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A Study on the Evaluation Method of Agility for Female College Basketball Players Based on the AHP-VIKOR Model

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Abstract

In promoting basketball sports among female college students, this paper introduces fuzzy sets of interval type-2 into the agility assessment model for our university's female basketball players. During the assessment, the expert language variables are converted to the second class of the interval. It combines the fuzzy analytic hierarchy process (AHP) and the entropy weight approach for calculating weights, integrating the VIKOR method to construct a fuzzy interval type-2 AHP-entropy weight-VIKOR risk assessment model. Based on the fuzzy logic of type I, this model explores the influence relationships among factors, effectively reduces information loss through the collaboration of multiple expert judgments, and enhances evaluation accuracy. Lastly, this model is used to evaluate the agility of women's basketball players. It has strong operability and feasibility compared to actual results and provides an effective evaluation basis.

Keywords

Agility, Evaluation, Model, Type-2 Fuzzy, Women's Basketball

1. Introduction

Enhancing the physical fitness of the Chinese population is one of the key tasks in the field of sports, receiving immense attention from the State Council and Communist Party Central Committee of China, serving as a crucial guarantee for accelerating the process of building a sports powerhouse in our country [1,2]. Basketball, favored by many due to its physical contact, complex technical and tactical aspects, and strong entertainment value, holds a significant place in sports. As a unique group, college students are required to excel in solid professional and scientific cultural knowledge and possess excellent overall physical qualities. Basketball, known for its appeal, is highly favored among college students. However, the number of female college students actively engaging in basketball for physical fitness is relatively low, and those proficient in basketball are even scarcer. In response, China organizes national women's college basketball competitions to increase female college students' participation and love for basketball [3-5].

In 2021, our university's women's basketball team won the 23rd Chinese University Basketball League championship in Liaoning Province and secured the fourth position in the national finals. Reflecting on the entire training and competition process, improving players' agility is deemed particularly crucial, given

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the emphasis on endurance and explosive power. To address the training process, we have established an agility assessment method that employs the interval type-2 fuzzy algorithm [6-8].

Some foreign scholars have put forward a variety of evaluation methods. Quantitative evaluation methods introduce threat and vulnerability evaluation methods, where expert opinions determine the scores of evaluation parameters. These parameters are then combined through their linear relationships, allowing for the identification of the most critical factors based on the calculated scores, thereby aiding the evaluation process. Furthermore, the evaluation standard system of sustainable performance evaluation is established, and the criteria are weighted and ranked based on the ranking technology of ideal solution similarity. According to the characteristics of different industries, domestic experts have established different evaluation models based on interval type-2 fuzzy. A sorting method is designed to extend the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) algorithm. In the entire decision-making process of the TOPSIS method for product scheme evaluation, the ranking method of type-2 fuzzy integral is defined by combining fuzzy mathematics, and the ranking model of risk factors is established. Introducing a type-2 fuzzy set improves the accuracy of dealing with uncertain factors in the fuzzy calculation process. Then, all schemes are sorted based on the approach to the ideal point method of interval type-2 fuzzy TOPSIS, which solves the shortcoming of the strong subjectivity of the traditional energy storage selection method. The traditional ORESTE method is extended to the multi-criteria group decision-making problem in an interval type-2 fuzzy environment, a new similarity measure and a global preference scoring function based on the new similarity measure are defined, and three structures of preference, indifference, and incomparable are constructed to achieve strong ranking of alternatives. In addition, some research institutions have developed various risk assessment models. Petri nets have advantages in analyzing structured systems and are often used in system modeling and analysis, which can describe the parallel relationship in the system more clearly [9-15].

Fuzzy Petri nets is an extension of traditional Petri nets, which can deal with the uncertainty and fuzziness of key factors and are widely used in information modeling and system performance evaluation. The training effect is evaluated through the interval type-2 fuzzy evaluation model, especially the improvement of female college students' agility, which is given a targeted evaluation conclusion. Through the analysis and evaluation of this model, the comprehensive quality and ability of female basketball players in our school have been effectively improved, and good results have been achieved in national college students' competitions over the years.

2. The Fuzzy of Interval Type-2 AHP-VIKOR Model

It consists mainly of the analytic hierarchy process (AHP), interval type-2 fuzzy-weight approach, and interval type-2 algorithm for fuzzy sets. In its early stage, the model uses an enhanced weight computation method utilizing the fuzzy logic of interval type-2. The subject weights shall be calculated using the AHP with interval type-2 fuzzy, and the target weights shall be obtained using the entropy mass approach. The amalgamation of these processes yields comprehensive weights. Subsequently, a model for assessing the agility of female basketball players is established, leveraging the improved VIKOR method with interval type-2 fuzzy logic. This involves scrutinizing the maximum benefit and regret values for each scenario, subsequently computing the compromise optimal values for these scenarios. The agility of female basketball players is finally evaluated based on real monitoring data, considering factors such as explosive power and endurance. The optimal values for each scenario are analyzed to provide a comprehensive assessment. Fig. 1 presents the details.

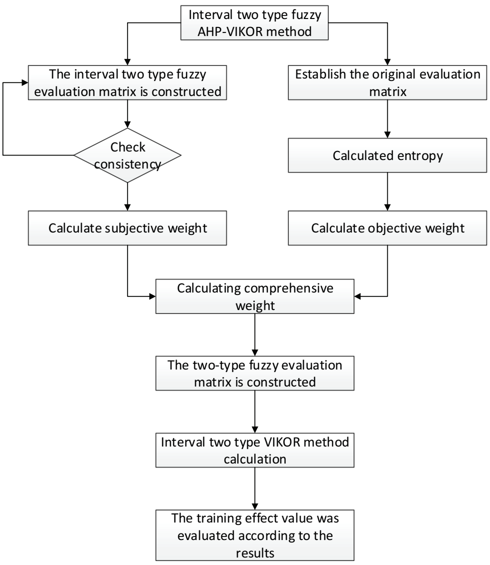

Fig. 1. Flow chart of interval type-2 fuzzy evaluation.

The fuzzy AHP with the fuzzy sets of the interval type-2

The AHP fuzzy breaks down the analysis object into the target objective establish criteria and identifies influencing factors. From a quantitative perspective, expert opinions are used to determine the indicator weights for each influencing factor. In this paper, we adopt the AHP method with the fuzzy of the interval type-2 to calculate the weights of the indicators. Elevating the dimension of fuzzy sets allows for constructing internal relationships within the set of elements and improves upon the limitations of traditional analytical hierarchy process methods.

We started by using linguistic variables to semantically transform the impact relationships between factors like heart rate and blood oxygen saturation among female basketball players. We derived the final subjective weights through a series of calculations, including geometric mean.

Step 1: Build an interval type-2 fuzzy evaluation matrix C. It is often difficult to standardize semantic expressions obtained directly from experts, so employing a unified linguistic variable fuzzy set can more effectively handle semantic issues. *N* experts evaluated the relationships among different indicators, with the corresponding linguistic variable of the fuzzy sets of the interval type-2 represented in Table 1.

Table 1. The fuzzy sets influence the degree of the Interval type-2 to linguistic variables

Influence variables	Fuzzy set of the interval type-2
Extremeness (AS)	(7.50, 8.20, 9.10, 9.50; 0.95, 0.95), (7.80, 8.50, 8.90, 9.20; 0.85, 0.85)
1/AS	(0.13, 0.12, 0.11, 0.10; 0.95, 0.95), (0.12, 0.11, 0.10, 0.09; 0.85, 0.85)
Strongly influence (VS)	(5.80, 6.50, 7.90, 9.10; 0.90, 0.90), (5.90, 6.70, 7.80, 8.80; 0.82, 0.82)
1/VS	(0.17, 0.15, 0.13, 0.11; 0.90, 0.90), (0.16, 0.14, 0.12, 0.10; 0.82, 0.82)
Obvious effect (FS)	(3.40, 4.20, 6.10, 7.20; 0.85, 0.85), (3.60, 4.30, 5.90, 6.80; 0.78, 0.78)
1/FS	(0.29, 0.24, 0.17, 0.14; 0.85, 0.85), (0.28, 0.23, 0.16, 0.13; 0.78, 0.78)
Slight impact (SS)	(1.20, 2.30, 3.80, 5.20; 0.80, 0.80), (1.40, 2.50, 3.70, 4.90; 0.75, 0.75)
1/SS	(0.83, 0.43, 0.26, 0.19; 0.80, 0.80), (0.71, 0.40, 0.27, 0.20; 0.75, 0.75)
Equal impact (E)	(1.00, 1.00, 1.00, 1.00; 1.00, 1.00), (1.00, 1.00, 1.00, 1.00; 1.00, 1.00)

Step 2: The mutual influence relationship compares each indicator pair wise between influencing factors. This relation integrates the fuzzy sets of interval type-2 with the influence degree's linguistic variable and builds a fuzzy assessment matrix of interval type-2, depicted in Formula (1). Assuming *n* experts are evaluating and *n* indicators of the influencing factors. Doing geometric averaging of each indicator in the evaluated matrix, it is to reduce the difference between different expert evaluations. If by, this is the degree of impact of the parameter *i* and the exponent. The formula is as follows:

$$\tilde{c}_{ij} = \left[\tilde{c}_{ij}^{1} \otimes \tilde{c}2_{ij} \otimes \cdots \otimes \tilde{c}_{ij}^{k}\right]^{1/n} = \sqrt[n]{\tilde{c}_{ij}^{1} \otimes \tilde{c}_{ij}^{2} \otimes \cdots \otimes \tilde{c}_{ij}^{k}}, \tag{1}$$

$$\sqrt[n]{\tilde{c}_{ij}} = \begin{pmatrix} \sqrt[n]{\tilde{c}_{ij1}^{U}}, \sqrt[n]{\tilde{c}_{ij2}^{U}}, \sqrt[n]{\tilde{c}_{ij3}^{U}}, \sqrt[n]{\tilde{c}_{ij4}^{U}}; H_1^U\left(\tilde{c}_{ij}\right), H_2^U\left(\tilde{c}_{ij}\right); \\ \sqrt[n]{\tilde{c}_{ij1}^{L}}, \sqrt[n]{\tilde{c}_{ij2}^{L}}, \sqrt[n]{\tilde{c}_{ij3}^{L}}, \sqrt[n]{\tilde{c}_{ij4}^{L}}; H_1^L\left(\tilde{c}_{ij}\right), H_2^L\left(\tilde{c}_{ij}\right) \end{pmatrix}. \tag{2}$$

Step 3: A test is conducted based on the assessment matrix to mitigate potential discrepancies in expert judgment. The derivation of a new evaluation matrix involves computing the geometrical average in the fuzzy assessment matrix of interval type-2. The new evaluation matrix is subjected to defuzzification using Buckley's method. Verify that the consistency of the corresponding fuzzy judgment of matrix interval type-2 becomes feasible if the de-fuzzified assessment matrix is deemed qualified. Eq. (3) is used to eliminate the ambiguity of the evaluation matrix. The fuzzy assessment matrix agreement of the interval type-2 is determined based on the consistency ratio (CR). The CR is calculated, and the random index (RI) divides the consistency index (CI). With the array sequence 1, 2, 3, 4, 5, 6, 7, 8, 9, 9, 10, 10, 0, the assessment matrix is confirmed to be consistent.

$$Def(\tilde{c}_i) = \frac{\left[\begin{array}{l} \dfrac{(c_{i4}^U - c_{i1}^U) + (H_1(\tilde{c}_i^U) * c_{i2}^U - c_{i1}^U) + H_2(\tilde{c}_i^U) * c_{i3}^U - c_{i1}^U)}{4} + c_{i1}^U \\ + \dfrac{(c_{i4}^L - c_{i1}^L) + (H_1(\tilde{c}_i^L) * c_{i2}^L - c_{i1}^L) + H_2(\tilde{c}_i^L) * c_{i3}^L - c_{i1}^L)}{4} + c_{i1}^L \end{array}\right]}{2}. \tag{3}$$

Step 4: After compliance verification, using Formula (4), the geometric average of the effect relations among the respective impact factors shall be computed. In express (4), it represents the influence of geometric mean with different factors.

$$\tilde{r}_i = [\tilde{c}_{i1} \otimes \tilde{c}_{i2} \otimes \tilde{c}_{i3} \otimes \tilde{c}_{i4} \otimes \tilde{c}_{i5} \otimes \cdots \otimes \tilde{c}_{in}]^{1/n}. \tag{4}$$

Step 5: Normalization is applied to the relationships between various agility-influencing factors, and the fuzzy weights are calculated as $\widetilde{w}_i$.

$$\widetilde{w}_i = \tilde{r}_i \otimes [\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3 \oplus \tilde{r}_4 \oplus \tilde{r}_5 \oplus \cdots \oplus \tilde{r}_n]^{-1} \tag{5}$$

Using Formula (3), the specific fuzzy weights are de-fuzzified and denoted as w.

Step 6: The entropy weight method, as compared to the AHP, reduces subjective biases from experts and enhances realism and objectivity. In the practical evaluation process, AHP can rely on weightings provided by expert experience, leading to a lack of objectivity. To overcome these drawbacks, the model incorporates the entropy weight method and leverages the higher precision fuzzy sets of the interval type-2 in handling model uncertainty. The combination of the entropy weight method and fuzzy sets of the type-2is applied in the multi-attribute evaluation with the fuzzy context of the interval type-2.

Step 7: involves establishing evaluation matrices for each indicator based on experimental data. The evaluation matrices are then subjected to a defuzzification process using Formula (3) and Formula (5) to obtain the standard matrix $A_{m\times n} = A_{ij}$. There are *M* plans and *N* evaluation indicators.

$$\tilde{A} = \begin{bmatrix} \tilde{A}_{11} & \cdots & \tilde{A}_{1m} \\ \vdots & \ddots & \vdots \\ \tilde{A}_{n1} & \cdots & \tilde{A}_{nm} \end{bmatrix}. \tag{6}$$

Step 8: Use the entropy weight method to calculate the entropy value of indicator information e_j.

$$e_j = -\frac{1}{ln\, m} \sum_{i=1}^{m\Sigma \quad ij} A_{ij} ln. \tag{7}$$

Step 9: Calculate objective weight values for the information entropy values of each indicator w_j.

$$w_j = \frac{(1 - e_j)}{\sum_{j=1}^{n}(1 - e_j)}. \tag{8}$$

Step 10: Combining the AHP with the entropy weight method, a model of interval type-2 is proposed to solve the objective of each indicator weight using the entropy weight method. This combines objective weights with supervisor weights, overcoming the disadvantage of using a single method to calculate weight values. The comprehensive weights for each indicator are calculated as follows:

$$w = \frac{\sqrt{w_i w_j}}{\sum_{j=1}^{n} \sqrt{w_i w_j}}. \tag{9}$$

3. Experimental Data Analysis

To validate the scientific, reasonable, and applicable nature of this model, we used the heart rate, blood pressure, oxygen content, and sleep time of women basketball players. This study performed a longitudinal comparison analysis to assess the flexibility of the two models, offering effective recommendations and countermeasures based on the specific assessment. Fig. 2 depicts the device and the current image.

(a) (b)

Fig. 2. (a) The wearable device and (b) the actual picture.

The basic situation is as follows: a case study selected the data of female basketball team members from Liaoning University of Petrochemical from 2019 to 2023 as the research plan. The indicator system includes heart rate, blood pressure, oxygen content, and respiratory rate. Four plans were assessed based on the established model, and some experts were selected to evaluate the mutual influence between the indicators. They are assigned to score based on the language set, as depicted in Table 2.

Table 2. Expert evaluation scheme indicator impact relationship

	c_1	c_2	c_3	c_4
c_1	E, SS, E, SS, E	1/VS, VS, 1/SS, AS, 1/FS	1/SS, SS, FS, FS, SS	1/SS, E, FS, AS,VS
c_2	1/VS, VS, 1/SS, AS, 1/FS	SS, SS, E, SS, E, SS, SS, VS	1/AS, VS, 1/AS, 1/VS, 1/FS	1/FS, SS, 1/VS, 1/AS, SS
c_3	1/SS, SS, FS, FS, SS	AS, FS, SS, E, FS, VS, AS	SS, E, SS, E, SS	SS, E, E, 1/FS, AS
c_4	AS, VS	VS, AS	VS, SS	SS, SS, E, SS, E

By using the fuzzy AHP of the interval type-2 and conducting consistency checks, the final weight is determined to be $\mathrm{W(C_1)}$= 0.2409, $\mathrm{W(C_2)}$=0.1290, $\mathrm{W(C_3)}$=0.3091, $\mathrm{W(C_2)}$= 0.2834. The final weight calculated through the entropy weight method is $\mathrm{W(e_1)}$=0.2632, $\mathrm{W(e_2)}$=0.0128, $\mathrm{W(e_3)}$=0.3707, $\mathrm{W(e_4)}$=0.3533. The final comprehensive weight obtained is $\mathrm{W_1}$=0.2441, $\mathrm{W_2}$=0.0312, $\mathrm{W_3}$=0.3988, $\mathrm{W_4}$=0.3259.

Table 3. Test sample data of different schemes

Sample data	Heart rate (bpm)	Blood pressure (mmHg)	Blood oxygen content (%)	Respiratory rate (/min)
E_1	121	130	95	22
E_2	118	135	95	21
E_3	126	138	96	23
E_4	115	132	95	19

Based on the sample test data of different schemes in Table 3, four experts were selected as E_1, E_2, E_3, E_4; they evaluated the performance of each women's basketball team member's plan under different indicators. Experts will understand the relevant materials of the project and conduct on-site investigations to ensure a full understanding of the project situation. The risk scores for each plan are depicted in Table 4, as indicated in Table 2 of the expert language set.

Table 4. Expert evaluation scheme risk degree

	E_1	E_2	E_3	E_4
C_1	L, M, L, M	H, M, M, L	M, VH, M, H	L, M, L, VH
C_2	M, L, M, VH	M, M, L, L	L, VH, M, M	L, M, L, VH
C_3	M, H, L, VH	M, M, VL, L	L, VL, M, L	L, M, L, M
C_4	H, M, VH, M	VH, L, M, M	M, L, VH, L	L, M, VH, L

VL=very low, L=low, M=medium, H=high, VH=very high.

Based on the evaluation results, the highest benefit value can be obtained as S_i andmaximum regret level R_i. The compromise value of the evaluation plan is Q_i. The ranking is shown in Table 5. To evaluate the agility of women's basketball players, the optimal and worst solutions of the plan were further obtained.

The calculation results indicate that after evaluating four distinct indicators—cardiac rhythm, blood pressure, blood oxygen content, and sleep duration—the median ranking of the evaluation scheme closely aligns with the actual output ranking, demonstrating its effectiveness as a model for evaluation. In the E_3 scheme, the weight coefficient is also ranked behind in the case of the lowest intensity, resulting in the compromise value being ranked last. During the E_2 year, while the training intensity value may not be the highest, the agility coefficient stands out as the highest, securing the top position in the compromise value of the final evaluation scheme. Therefore, according to the E_2 year parameter control, improving the training method and agility is the best solution.

Table 5. Final results

	S_i	R_i	Q_i	Ranking (a)	Actual output (%)	Actual output ranking (b)	Ranking difference (a–b)
E_1	5.8667	0.1010	0.4039	1	2.79	1	0
E_2	9.3780	0.0012	0.4689	4	2.49	4	0
E_3	5.5117	0.1206	0.4077	2	2.71	2	0
E_4	6.8277	0.0686	0.4165	3	2.51	3	0

The bi-direction projection method and Dempster-Shafer (D-S) evidence theory are applied as comparative evaluation algorithms in an example and compared with the evaluation results obtained by this model. Fig. 3 compares the evaluation results.

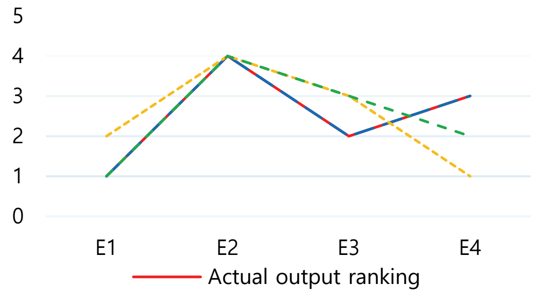

Fig. 3. The contrast curves.

The VIKOR evaluation algorithm has significant advantages in balancing data uncertainty because of its data compromise characteristics, which can effectively extract weighted data information and reduce the interference of extreme data on evaluation ranking. Compared with the ranking of evaluation results of this model and the actual output ranking, the evaluation results of the AHP-VIKOR model are more accurate. The results of the bi-directional projection method are the same as the actual results in the ranking of maximum and minimum items, but the evaluation results are reversed in the ranking of intermediate items. The bi-directional projection method uses the projection length on the positive and negative ideal solution vectors to evaluate the data, which can realize the systematic data analysis. However, due to the high sensitivity of the bi-directional projection method, small changes in the weighted data can easily affect the final evaluation results. Compared with the AHP-VIKOR model, the Bi-directional projection method is not stable in the evaluation results, and it cannot achieve effective evaluation in the data processing of conflicting indicators, which has high application limitations. The theoretical results of the D-S evidence are quite different from the actual results, and only E_2 is the same as the actual results in terms of comparison and ranking. D-S evidence theory has unique advantages in dealing with conflicting indexes and uncertain information data; however, it has disadvantages, such as fuzzy and poor robustness of similar data evaluation. Compared with the AHP-VIKOR model, the evaluation results of the D-S evidence theory are easily influenced by extreme data, and the evaluation results are not accurate.

In this study, we converted the fuzzy sets of the interval type-2 into the agile assessment model of the women's basketball team into the fuzzy set of the interval type-2. With the combination of fuzzy AHP and entropy-weight approach, VIKOR built a new type of AHP entropy-weight VIKOR. Based on type-1 fuzzy theory, this model is used to investigate the relationship among various factors, and it is used in combination with multi-expert assessment to decrease information loss and increase the precision of assessment. Finally, this method is used in the research of non-catalytic oxidation of cyclohexane, and it is feasible. The weaknesses of this study are that there are no sufficient parameters for impact indicators and subjective assessments are strongly affected by the assessment of impact factors.

4. Conclusion

In this study, the agility of female basketball players is evaluated by interval type-2 fuzzy sets, and the expert language variables of interval type-2 fuzzy sets are obtained. Using the AHP fuzzy method and entropy weight method, a VIKOR fuzzy risk assessment model with non-entropy weight is established using the VIKOR method. Compared with the comprehensive analysis of the two traditional assessment algorithms, this model can extract data information, understand the compromise between fluctuating data and extreme information, reduce the analysis error of similar items, and make the assessment results more robust and accurate. Based on the type-1 fuzzy theory, the model analyzes the influence of various factors and is used to study the non-catalytic hydrogenation of cyclohexane. Compared with practical applications, this model is feasible. The disadvantage of this method is that it does not have enough influence on the index, and subjective views largely influence the evaluation of influencing factors.

Conflict of Interest

The authors declare that they have no competing interests.

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