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Analytic hierarchy process-based Chinese public sports service equalization evaluation system research and application

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ABSTRACT

Party's 18th Third Session puts forward updated requirements on building a comprehensive well-off society and Chinese undertakings in various fields, from which public sports development is one of important parts. The paper just starts from national perspective, analyzes Chinese sports public service equalization degree. By applying analytic hierarchy process method, it quantizes Chinese public sports service level equalization aspect input, output and efficiency such three main aspects importance degrees in the form of weights. The system provides theoretical conditions for realizing Chinese comprehensive well-off society construction and Chinese sports public service equalization.

Key words: public sports service, evaluation system, analytic hierarchy process, equalization

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INTRODUCTION

Vigorously advance public sports service system construction is an important guarantee of implementing the 18th spirit, improve sports public service equalized evaluation level is also an important guarantee of comprehensively deepening reform, therefore establish reasonable public sports service system has an important significance in building socialism with Chinese characteristics.

Regarding public sports service research, many scholars have made contributions, such as: in the aspect of government functions, Liu Yu thought public sports service was government provided different, basic criterion for broad masses, and on the premise that provided largest equalization sports public service indicator. Ji Jiang-Ming and others in sports public service quality investigation analysis, they proposed to apply a kind of entropy weight *TOPSIS* method in sports service satisfaction degree evaluation to evaluate multiple cities' sports public service quality, final result showed that Chinese eastern part developed region's sports public service satisfaction degree was obviously higher than western part; Qin Xiao-Ping proposed that to equalize sports service, no matter in village or in city, every citizen could obtain government provided public sports service sources' sport public product that needed every citizen in society to make joint efforts.

On the basis of this, the paper proceeds with more deep researches, uses analytic hierarchy process method to evaluate on government public sports service equalization, meanwhile it puts forward constructive opinions, which provides premise for improving public sports service equalization levels.

2 Sports public service evaluation system theoretical analysis

A system is composed of multiple elements, these elements decide system attributes, and so these elements become comprehensive evaluation theoretical basis. So in Chinese public sports service equalization research, comprehensive evaluation becomes equalization evaluation system central content, by combining with the paper researched contents, it draws Chinese basic public sports service equalization indicator system flow chart Figure 1:

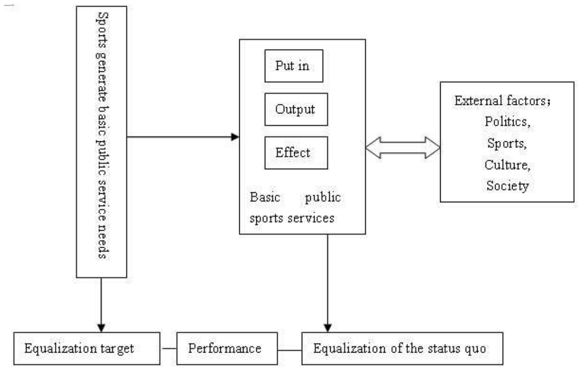

Figure 1: Equalization of basic public sports service evaluation index system theoretical framework

It's worth noting that above evaluation system's result will change during running process following environment, subject and object differences, but such impacts are not big, in data input process, note arrangement and then it can avoid its influence.

Regarding Chinese sports service equalization evaluation analysis, due to each variable unit is not the same, it needs to make dimensionless processing with each variable, from which there are many kinds of dimensionless handling methods, common used one is relative processing method, principle is firstly it should define a standard indicator x_m, after that make comparison of other each indicator x_i and standard indicator x_m, and it will get every indicator realization degree, corresponding formula is:

$$\frac{x_i}{x_m}\times 100\% = \text{single indicator realizaton degree} \qquad (i=1,2,\cdots,n)$$

3 Select proper comprehensive evaluation method
After certain processing with multiple factors, it can get each indicator total evaluation system; the method is called comprehensive evaluation method. For the method, formers have put forward many ways, combines with the paper researched contents, it selects broad scholars common used one kind——weighted geometric average method, arithmetic average method.

Regarding weighted geometric average method, from which let evaluation indicators number to be n; let single indicator evaluation value to be y_i; let evaluation indicator weight to be w_i; evaluated objects comprehensive evaluation value is y, corresponding equation is:

$$y=\prod_{i=1}^{n} y_i^{w_i} \qquad (i=1,2,\cdots,n) \tag{1}$$

Then corresponding weighted geometric average method equation is:

$$y=\sum_{i=1}^{n} w_i y_i \qquad (i=1,2,\cdots,n) \tag{2}$$

Due to the method is relative simpler, and conforms to the paper.

3.1 Analytic Hierarchy Process model
AHP features are hierarchizing complicated problems, making clear about primary and secondary, possessing stronger logicality and hierarchical structure, the algorithm mainly is calculating indicators' weights. It is applicable to comprehensive assessment system, is a powerful mathematical method that converts problems into quantitative research. Nowadays analytic hierarchy process has already widely used in each field to solve practical problems. Chinese public sports service equalization comprehensive assessment involves multiple reference indicators, the decision problems is suitable to analytic hierarchy process, corresponding flow chart is as following figure show:

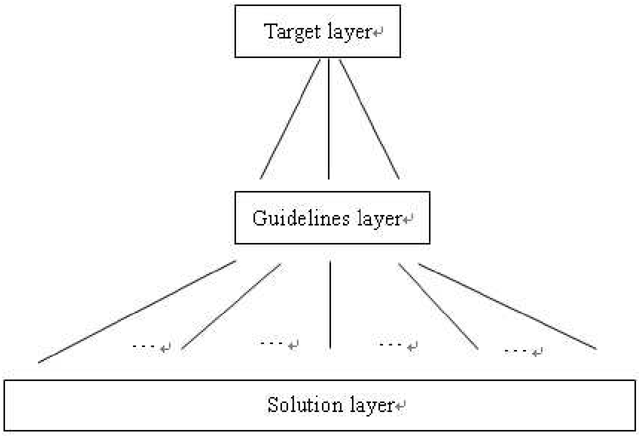

Figure 2: Hierarchical model

3.2 Analytic hierarchy process calculate indicator weight

For above criterion layer's three kinds of indicators, it makes meticulous comparison of the two relative importance to construct judgment matrix. Such as: Take T_i, T_j to make important comparison, the structure is using b_{ij} to express, and then all factors after comparing can get judgment matrix U . Its expression is as following.

$$U = \begin{pmatrix} b_{11} & b_{12} & \cdots & b_{1j} \\ b_{21} & b_{22} & \cdots & b_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ b_{i1} & b_{i2} & \cdots & b_{ij} \end{pmatrix} \quad (3)$$

In formula, b_{ij} the two compared importance uses quantized value to express, uses1—9 number to describe, number representative meaning is as following Table 1 show:

Table 1: 1—9 scale meaning

Scale	Meaning
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 more important than the later by comparing two factors
7	Indicates the former is relatively more important than the later by comparing two factors
9	Indicates the former is extremely more important than the later by comparing two factors
Even number	Represents importance is between two odd numbers
Reciprocal	Represents factors positive and negative comparison order

According to first grade indicator's judgment matrix vector, carry out normalization with it; solve the sum and then make normalization, then it can get weight vector. According to feature value and feature vector relations, it can solve feature value; its implementation method is as following:

Firstly, normalize judgment matrix every column, its result is:

$$b_{ij} = b_{ij} / \sum_{k=1}^{n} b_{kj} (i, j = 1, 2, \cdots, n) \quad (4)$$

Then solve the sum by lines on judgment matrix that makes normalization by column, it can get:

$$\overline{W_i} = \sum_{j=1}^{n} b_{ij} (i = 1, 2, \cdots, n) \quad (5)$$

Above vector $\overline{W} = \left[\overline{W_1}, \overline{W_2}, \cdots, \overline{W_n}\right]^T$ proceeds with normalization processing:

$$\overline{W_i} = \frac{\overline{W_i}}{\sum_{j=1}^{n} \overline{W_j}} (i = 1, 2, \cdots, n) \quad (6)$$

Then: $W=[W_1, W_2, \ldots, W_n]^T$ is solved feature vector.

In addition, calculate maximum feature root, the process is:

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i} \quad (7)$$

In above formula $(AW)_i$ represents vector AW's i component.

According to above formula, we can respectively solve comprehensive assessment analysis first grade indicator, second grade indicator to first grade indicator weight and maximum feature value.

3.2 Consistency test

To matrix $U = \left(b_{ij}\right)_{n*n}$, if matrix element meets $b_{ij} b_{jk} = b_{ik}$, then matrix is straight matrix. Among them, $b_{ij} > 0$, $b_{ij} = 1/b_{ji}$. In order to use it to calculate factor weight, it requires that matrix inconsistency only under acceptable conditions. When problems are relative complicated, we cannot take all factors into account, which causes paired comparison construct judgment matrix instant, judgment matrix cannot arrive at ideal state consistency.

Judgment matrix consistency indicator CI, and judgment matrix consistency ratio CR, its computational method is as following formula show:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (8)$$

Among them, n represent order number of judgment matrix that is also the number of compared factors.

$$CR = \frac{CI}{RI} \quad (9)$$

Among them, RI represents Random Consistency Index value, as following Table 2show.

Table 2: RI value table

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

When $CR \geq 0.1$, it is thought that judgment matrix occurs inconsistency that needs to make adjustment on judgment matrix again. When $CR < 0.1$, judgment matrix inconsistency is within acceptable range.

By calculating, it gets four judgment matrixes consistency indicator CI, and consistency ratio CR, single hierarchy judgment matrix conforms to consistency requirements by consistency testing; It can be thought that calculated weight is reasonable. Next step is doing combination consistency testing. Assume that in one layer, m pieces of factors weight calculation result is α_m, corresponding consistency indicator value respectively is CI_m, combination consistency test consistency ratio is:

$$CR = \frac{\sum_{j=1}^{m} \alpha_j CI_j}{\sum_{j=1}^{m} \alpha_j RI_j} \quad (10)$$

By calculating, combination consistency ratio calculated value is:

$$CR < 0.1$$

So hierarchical total arrangement's consistency testing meets consistency requirement. It can be thought that each indicator weight calculation result is reasonable that can be applied into assessment.

3.3 Weight calculation arrangement

If in one layer, m pieces of factors weight calculation result is α_m, corresponding consistency indicator value respectively is CI_m, in next layer n pieces of factors to A layer calculation weight is β_{nm}, then in T layer factors total arrangement weight is:

$$w_i = \sum_{j=1}^{m} \alpha_i \beta_{ij} \quad (11)$$

By above formula calculating, it gets each indicator weight in total target.

4 Chinese sports public service equalization indicator selection

By researching previous Chinese sports public service equalization relative documents, combine with the paper research contents, it selects eleven third grade indicators, three second grade indicators and one first grade indicator, screens above process, and uses expert to indicator coordination degree, discrete degree, concentration degree to make assigning test.

In coordination degree, all indicators grades and indicator i grade as well as arithmetic mean value differences is using S_i to express； number of indicators is using c to express； Total amount of experts is using d to express； W expert evaluation coordination degree； V_i reflects expert to i indicator evaluation coordination degree, and then it has:

$$V_i = \frac{\sigma_i}{E_i} \quad (12)$$

$$W = \frac{12}{d^2(c^3 - c)} \sum_{i=1}^{n} S_i^2 \quad (13)$$

Same grade opinion coordination formula:

$$W = \frac{12}{d^2(c^3 - c) - d\sum_{k=1}^{d} T_k} \sum_{i=1}^{n} S_i^2 \quad (14)$$

In correction coefficient T_k group L, same grade number is using t_i to express； number of evaluation groups is using L to express, then it has:

$$T_k = \sum_{i=1}^{L} (t_i^3 - t_i) \quad (15)$$

In discrete degree, expert evaluation result discrete degree is using σ_i to represent, then it has:

$$\sigma_i = \sqrt{\frac{1}{d-1}\sum_{j=1}^{5} c_{ij}(E_j - \overline{E_i})^2} \tag{16}$$

In concentration degree formula, number of indicators is using c to express; evaluation indicator value is j number of experts that uses c_{ij} to express; indicator i to system importance value is using E_j to express; number of experts is using d to express; the i indicator expert opinion concentration degree is using $\overline{E_i}$, then it has:

$$\overline{E_i} = \frac{1}{d}\sum_{j=1}^{5} E_j c_{ij} \qquad (i = 1, 2, \cdots, n) \tag{17}$$

According to previous experiences, coordination degree can be randomly, and corresponding coefficient is a kind of significance $p < 0.05$, variation coefficient valid range is $V_i < 0.25$, discrete degree valid range is $\sigma_i < 0.6$, concentration degree valid range is $\overline{E_i} > 3.5$.

According to above method, respectively test selected three grades indicators, from which first grade indicator only in one case, so here will not discuss, second, third grade indicators results are as following Table 3, Table 4 show:

Table 3: Second grade indicators statistical table

Indicator	$\overline{E_i}$	σ_i	V_i	W	x^2	$Asymp.Sig$
Input (b_1)	5.5	0.00	0.00	0.46	7.8	0.021
Output (b_2)	4.9	0.49	0.15			
Efficiency (b_3)	4.7	0.52	0.19			

By above Table 3, we can get coordination coefficient is 0.46, calculate and get significance test $p < 0.05$, variation coefficient is less than 0.25, discrete degree is less than 0.6, concentration degree is above 3.5, then we can summarize each expert to second grade each indicator screening conforms to consistency.

Table 4: Third grade indicator statistical table

Indicator		$\overline{E_i}$	σ_i	V_i	W	x^2	$Asymp.Sig$
Input (b_1)	Fitness information (b_{11})	4.2	0.51	0.10	0.35	11.89	0.021
	Management organization (b_{12})	4.6	0.49	0.09			
	Site facility (b_{13})	4.9	0.48	0.11			
	Human resource (b_{14})	4.4	0.44	0.12			
	Funding level (b_{15})	4.8	0.56	0.08			
Output (b_2)	Events (b_{21})	4.1	0.52	0.13	0.49	10.45	0.005
	Physical test (b_{22})	4.3	0.47	0.11			
	Daily sports (b_{23})	4.5	0.53	0.12			
Efficiency (b_3)	Subjective attitude (b_{31})	4.2	0.45	0.08	0.38	7.256	0.032
	Sports population (b_{32})	4.9	0.51	0.13			
	Physical status (b_{33})	4.5	0.43	0.09			

Combine with second grade indicators analysis status, by above Table 4, we similarly can get each expert has consistency.

Combine with Chinese public sports service system construction, it finally defines one first grade indicator, three second grade indicators and five third grade indicators.

According to the paper previous stated analytic hierarchy process theory, combine with Chinese sports public service system, it gets second grade, third grade indicators judgment matrix, as following Table 5, Table 6 show.

Table 5: Second grade indicator statistical table

	b_1	b_2	b_3
b_1	1	4	3
b_2	1/4	1	3
b_3	1/5	1/4	1

Table 6: Partial indicator judgment matrix

b_1	b_{11}	b_{12}	b_{13}	b_{14}	b_{15}
b_{11}	1	1/2	1/4	1/2	1/3
b_{12}	2	1	1/3	2	3
b_{13}	4	4	1	4	4
b_{14}	2	2	1/4	1	2
b_{15}	3	1/3	1/4	1/3	1

According to analytic hierarchy process theory, by calculating, it similarly can get other three grades each indicator weight sizes, as following Table 7 show:

Table 7: Input three grades indicator partial indicators judgment matrix

First grade indicator	First grade indicator weight	Second grade indicator	Second grade indicator weight	Third grade indicator	Third grade indicator weight
Chinese basic public sports service equalization evaluation system	1.0	b_1	0.387	b_{11}	0．218
				b_{12}	0．144
				b_{13}	0．361
				b_{14}	0．188
				b_{15}	0．90
		b_2	0.198	b_{21}	0．626
				b_{22}	0．171
				b_{23}	0．204
		b_3	0.415	b_{31}	0．305
				b_{32}	0．310
				b_{33}	0．384

By above Table 7, we can clearly see the paper selected each indicator weight size.

CONCLUSION

For Chinese sports public service equalization evaluation, apply analytic hierarchy process method, it finally defines evaluation system weight, in sports public service, it meets resident life demand efficiency occupies main factor, and in three grades indicators, resident sports quality status occupies main factor, in addition, sports field infrastructure status is also very big in total weight, meanwhile use the model it can play guiding roles in Chinese basic public sports service efficiency improvement.

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