Study on the Evaluation Index of Cadet’s Physical Training Based on the Entropy Weight

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Abstract. This paper studies the principle and method of the entropy weight and fuzzy comprehensive evaluation method applied in the assessment of students’ physical training comprehensive evaluation. The paper focuses on the standardized evaluation matrix, as well as the combination of subjective and objective weights to get synthesis weights and other aspects, and introduces the application of the method in the cadet training evaluation comprehensive performance.

Introduction

Cadets, male and female, are required to do physical training every day from boot camp to the joint physical fitness examination. What’s more, if cadets cannot pass the head office physical examination, they will not graduate. Through comprehensive evaluation of its daily training, it is of great significance to perfect the assessment’s rationality, timely adjust the training focus, to ensure the effect of training, to establish the regular combat readiness and training. The daily training assessment of military cadets is carried out under the condition of risk and randomness. Therefore, in order to improve the assessment accuracy and reduce the assessment risk, this paper applies the fuzzy comprehensive assessment method that based on entropy weight to establish the comprehensive assessment model of physical training assessment suitable for military cadets according to the actual situation of military cadets.

The Establishment of Physical Training Evaluation Index System

The determination of the comprehensive evaluation index system of cadet training assessment is the first step of the comprehensive evaluation of physical training assessment. The determination of the evaluation index system is determined according to the characteristics of cadet’s physical training. The index are required to be independent each other and have strong comparability in principle. If there are overlapping indicators, the role of the indicators will be exaggerated, affecting the accuracy of the assessment.

It is designed to evaluate the daily training of n cadets, there are m assessment index factors. The evaluation matrix of m index factors for n cadets can be obtained according to the principle of combining qualitative and quantitative analysis:

\[
X = (x_{ij})_{m \times n} = \begin{bmatrix}
x_{11} & x_{12} & \cdots & x_{1n} \\
x_{21} & x_{22} & \cdots & x_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
x_{m1} & x_{m2} & \cdots & x_{mn}
\end{bmatrix}. \tag{1}
\]

Let’s represent the assessment result of the jth cadet under the ith index. The below is the standardization methods of forward index and reverse index\cite{1,2}.

For the forward index:
\[ r_{ij} = \frac{(x_{ij} - \min_{i}^{x_{ij}})}{(\max_{i}^{x_{ij}} - \min_{i}^{x_{ij}})} \]  \quad (2)

or

\[ r_{ij} = \frac{x_{ij}}{\max_{i}^{x_{ij}}} \]  \quad (3)

For the reverse index:

\[ r_{ij} = \frac{(\max_{i}^{x_{ij}} - x_{ij})}{(\max_{i}^{x_{ij}} - \min_{i}^{x_{ij}})} \]  \quad (4)

or

\[ r_{ij} = \frac{\min_{i}^{x_{ij}}}{x_{ij}} \]  \quad (5)

According to equations (2) ~ (5), the dimensionless normalization of X is carried out to obtain the fuzzy evaluation matrix \( R[3,4] \):

\[
R = (r_{ij})_{m \times n} = \begin{pmatrix}
 r_{11} & \cdots & r_{1n} \\
 \vdots & \ddots & \vdots \\
 r_{m1} & \cdots & r_{mn}
\end{pmatrix}.
\]  \quad (6)

In equations (6), \( r_{ij} \in [0,1] \) and all kinds of indicators are converted into forward indicators, with the optimal value being 1 and the worst value being 0.

The Determination of Comprehensive Weight of Evaluation Indexes

At present, the weight determination methods mainly include subjective weighting method and objective weighting method[5]. The advantage of subjective weighting method is that it can give full play to the subjective initiative of the evaluators, but it also have the weakness of being easily disturbed by uncontrollable factors of the evaluators. However, the objective weighting method is generally obtained through statistical methods, and the data are directly derived from the objective reality, so the objective basis of the weight obtained is strong. However, its disadvantage is that it cannot cope with the emergence of some accidental factors, such as “special cases”, and it lacks flexibility and practicality, and has certain defects[6,7]. Therefore, this paper adopts the method of combining subjective and objective weighting to determine the comprehensive weight of indexes.

The Determination of the Comprehensive Weight

Fuzzy comprehensive evaluation technology is mainly aimed at the uncertainty of the assessed system to explore the information and evaluate the system[8]. In the comprehensive evaluation of the cadets’ daily training assessment, there are two kinds of uncertainties, namely the uncertainty of the results of the daily training assessment and the ambiguity of the evaluation grade. Therefore, this paper uses entropy weight to determine the objective weight of the comprehensive assessment.

In all the daily training assessment results, the greater the uncertainty of the index value for any one index, the stronger the relative strength of the performance of different cadets for this index, and the greater the effect of the index on the daily training assessment results, which can show that it contains more information about the daily training assessment results.

Entropy is a measure of the uncertainty of system state, so it can be used to measure the amount of uncertain information above. The more information a certain indicator carries, the more important it is for the assessment results of trainees’ daily training.

Entropy of its system is:
\[ H(p_1, p_2, \cdots, p_n) = -k \sum_{i=1}^{n} p_i \ln p_i. \]  

(7)

\[ k = \frac{1}{\ln n}, \text{among it}, p_i \text{ follows } 0 \leq p_i \leq 1, \sum_{i=1}^{n} p_i = 1, \text{and stipulate } p_i = 0, -k \sum_{i=1}^{n} p_i \ln p_i = 0. \]

Combined with the standardized evaluation matrix obtained above, the entropy of the fourth index is:

\[ H_i = -k \sum_{j=1}^{n} f_{ij} \ln f_{ij} \quad (i = 1, 2, \cdots, m). \]

(8)

\[ f_{ij} = \frac{r_{ij}}{\sum_{j=1}^{r} r_{ij}} \]

(9)

And assume: when \( f_{ij} = 0 \), \( f_{ij} \cdot \ln f_{ij} = 0 \).

Then the entropy weight of the fourth index is defined as:

\[ w_i' = \frac{1 - H_i}{\sum_{i=1}^{n} (1 - H_i)} \]

(10)

The weight can reflect the role of different indicators in cadets’ daily training assessment results. When the entropy value of an index is small and the entropy weight is large, it means that the index provides more useful information to the training assessment results. Thus, the weight vector of the training assessment index based on entropy weight can be obtained:

\[ W_H = (w_{i1}', w_{i2}', \cdots, w_{in}') \]

(11)

The index weight determined by the entropy weight method is completely depend on the relationship between data, but sometimes the objective weights differ greatly with the actual situation, and the weights determined by the experts is obtained by practice experience, which are impacted by the human factors. So the weight of scientific value should be the comprehensive measures of expert evaluation (subjective weights) and entropy (objective weights). In this paper, the comprehensive weight is obtained by combining subjective and objective weight with the following formula:

\[ w_i = \frac{w_i' u^i}{\sum_{i=1}^{n} w_i' u^i} \quad 0 \leq w_i \leq 1. \]

(12)

\( w_i' \) is the weight determined by entropy weight method; \( u^i \) is the weight of expert evaluation. Then the final weight is

\[ W = (w_1', w_2', \cdots, w_n') \]

(13)

The Establishment of Comprehensive Fuzzy Evaluation Model

Based on the fuzzy evaluation matrix \( R \) and the comprehensive weight vector \( W \) of the comprehensive evaluation, the fuzzy comprehensive evaluation model is obtained by using the fuzzy mathematical theory as follows:
\[ B = W \cdot R = (w^1, w^2, \ldots, w^m) \cdot \begin{pmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{pmatrix} = (b_1, b_2, \ldots, b_n). \] 

(14)

Since W is normalized, the fuzzy relation can be synthesized by the addition and the multiplication of ordinary real numbers

\[ b_j = \sum_{i=1}^{m} w^i \cdot r_{ij}, \quad b_j \in [0,1], \quad j = 1, 2, \ldots, n. \] 

(15)

B Represents the value vector of the good and bad of student under assessment, the bigger of \( b_j \), it indicates that the jth student who is assessed has a higher comprehensive score. According to the value of \( b_1, b_2, \ldots, b_n \), the assessment results of all participants in the assessment of the comprehensive ranking can be realized.

**Conclusion**

If the values of the elements in the i row of the standardized evaluation characteristic matrix R are very close, the ith index is not comparable and plays a very small role in the evaluation. When the entropy value of an index is smaller and the entropy weight is larger, which indicates that the index provides more useful information to the examiners and has a greater impact on the evaluation results.

This paper applies the entropy theory and the fuzzy method to the comprehensive evaluation of the assessment of cadets’ physical training. Its advantage is that the index weights based on entropy weight fuzzy comprehensive evaluation method can have different dimensional index standardizing, which reflects the true level indicators and combined with the subjective weights of experts, objectively reflect the effect of the data itself, and conform to the actual situation of specific training evaluation. By using fuzzy evaluation model and appropriate fuzzy synthesis operator, the weight and index value information can be used to the greatest extent so that the evaluation results are reasonable and effective.

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