) \\ y_3 = c_{03} + c_{13}x_1 + c_{23}x_2 + c_{33}x_3 + \dots + c_{p3}x_p + \ln(q(y_3)) \\ \dots \\ y_n = c_{0n} + c_{1n}x_1 + c_{2n}x_2 + c_{3n}x_3 + \dots + c_{pn}x_p + \ln(q(y_n)) \end{cases}$$

In accordance with the current situation of community square body-building activities above, it is sure that the prior probability of community square body-building activities is  $q(y) = 0.55$ .

With the consideration of the prior probability, we can make a further step to get the Bayes classification function of the loving degree of different community square sports among people in different age groups:

$$y = 0.257x_1 + 0.114x_2 + 0.365x_3 - 0.083x_4 + 0.335x_5 + 0.298x_6 - 0.886x_7 + 0.029x_8 + 38.106 + \ln(0.55)$$

That is:

$$y = 0.257x_1 + 0.114x_2 + 0.365x_3 - 0.083x_4 + 0.335x_5 + 0.298x_6 - 0.886x_7 + 0.029x_8 + 38.7.508$$

The function above is the judgment function about the loving degree of different community square sports among people in different age groups. Now we need to make sure its classification standards.

**Make sure the classification and conclusions**

According to the discriminant analysis and the data in the statistic TABLE above, we can obtain the discriminant standards:

Teenagers:  $\leq 30$  yeas old,  $y > 30\%$  ; Middle-aged and elderly people:  $\gg 30$  years old,  $20\% < y < 30\%$

To make the comprehensive analysis of the data in the statistic TABLES can draw the final conclusion that teenagers love community square body-building activities like football, basketball, badminton, rope skipping, shuttlecock kicking,etc the best. Middle-aged and elderly people love social dance, square dance, tai chi chuan and badminton the best.

**THE IMPROVEMENT SCHEME OF COMMUNITY SQUARE BODY-BUILDING ACTIVITIES BASED ON AHP MODEL**

Through the game analysis of community square body-building activities and combining the conclusion of the discriminant analysis, we can know that people in different age groups have different needs for community body-building activities and the preference of teenagers and middle-aged and elderly people is relatively deficient and common. This is because the influence of community sporting facilities, physical qualities, etc.

In order to improve the current situation of community square body-building activities, we need to consider more suitable sporting schemes for people in different age groups. Now we make the hierarchy analysis and compare the priorities of different community square body-building activities. In the end, we need to make sure the improvement scheme of community square body-building activities.

**The guiding ideology and model construction**

Construct the hierarchy structure as Figure 2 shows.

Goal: The community square fitness activities improved solution

Criteria: The influential factors of the scheme.  $C_1$  is football.  $C_2$  is basketball.  $C_3$  is badminton.  $C_4$  is rope skipping.  $C_5$  is shuttlecock kicking.  $C_6$  is social dance.  $C_7$  is square dance.  $C_8$  is tai chi chuan.

Alternatives:  $A_1$  means very positive.  $A_2$  means more positive.  $A_3$  means common.  $A_4$  means not too positive.

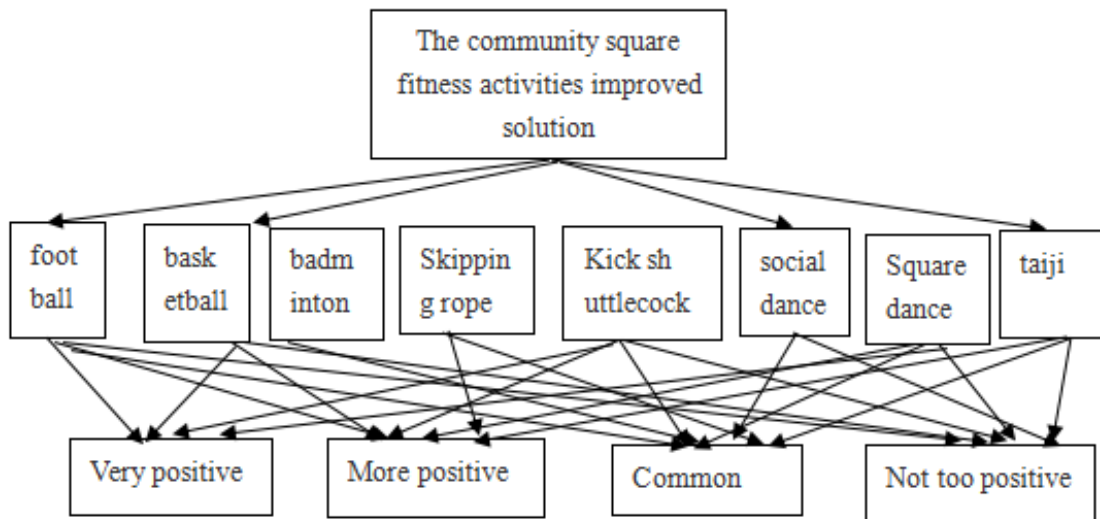


Figure 2 : Class hierarchy

**Establish pairwise comparison matrices**

Establishing pairwise comparison matrices means to establish priorities among the elements of the hierarchy by making a series of judgments based on pairwise comparisons of the elements in the form of matrices. Here we cite the ratio scale 1~9.

**TABLE 5 : The meaning of scale 1~9**

Scale $a_{ij}$	Definition
1	Factor i and Factor j are equally important
3	Factor i is a little bit more important than Factor j
5	Factor i is more important than Factor j
7	Factor i is much more important than Factor j
9	Factor i is absolutely more important than Factor j
2, 4, 6, 8	The corresponding scale values of the mediacy between the judgments above

Based on the scale TABLE 5, assume the judgment matrix  $A$  is:

$$A = \begin{pmatrix} 1 & 2 & \frac{1}{2} & \frac{1}{4} & \frac{1}{5} & \frac{1}{3} & \frac{1}{2} & \frac{1}{3} \\ \frac{1}{2} & 1 & \frac{1}{2} & \frac{1}{5} & \frac{1}{7} & \frac{1}{4} & \frac{1}{3} & \frac{1}{4} \\ 2 & 2 & 1 & \frac{1}{4} & \frac{1}{5} & \frac{1}{3} & \frac{1}{2} & \frac{1}{5} \\ 4 & 5 & 4 & 1 & \frac{1}{2} & 2 & \frac{1}{6} & \frac{1}{4} \\ 5 & 7 & 5 & 2 & 1 & 3 & \frac{1}{3} & \frac{1}{2} \\ 5 & 7 & 5 & 2 & 3 & 1 & \frac{1}{5} & \frac{1}{6} \\ 2 & 3 & 2 & 6 & 3 & 5 & 1 & \frac{1}{3} \\ 3 & 4 & 5 & 4 & 2 & 6 & 3 & 1 \end{pmatrix}$$

All the judgment matrices of Alternatives corresponding to different Criteria are as follow. They are TABLE 6~8.

**TABLE 6 : Judgment matrix  $C_1$  of criteria**

$C_1$	$A_1$	$A_2$	$A_3$	$A_4$	$C_2$	$A_1$	$A_2$	$A_3$	$A_4$
$A_1$	1	3	4	5	$A_1$	1	2	3	5
$A_2$	1/3	1	4	4	$A_2$	1/2	1	4	5
$A_3$	1/4	1/4	1	3	$A_3$	1/3	1/4	1	3
$A_4$	1/5	1/4	1/3	1	$A_4$	1/5	1/5	1/3	1

**TABLE 7 : Judgment matrix  $C_3$  of criteria**

$C_3$	$A_1$	$A_2$	$A_3$	$A_4$	$C_4$	$A_1$	$A_2$	$A_3$	$A_4$
$A_1$	1	2	3	5	$A_1$	1	2	3	3
$A_2$	1/2	1	3	3	$A_2$	1/2	1	3	4
$A_3$	1/3	1/3	1	1/3	$A_3$	1/3	1/3	1	1/3
$A_4$	1/5	1/3	3	1	$A_4$	1/3	1/4	3	1

**TABLE 8 : Judgment matrix  $C_5$  of criteria**

$C_5$	$A_1$	$A_2$	$A_3$	$A_4$	$C_6$	$A_1$	$A_2$	$A_3$	$A_4$
$A_1$	1	2	3	4	$A_1$	1	3	4	7
$A_2$	1/2	1	2	3	$A_2$	1/3	1	3	4
$A_3$	1/3	1/2	1	1/3	$A_3$	1/4	1/3	1	1/3
$A_4$	1/4	1/3	3	1	$A_4$	1/7	1/4	3	1

**Judge priorities**

Check the consistence.

The consistency standard:  $CI = \frac{\lambda_{max} - n}{n - 1}$

Random consistency standard: Produce several matrices randomly and add the consistency standard of every matrix. Then take the average and RI is gained. As TABLE 9 shows.

**TABLE 9 : Random consistency standard**

$n$	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

Consistency rate: if  $CR = \frac{CI}{RI} < 0.1$ , the pairwise comparison matrix A can pass the consistency test.

For the judgment matrix:

$$A = \begin{pmatrix} 1 & 2 & \frac{1}{2} & \frac{1}{4} & \frac{1}{5} & \frac{1}{3} & \frac{1}{2} & \frac{1}{3} \\ \frac{1}{2} & 1 & \frac{1}{2} & \frac{1}{5} & \frac{1}{7} & \frac{1}{4} & \frac{1}{3} & \frac{1}{4} \\ 2 & 2 & 1 & \frac{1}{4} & \frac{1}{5} & \frac{1}{3} & 1 & 1 \\ 4 & 5 & 4 & 1 & \frac{1}{2} & 2 & \frac{1}{1} & \frac{1}{1} \\ 5 & 7 & 5 & 2 & 1 & 3 & \frac{1}{3} & \frac{1}{2} \\ 5 & 7 & 5 & 2 & 3 & 1 & \frac{1}{5} & \frac{1}{6} \\ 2 & 3 & 2 & 6 & 3 & 5 & 1 & \frac{1}{3} \\ 3 & 4 & 5 & 4 & 2 & 6 & 3 & 1 \end{pmatrix}$$

First use MATLAB to manage and we can gain:

$$W^0 = \begin{pmatrix} 0.211 \\ 0.156 \\ 0.705 \\ 0.572 \\ 0.447 \\ 0.356 \\ 0.322 \\ 0.157 \end{pmatrix}$$

Then, through  $A \times W^0$  we can know that  $\lambda_{max}^0 = 3.985$ .

Similarly, we can get the biggest characteristic value and feature vector corresponding to the judgment matrices of Criteria.

Through calculating we can learn that the biggest characteristic value of pairwise comparison matrix A:

$$\lambda_{\max} = 3.985, RI = 0.90$$

According to the consistency standard  $CI = \frac{\lambda_{\max} - n}{n - 1}$ , put in the statistics and we can get:

$$CI = \frac{4.242 - 4}{4 - 1} = 0.081$$

For the consistence rate  $CR = \frac{CI}{RI} = \frac{0.081}{0.90} = 0.089 < 0.1$ , the pairwise comparison matrix A passes the consistency test. Similarly, we can verify that the criteria judgment matrices also pass the consistence test.

**Calculate and combine weight vectors**

In accordance with  $W^1 = (w_1, w_2, w_3, w_4)$  and  $W = W^1 \times W^0$ , we can get the result:

$$W = \begin{pmatrix} 0.553 \\ 0.498 \\ 0.308 \\ 0.337 \\ 0.402 \\ 0.515 \\ 0.477 \\ 0.376 \end{pmatrix}$$

**The assessment results**

Through the hierarchy analysis of the eight kinds of community sports we can know that the priority of football, basketball, badminton, rope skipping, shuttlecock kicking, social dance, square dance and tai chi chuan is almost same. But in the improvement study of the community square body-building activities, teenagers love basketball, football, badminton, etc. But the participating rate and the enthusiasm to take part in are not proportional because of the condition limitations. And teenagers don't have much passion for social dance, square dance, etc. So, in the process of improving community square body-building activities, attention are supposed to be paid to the construction of small football and basketball courts in communities in order to meet teenagers' sporting needs. Moreover, middle-aged and elderly people should be encouraged to take part in rope skipping, shuttlecock kicking, etc as much as possible and their physical qualities should be considered. In this way, the development of rope skipping and shuttlecock kicking can be promoted in community square body-building activities,

**CONCLUSION**

(1) This text did the game analysis of community square body-building activities at the beginning. It started from people groups participating community square body-building activities to analyze the participation and satisfaction degree for football, basketball, badminton, rope skipping, shuttlecock kicking, social dance, square dance and tai chi chuan among people in different age groups. In the text, the Discriminant Analysis was used to study the most popular body-building activities among middle-aged people, elderly people and teenagers.

(2) Moreover, the text also made the improvement study of community square body-building activities and through AHP assessed eight sporting activities of football, basketball, badminton, rope skipping, shuttlecock kicking, social dance, square dance and tai chi chuan. By comparing priorities, the text studied the community square sports that are suitable for middle-aged people, elderly people and teenagers.

(3) Through the study and analysis above, this text draw the final conclusion that according to the situation that teenagers are more passionate for football and basketball, community square sporting activities should pay attention to the construction of small football and basketball courts in order to meet teenagers' sporting needs. Moreover, social dance, square dance and tai chi chuan are deeply loved by middle-aged and elderly people, but sports like rope skipping, shuttlecock kicking, etc are not that pop. So middle-aged people, elderly people and teenagers are supposed to be encouraged to participate in rope skipping and shuttlecock kicking to try new sports based on those old sports.

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