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Test research for the consistency of index weight of volleyball athletes' selection based on AHP

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ABSTRACT

We screen volleyball players in the advice of experts and teachers' selection reference indicator, through the establishment of the index of volleyball players. We establish different levels of indicators respectively from different angles and get the comparison matrix by using the analytic hierarchy process to compare the index, then solving the weight of indexes at all levels gradually according to different layers. With the help of the computer operation ability, we can calculate and sort the weight. The weights are finally established and the comprehensive evaluation system is built up, which helps to provide a scientific and reasonable method for the volleyball athletes' selection.

KEYWORDS

Analytic hierarchy process; Volleyball players; Comprehensive evaluation; The index weight; Physical characteristics.

INTRODUCTION

Volleyball athletes need to have good physical quality, at the same time, volleyball is a team project which requires the players to cooperate with each other. Athletes with their own advantages should cooperate with the teammates and play together. Volleyball sport in our country is in at the forefront of the world. However, how to select optimum volleyball athletes is the key point to cultivate the next generation of volleyball players, there are many factors to decide comprehensive ability index of volleyball players, so the quantitative evaluation system is needed. In this paper, we use the analytic hierarchy process to establish the hierarchy structure by stratifying the index of volleyball players, and the weights are researched, thus establishing the evaluation model of the quantitative evaluation of volleyball mobilization by hierarchical analysis method which provides reference for the selection and evaluation of volleyball players.

VOLLEYBALL ATHLETES' SELECTION INDEX

Volleyball athletes' selection is established of the of high layer goal (top layer target) in this paper, according to the researching question and the investigation of expert and volleyball coaches. Rule layer is the primary index of volleyball technology, physical quality, and psychological quality. There are three level indicators of sub-level index criterion layer under the corresponding level indicator, the lowest layer is for the solution, namely for the selection of the players. Volleyball athletes' selection index is in the following TABLE 1.

### TABLE 1: Volleyball athletes' selection index

Target	Level indicators	Secondary indicators
Volleyball athletes' selection (O)	volleyball techniques(C_1)	Defensive success rate(C_{11})
		Offensive success rate(C_{12})
		first service C_{13})
	physical quality C_2)	Physical endurance (C_{21})
		speed (C_{22})
		sensitivity (C_{23})
	psychological quality C_3)	Experience in the field (C_{31})
		Strain capacity (C_{32})
		volitional quality (C_{33})

CALCULATING THE INDEX WEIGHT BY ANALYTIC HIERARCHY PROCESS

Analytic hierarchy process(AHP). Its characteristic is having simple ideas, distinct hierarchy, extensive use, and the core of the algorithm is the weight calculation. It is especially suitable for multiple solution problems and the decision problem of complex system, it is a powerful mathematical methods which can transforms the problem into a quantitative research as well. Analytic hierarchy process is now widely used in each domain to solve practical problems. Volleyball athletes' selection involves a number of athletes and multiple reference indicators; this is what we use analytic hierarchy process. Volleyball athletes' selection indexes can be hierarchical by using AHP to solve volleyball selection index weight, and finally establish a comprehensive evaluation system.

Volleyball selection index hierarchy

Basing on the selection of indicators in the TABLE 1, we establish a hierarchy structure by analytic hierarchy process as follows in figure 1.
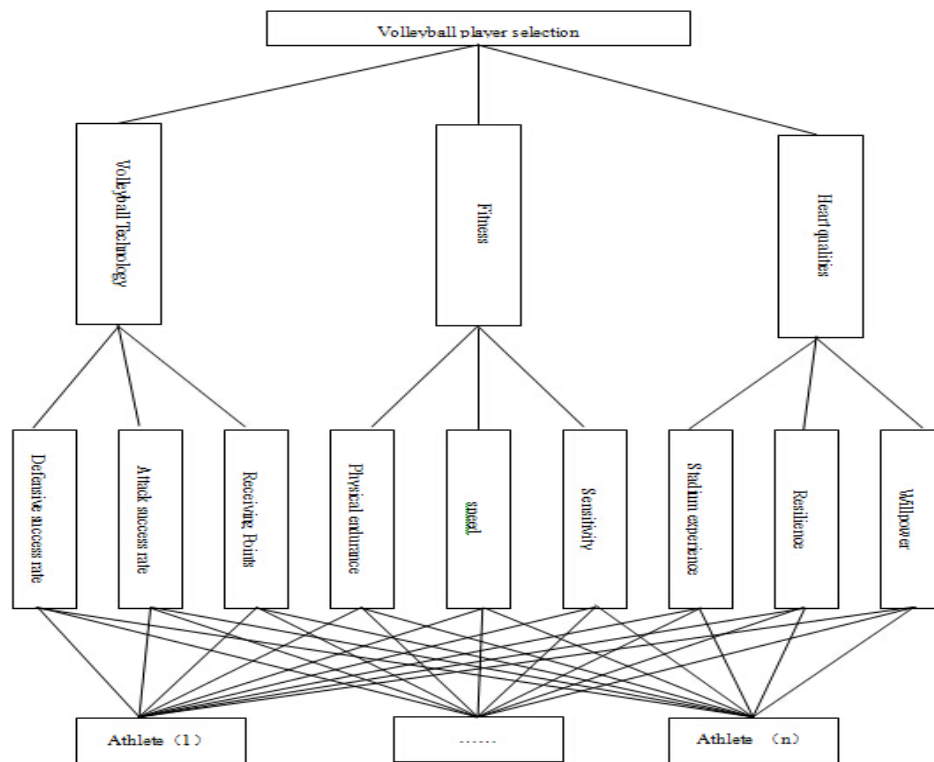
Figure 1: Volleyball selection index hierarchy

The construction of judgment matrix

Comparing the volleyball techniques, physical quality and psychological quality of the primary index of are in pairs, and constructing the judgment matrix by comparing the relative importance between each other. For example, if we take C_i, C_j to be compared by their relative importance and use a_{ij} to represent, then we can get the judgment matrix A after all the elements are compared, just as is shown in the following:

$$A = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1j} \\ a_{21} & a_{22} & \cdots & a_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ a_{i1} & a_{i2} & \cdots & a_{ij} \end{pmatrix}$$

a_{ij} is the description of quantitative values by comparing the importance in pairs, we number 1-9 to represent, its meaning is in the TABLE 2.

TABLE 2 : The meaning of 1~9 scale

Scale	Meaning
1	Two factors of the target are equally important
3	The former factor is slightly important than the next one
5	The former factor is important than the next one
7	The former factor is more important than the next one
9	The former factor is much more important than the next one
even number	represent the importance between the two Odd numbers
reciprocal	Represent the order of the front-to-back ratio of the factors

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We can construct the judgment matrix by the above method:

O	C_1	C_2	C_3
C_1	1	3	2
C_2	1/3	1	1/2
C_3	1/2	2	1

Similarly, we establish judgment matrix of the defensive success rate, offensive success rate, the service rate of the secondary indexes which is under the primary index, the respective construction of the judgment matrix of the rest of the secondary indexes is as follows:

C_1	C_{11}	C_{12}	C_{13}
C_{11}	1	1	2
C_{12}	1	1	2
C_{13}	1/2	1/2	1

C_2	C_{21}	C_{22}	C_{23}
C_{21}	1	1	3
C_{22}	1	1	3
C_{23}	1/3	1/3	1

C_1	C_{11}	C_{12}	C_{13}
C_{11}	1	2	5
C_{12}	1/2	1	2
C_{13}	1/5	1/2	1/3

The calculation of the weight vector and the maximum eigenvalue

We normalize the column vector by the judgment matrix of the primary index after summing the every row, we normalize again, and then the weight vector can be obtained. According to the relationship between eigenvalue and eigenvectors, the eigenvalue can be solved. The method is as follows:

$$A = \begin{pmatrix} 1 & 3 & 2 \\ 1/3 & 1 & 1/2 \\ 1/2 & 2 & 1 \end{pmatrix} \xrightarrow{\text{列向量归一化}}$$

$$\begin{pmatrix} 0.546 & 0.5 & 0.571 \\ 0.182 & 0.167 & 0.143 \\ 0.273 & 0.333 & 0.286 \end{pmatrix}$$

$$\xrightarrow{\text{按行求和}} \begin{pmatrix} 1.617 \\ 0.491 \\ 0.892 \end{pmatrix} \xrightarrow{\text{归一化}} \begin{pmatrix} 0.539 \\ 0.164 \\ 0.297 \end{pmatrix}$$

The primary index weight vector: $w = \begin{pmatrix} 0.539 & 0.164 & 0.297 \end{pmatrix}^T$

The calculation of the maximum eigenvalue, form the judgment matrix we know : $Aw = \lambda_{max} w$,

then: $Aw = \begin{pmatrix} 1 & 3 & 2 \\ 1/3 & 1 & 1/2 \\ 1/2 & 2 & 1 \end{pmatrix}\begin{pmatrix} 0.539 \\ 0.164 \\ 0.297 \end{pmatrix} = \begin{pmatrix} 1.625 \\ 0.492 \\ 0.894 \end{pmatrix}$

So: $\lambda_{max} = \frac{1}{3}(\frac{1.625}{0.539} + \frac{0.492}{0.164} + \frac{0.894}{0.297}) = 3.009$

All in all, the maximum eigenvalue is $\lambda_{max} = 3.009$. The weight vector is $w = (0.539 \quad 0.164 \quad 0.297)^T$.

We can get the athletes 'primary index weight, Secondary index weight, and the maximum eigenvalue. The result is in the TABLE 3.

TABLE 3 : The weight of index

Index	C_1	C_2	C_3
The primary index weight	0.539	0.164	0.297
	0.4	0.429	0.595
Secondary index weight	0.4	0.429	0.275
	0.2	0.142	0.130
eigenvalue	3	3	3.005

Consistency check

he definition of consistent matrix:as for matrix $A = (a_{ij})_{n*n}$,if $a_{ij}a_{jk} = a_{ik}$,so the matrix is consistent matrix. Among them, $a_{ij} > 0$, $a_{ij} = 1/a_{ji}$. In order to use it to calculate the factor's weight, the inconsistency of the matrix should in an acceptable condition. However, the more difficult problem is that we can not take all the factors into consideration, which means that the judgment matrix can not reach the ideal state when comparing in pairs.

he consistency of judgment matrix CI ,and Judgment matrix consistency ratio CR ,computational formula is in the following:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Among them n represents the Order number of the judgment matrix, also means the number of comparisons.

$$CR = \frac{CI}{RI}$$

Among them RI represents the number of Random Consistency Index,which is shown in the TABLE 4

TABLE 4 : RI value list

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 $CR \geq 0.1$,we think that the inconsistency of judgment matrix appears and need to adjust it. when $CR < 0.1$,the inconsistency of the matrix is in an acceptable condition and we can go on calculating. And we calculate the overall level of sorting and consistency check further more. Finally we can get the four consistency of judgment matrixes CI consistency rate CR after calculation. As is shown in TABLE 5:

TABLE 5 : Calculation check table of the consistency

Judgment matrix	O	C_1	C_2	C_3
CI	0.005	0	0	0.003
CR	0.009	0	0	0.005

The sheer level judgment matrix conforms to the requirement of consistency, so that the calculation of weight can be thought reasonable. The next step is the consistency check, if there have m weight factors in one layer, and its the result is α_m ,the corresponding consistency index is CI_m , The combinational consistency ratio is:

$$CR = \frac{\sum_{j=1}^{m} \alpha_j CI_j}{\sum_{j=1}^{m} \alpha_j RI_j}$$

After calculation the result is: $CR = 0.005 < 0.1$

So the consistency checks of all levels of the total sorts conform to requirements of the consistency. The calculation results of weight of each index can be thought reasonable in the volleyball selection, so it can be used in the selection of the players.

The order of weight calculation

If there have m weight factors in one layer and its result is α_m ,the corresponding consistency index is CI_m , and in the next layer A, there have n weight factors, and its result is β_{nm} ,so the total ordering weights in the layer B is:

$$w_i = \sum_{j=1}^{m} \alpha_i \beta_{ij}$$

The weight of the various indicators in the overall goal is in the TABLE 6.

TABLE 6 : The calculation results of index weight

Target	Level indicators	Weight	Secondary indicators	Weight	Total sorts
			Defensive success rate(C_{11})	0.2156	1
	volleyball techniques(C_1)	0.539	Offensive success rate(C_{12})	0.2156	1
			first service(C_{13})	0.1078	4
			Physical endurance (C_{21})	0.0704	6
Volleyball athletes' selection	physical quality(C_2)	0.164	speed (C_{22})	0.0704	6
			sensitivity C_{23})	0.0233	9
			Experience in the field (C_{31})	0.1767	3
	psychological quality(C_3)	0.297	Strain capacity (C_{32})	0.0817	5
			volitional quality (C_{33})	0.0386	8

CONCLUSIONS

According to the calculation of this article, we can see that in the selection of the volleyball players, the volleyball technique of primary index occupies a large position, which means that volleyball technique is the important key that needs to be considered. Success rate of defensive and the offensive success rate occupy a large position in the secondary index weight, and the next is the experience in the field. The smallest two positions are the sensitivity and volitional quality. Through the different secondary indexes and weights we can establish a comprehensive ability of volleyball players correspondingly and make a comprehensive and reasonable evaluation system of volleyball sport ability as well.

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