Fuzzy Analytic Hierarchy Process-based Chinese Resident Best Fitness Behavior Method Research

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Abstract: With explosive development in Chinese economy and science and technology, people's pursuit of health becomes more and more intense, therefore Chinese resident sports fitness activities have been rapidly developed. However, different fitness events popularity degrees and effects on body energy consumption are different, so bases on this, the paper researches on fitness behaviors and gets Chinese residents sports fitness behaviors exercise guide, which provides guidance for propelling to national fitness plan's implementation and improving Chinese resident fitness scientization. The paper starts from the perspective of energy consumption, it mainly adopts experience method, determines Chinese resident favorite sports fitness event energy consumption through observing all kinds of fitness behaviors energy consumption, and applies fuzzy analytic hierarchy process to make evaluation on bicycle riding, shadowboxing practicing, swimming, rope skipping, jogging, running, aerobics these seven fitness events. By calculating fuzzy rate model's membership and comparing their sizes, it gets fitness behaviors that are more helpful for resident health, more effective and popular. Finally, it gets conclusions that swimming is a best exercise mode and its membership is the highest. Besides, the memberships of running, rope skipping and shadowboxing practicing are also relative higher. It should go in for body-building by synthesizing above several kinds of fitness events according to different physical conditions; different living conditions so that can better achieve the purpose of fitness exercises.

Keywords: Analytic hierarchy process, energy consumption, fuzzy comprehensive evaluation, fitness behavior.

1. INTRODUCTION

Since "Outline of nationwide fitness program" was issued in 1995, scholars had constantly researched on sports fitness. Chinese systematical research on mass sports fitness exercises problems started in the beginning of the eighties, 20th century when state politics set things right, after that, social economy began to recover, mass sports, school sports and competitive sports had been taken seriously again and developed in the social background [1]. Seen from Chinese recent years' sports fitness behaviors research results, the research mainly reflects in two aspects:

The first aspect is basic research .It adopts research method of combining quantity and quality, comprehensive applies and crossover uses psychology, sociology, physiology, biology and economic as well as other study fields' relevant theories to make research on sports fitness behavior. Such as: Song Yan, Zhang Wen-Qiao and other scholars, they take environmental theory as research base, analyze environmental factors in sports fitness behaviors formation and insistence, who think harmony and unity in" human-sports-environment" is the fundamental to keep fitness behaviors [2].

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The second aspect is applied research aspect. The fundamental purpose of sports fitness behavior research is to serve people, propel to improvement of people's body, psychology and social adaptive capacity and others so that realize people's all-round development [3]. Such as Ma Shen, Huang Bing, Gao Chu-Xiu and other scholars adopt intervention means in physical behaviors cognition for university students group so as to impel the group's physical and psychological health study [4].

Sports lifestyle has already become a trend; more and more masses start to realize the important of sports fitness to individual healthy life. Fitness not only increases resident sense of identity to society, creates good interpersonal relationships, but also improves residents' social civilization levels and personal quality. Research confirms that fitness exercises can improve resident happiness index to great degree [5].

To let resident more effective, more healthy go in for physical exercises, the paper carries out fuzzy comprehensive evaluation on fitness events bicycle riding, shadowboxing practicing, swimming, rope skipping, jogging, running, aerobics, and on this basis, it applies analytic hierarchy process to make quantitative analysis of seven kinds of fitness events so that gets the most proper exercise way.

2. FUZZY ANALYTIC HIERARCHY PROCESS METHOD MODEL

Chinese resident fitness behaviors include two main aspects, one is anaerobic exercise, the anaerobic exercise is high speed violent exercise that muscle takes in the state of "hypoxia", regular sports ways are sprinting, weight lifting, long jumping, push-and-pull, push-up, muscle force training and so on; the other is aerobic exercise, the aerobic exercise refers to physical exercises that body takes on the condition of sufficient oxygen supply, regular sports ways are walking, jogging, ice-skating, swimming, bicycle riding, shadowboxing practicing, aerobics exercising and so on.

By investigation and analyzing, relative more fitness behaviors among Chinese residents are bicycle riding, shadowboxing practicing, swimming, rope skipping, jogging, running, and aerobics.

2.1. Fuzzy Comprehensive Evaluation Method

Define evaluation indicator set: through consulting documents literature and relevant internet data, it can get that Chinese resident fitness behavior generally is:

$$U = \{u_1, u_2, \cdots, u_m\}, m = 1, 2, 3, \cdots, 7$$

Define evaluation grade set: when researching on Chinese resident fitness behaviors, it utilizes expert evaluation method to define evaluation grade set. According to:

$$V = \{v_1, v_2, \cdots, v_n\}, n = 1, 2, 3, 4$$

Sports fitness behavior's evaluation grade set is = {very good, good, ordinary, and bad}.

Define each evaluation indicator weight: Weight main expression method is:

$$w = \{\mu_1, \mu_2, \cdots, \mu_m\}, m = 1, 2, \cdots, 7$$

Among them: $\sum_{m=1}^{7} \mu_m = 1$

Define evaluation indicator weight method mainly has analytic hierarchy process and normalization method, from which normalization method formula is as following:

$$w_i = \frac{\dfrac{C_i}{\overline{S_i}}}{\sum_{i=1}^{n} \dfrac{C_i}{\overline{S_i}}}, (i = 1, 2, \cdots, m)$$

Among them, w_i is evaluation parameter i monitoring value; $\overline{S_i}$ is evaluation parameter i grade m criterion arithmetic average value, then weight set is:

$$w = \{w_1, w_2, \cdots, w_m\}$$

Here, apply normalization method to calculate weights, physical behavior energy consumption evaluation indicator weight is:

$$w = \left\{ \begin{matrix} 0.04 & 0.18 & 0.25 & 0.14 & 0.07 & 0.21 & 0.11 \end{matrix} \right\}$$

2.2. Analytic Hierarchy Process-based Fitness Behavior Energy Consumption Evaluation Matrix

Comprehensive evaluation matrix R evaluation methods mainly have expert evaluation method, analytic hierarchy process, and membership function method. In above three methods, expert evaluation method is based on questionnaire survey and experts' evaluation result, subjectivity's proportion is larger, so the result will have certain errors. So as to let computed result to be more accurate, the paper uses analytic hierarchy process, define fuzzy relation matrix R, from which:

$$R = \left(\begin{matrix} R_1 & R_2 & R_3 & R_4 & R_5 & R_6 & R_8 \end{matrix} \right)^T.$$

Establish hierarchical structure:

Target layer(A): Fitness behavior energy consumption evaluation

Criterion layer(C): Scheme influence factors, C_1 is bicycle riding, C_2 is shadowboxing practicing, C_3 is swimming, C_4 is rope skipping, C_5 is jogging, C_6 is running, C_7 is aerobics. Scheme layer(P): P_1 is very good, P_2 is good, P_3 is ordinary, P_4 is bad.

Construct judgment matrix and value: according to hierarchical structure, it can easily construct judgment matrix.

Take every factor that has downward membership as first factor of judgment matrix, its affiliated factors subsequently rank in the first line and first column.

According to judgment matrix criterion, it carries out paired comparison of two factors of them, values the importance degrees according to 1 to 9; the definition table is as Table **1**.

Table 1. Importance scale definition 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 extremely more important than factor j
9	factor i is absolute more important than factor j
2, 4, 6, 8	Indicates middle state corresponding scale value of above judgments
Reciprocal	If the importance ratio between factor i and factor j is a_{ij}, then the importance ratio between factor j and factor i is $a_{ij} = 1 / a_{ji}$

According to above scale table, set judgment matrix A as:

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

And constructed scheme layer judgment matrixes correspond to different criterion layers are as following Table **2**, Table **3**, Table **4**, Table **5**.

Table 2. C-P judgment matrix.

C_1	P_1	P_2	P_3	P_4	C_2	P_1	P_2	P_3	P_4
P_1	1	1/3	1/3	1/4	P_1	1	3	3	5
P_2	3	1	1	1/3	P_2	1/3	1	2	4
P_3	3	1	1	1/2	P_3	1/3	1/2	1	3
P_4	4	3	2	1	P_4	1/5	1/4	1/3	1

Table 3. C-P judgment matrix.

C_3	P_1	P_2	P_3	P_4	C_4	P_1	P_2	P_3	P_4
P_1	1	2	3	3	P_1	1	2	2	3
P_2	1/2	1	2	3	P_2	1/2	1	3	3
P_3	1/3	1/2	1	1/3	P_3	1/2	1/3	1	2
P_4	1/3	1/3	3	1	P_4	1/3	1/3	1/2	1

Table 4. C-P judgment matrix.

C_5	P_1	P_2	P_3	P_4	C_6	P_1	P_2	P_3	P_4
P_1	1	1/3	2	3	P_1	1	1/2	2	3
P_2	3	1	3	3	P_2	2	1	3	4
P_3	1/2	1/3	1	1/3	P_3	1/2	1/3	1	2
P_4	1/3	1/3	3	1	P_4	1/3	1/4	1/2	1

Table 5. C-P judgment matrix.

C_7	P_1	P_2	P_3	P_4
P_1	1	2	2	3
P_2	1/2	1	3	3
P_3	1/2	1/3	1	2
P_4	1/3	1/3	1/2	1

Consistency test steps:

Step one: Make normalization of judgment matrix

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

It gets results as Table **6**.

And it solves: $\lambda_{\max} = \sum_{i=1}^{7} \frac{(A\omega_A)_i}{n\omega_{Ai}} 7.550306628$

Step two: Carry out consistency indicator C.I. calculation.

$$C.I. = \frac{\lambda_{\max} - n}{n-1} = \frac{7.550306628 - 7}{7-1}$$

Step three: Define its average random consistency indicator R.I...

According to judgment matrix different orders, consult Table **7**, it gets that average random consistency indicator R.I. is 1.36.

Step four: Calculate consistency proportion C.R. to judge.

$$C.R. = \frac{C.I.}{R.I.} = 0.091717771 < 0.1$$

Because C.R.<0.1, it is thought that judgment matrix consistency is acceptable.

Similarly, criterion layer judgment matrix corresponding maximum feature value and feature vector are successively :

$$\lambda_{\max 1} = 2.863, \omega_1 = \begin{pmatrix} 0.423 \\ 0.545 \\ 0.782 \\ 0.643 \\ 0.533 \\ 0.682 \\ 0.612 \end{pmatrix} \quad \lambda_{\max 2} = 2.865, \omega_2 = \begin{pmatrix} 0.183 \\ 0.354 \\ 0.785 \\ 0.848 \\ 0.414 \\ 0.747 \\ 0.382 \end{pmatrix}$$

$$\lambda_{\max 3} = 2.874, \omega_3 = \begin{pmatrix} 0.297 \\ 0.461 \\ 0.734 \\ 0.452 \\ 0.334 \\ 0.673 \\ 0.545 \end{pmatrix}$$

Table 6.   Normalized judgment matrix.

A	C_1	C_2	C_3	C_4	C_5	C_6	C_7	ω_A
C_1	0.0107574	0.0021514	0.0015383	0.0026893	0.0053787	0.0017964	0.0035822	0.031678311
C_2	0.0537871	0.0107574	0.0035822	0.0215148	0.0537871	0.0053787	0.0430297	0.189851746
C_3	0.0753020	0.0322722	0.0107574	0.0430297	0.0645445	0.0215148	0.0322722	0.353355471
C_4	0.0430297	0.0053787	0.0026893	0.0107574	0.0322722	0.0035822	0.0215148	0.110082325
C_5	0.0215148	0.0021514	0.0017964	0.0035822	0.0107574	0.0017964	0.0053787	0.043337445
C_6	0.0645445	0.0215148	0.0053787	0.0322722	0.0645445	0.0107574	0.0107574	0.278294731
C_7	0.0322722	0.0026893	0.0035822	0.0053787	0.0215148	0.0053787	0.0107574	0.080686493

Table 7.   Average random consistency indicator R.I. table (1000 times positive reciprocal matrix calculation result).

Amount of matrix order	1	2	3	4	5	6	7	8
R.I.	0	0	0.52	0.89	1.12	1.26	1.36	1.41
Amount of matrix order	9	10	11	12	13	14	15	
R.I.	1.46	1.49	1.52	1.54	1.56	1.58	1.59	

$$\lambda_{\max 4} = 2.865, \omega_4 = \begin{pmatrix} 0.416 \\ 0.648 \\ 0.848 \\ 0.556 \\ 0.332 \\ 0.687 \\ 0.497 \end{pmatrix} \lambda_{\max 5} = 2.874, \omega_5 = \begin{pmatrix} 0.297 \\ 0.341 \\ 0.832 \\ 0.447 \\ 0.321 \\ 0.678 \\ 0.411 \end{pmatrix}$$

$$\lambda_{\max 6} = 2.874, \omega_6 = \begin{pmatrix} 0.184 \\ 0.450 \\ 0.862 \\ 0.448 \\ 0.255 \\ 0.700 \\ 0.321 \end{pmatrix} \lambda_{\max 7} = 2.862, \omega_7 = \begin{pmatrix} 0.441 \\ 0.536 \\ 0.826 \\ 0.406 \\ 0.252 \\ 0.731 \\ 0.527 \end{pmatrix}$$

And then it can get comprehensive evaluation matrix as following:

$$R = \begin{pmatrix} 0.423 & 0.183 & 0.297 & 0.416 & 0.297 & 0.184 & 0.441 \\ 0.545 & 0.354 & 0.461 & 0.648 & 0.341 & 0.450 & 0.536 \\ 0.782 & 0.785 & 0.734 & 0.848 & 0.832 & 0.862 & 0.826 \\ 0.643 & 0.848 & 0.452 & 0.556 & 0.447 & 0.448 & 0.406 \\ 0.533 & 0.414 & 0.334 & 0.332 & 0.321 & 0.255 & 0.252 \\ 0.682 & 0.747 & 0.673 & 0.687 & 0.678 & 0.700 & 0.731 \\ 0.612 & 0.382 & 0.545 & 0.497 & 0.411 & 0.321 & 0.527 \end{pmatrix}$$

Finally, it can get fuzzy evaluation set S :

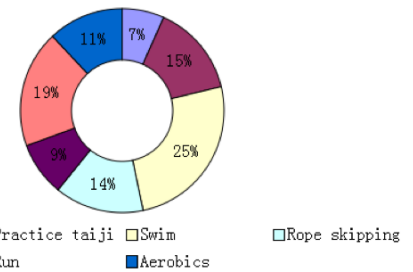$$S = \{0.347 \quad 0.756 \quad 1.323 \quad 0.734 \quad 0.446 \quad 0.965 \quad 0.623\}$$

CONCLUSION

According to maximum membership principle, it makes evaluation on fuzzy evaluation set, in order to more intuitively judge   maximum membership value, express each subset distribution status in   by doughnut chart as Fig. (**1**).

Fig. (1). S subsets proportion chart.

From Fig. (**1**), it is clear that swimming is one fitness behavior with maximum energy consumption membership, next are running, shadowboxing practicing, rope skipping, aerobics, jogging, and bicycle riding. So as to research how to better apply fitness behavior into people, the paper bases on fuzzy comprehensive analysis method, and applies analytic hierarchy process to make evaluation on fitness events bicycle riding, shadowboxing practicing, swimming, rope skipping, jogging, running, aerobics. And it obtains results of fuzzy evaluation set through maximum membership principle. The obtained result is that swimming membership is the highest, which is the most suitable fitness exercise. The result most considers energy consumption, therefore to let Chinese resident to more effective and

healthy to carry out fitness exercise, they should participate in swimming more, and exercises together with running, shadowboxing practicing and rope skipping and else according to their own affordable situations. Obtained result conforms to practical situation, which indicates the model has certain rationality.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

ACKNOWLEDGEMENTS

Declared none.

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