Evaluation Research on Competitive Ability of Volleyball Player
Based on Fuzzy Set of Evaluation Index and Weight

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Abstract: In order to evaluate the competitive ability of volleyball player, the fuzzy comprehensive evaluation
and analytic hierarchy process are applied in it and the fuzzy sets of evaluation index and weight are introduced
into the evaluation method. First, the connotation of competitive ability of volleyball player is discussed.
Second, the basic theories of competitive ability of volleyball player are analyzed. Then the steps of evaluation
for competitive ability of volleyball player are established. Finally, the simulation is carried out and results show
that this evaluation method can get the effective evaluation value.

Key words: Competitive ability, volleyball player, fuzzy set, evaluation index, weight

INTRODUCTION

Volleyball sport is open type athletics. Both sides
of match confront across the net during the procession of
volleyball sport. The transition between attack and
defense is completed through the interaction and
coordination of volleyball players. Therefore, the
volleyball sport has the following characteristics,
antagonism and aggregative feature that apply tactics and
the aggregative feature is achieved based on knowing the
volleyball player individual with special sport skill.
Therefore, it is significant for development of volleyball
sport theory and practice to analyze the competitive
ability of volleyball player. So far, there is not a united
standard to analyze the competitive ability of volleyball
player and united competitive ability test of volleyball
player before volleyball contest lacks also (Meng, 2011;
Jin et al., 2007). The proper evaluation of competitive
ability of player can not be achieved and the competitive
ability of volleyball player can not develop. It is necessary
to find out an effective evaluation method for analyzing
the competitive ability of volleyball player. Fuzzy
comprehensive evaluation is a method for qualitative and
quantitative analysis, it has been applied in many fields,
such as engineering technology and economic
management. The main problem of fuzzy comprehensive
evaluation is the confirming method of fuzzy
membership grade which shows the effect of every
evaluation index on the system. Analytic hierarchy
process is a system engineering method and it can
complete mathematization of thinking process of complex
system, quantification of qualitative analysis based on
subjective judgment, quantization of difference among
different evaluation indexes. It can confirm the weight of
different evaluation indexes. Evaluation system of
competitive ability of volleyball player has strong
nonlinear characteristics, therefore, single evaluation
method has difficulty in reflecting competitive ability of
volleyball player. The fuzzy comprehensive evaluation
and analytic hierarchy process can be combined to
construct the evaluation system of competitive ability of
volleyball player.

CONNOTATION OF COMPETITIVE ABILITY OF
VOLLEYBALL PLAYER

The competitive ability of volleyball mainly refers
to ability of working in volleyball sport which can be
showed in volleyball competitive sport. The competitive
ability of volleyball is the ability needed that
entering training and contest (Zhang et al., 2011). The
competitive ability of volleyball has the system
characteristic, the competitive ability of volleyball player
is constructed according to the subordinate
relationship and hierarchy principle and the structure and
factors of competitive ability of volleyball player are
shown in Table 1.

| Table 1: Structure and factors of competitive ability of volleyball player |
| Object level |
| First level | Second level |
| Competitive ability of volleyball player | Physical shape |
| Physical strength | Physical function |
| Technical ability | Sport quality |
| Mental ability | Skill |
| Kinesthetic intelligence | Tactics |
| | Cooperation |
| | Sensation and perception |
| | Reason ability |
| | Self-awareness |
| | Information Processing speed |
| | Cognitive strategy |
Evaluation of competitive ability is important for volleyball player; it can decide the quality of training and achievement of contest and therefore, the fuzzy comprehensive and analytic hierarchy process are applied in evaluating the competitive ability of volleyball players in this study.

**BASIC THEORY OF COMPETITIVE ABILITY OF VOLLEYBALL PLAYER**

**Fuzzy set theory:** Fuzzy evaluation is a method that evaluates the system based on fuzzy set theory. The competitive ability of volleyball player can be evaluated after the fuzzy transform according to the evaluating standard and test value. This method can process the uncertain information based on the quantitative method and the qualitative decision is changed to quantitative decision and the visibility and correctness of evaluation results can be improved (Zhang et al., 2012).

Set the map \( \mu \) is given in domain U, that is \( \mu: U \rightarrow [0,1] \), \( \mu \) confirm a Fuzzy subset in U which is defined as A and \( \mu \) is the membership function of A, which is written as \( \mu_{\alpha}(u) \).

Two domains U and V are given, the Fuzzy subset \( \tilde{R} \) of productive set is Fuzzy compatible relation in \( U \times V \) which is expressed as shown in Eq. 1:

\[
U \times V = \{(u,v)| u \in U, v \in V\}
\]  

(1)

Membership grade \( R(u, v) \) reflect the relating degree between u and v.

Set \( U = \{u_1, u_2, \ldots, u_n\} \), \( V = \{v_1, v_2, \ldots, v_m\} \) and the following Eq. 2 is obtained:

\[
\tilde{R} = (r_{ij})_{m \times n}, \tilde{R} \in \mathcal{F}(U \times V)
\]  

(2)

where, \( r_{ij} = \tilde{R}(u_i, v_j) \), i ≤ n, j ≤ m and \( \tilde{R} \) is fuzzy matrix.

For an index of evaluation system of competitive ability of volleyball player, it can be manifested as fuzzy interval \( X = [x_i, x_j] \) that satisfies a kind of fuzzy distribution, where, \( x_i \) and \( x_j \) are lower limit and upper limit, respectively. Gaussian fuzzy distribution is used in this study and the membership grade function of fuzzy interval is expressed as shown in Eq. 3 (Ishizaka et al., 2012):

\[
\mu_{\alpha}(s) = e^{-\left[ \frac{x-s}{\sigma} \right]^2}
\]  

(3)

where:

\[
\mu = \frac{x_i+x_j}{2}
\]

\( \mu \) is the central value of fuzzy interval, \( \sigma \) can choose:

\[
\frac{x_j-x_i}{2}
\]

which is the one fourth of fuzzy interval length.

The membership relationship of every evaluation index to every evaluation grade is a fuzzy distribution. And the Gaussian fuzzy distribution is used in this research, then the membership function of every evaluation index \( v_i \) (i = 1, 2, ..., n) to every evaluation grade \( p_i \) (i = 1, 2, ..., m) satisfies the normal distribution, which can be expressed as shown in Eq. 4:

\[
\mu_{\alpha}(v_i) = e^{-\left[ \frac{v_i-m_i}{\delta_i} \right]^2}
\]  

(4)

where, \( \mu_{\alpha}(v_i) \) is the membership grade, \( m_i \) is the statistic mean and \( \delta_i \) is the statistic variance.

The evaluation index is expressed by a fuzzy set and the element \( r_{ij} \) in fuzzy evaluation matrix \( R_{mn} \) can be calculated through close degree of relating fuzzy set and the corresponding expression is listed as shown in Eq. 5 (Cagman and Karatas, 2013):

\[
r_{ij} = \alpha(v_i, p_j) = \frac{1}{2}(v_i \cdot p_j + (1 - v_i \cdot p_j))
\]  

(5)

While, \( V_i \) and \( P_j \) are independent in every dimensional distribution and the following expressions can be obtained as in Eq. 6 and 7:

\[
V_i \cdot P_j = e^{-\left[ \frac{|m_{ij}-m_j|}{\delta} \right]^2}
\]  

(6)

\[
V_i \oplus P_j = 0
\]  

(7)

Equation 5 is further simplified and the following equation is obtained finally:

\[
r_{ij} = \frac{1}{2}(e^{-\left[ \frac{|m_{ij}-m_j|}{\delta} \right]^2} + 1)
\]  

(8)

where, \( \mu_{ij} \) is the mean of ith evaluation index of fuzzy set, \( \sigma_{ij} \) is the variance of ith evaluation index of fuzzy set, \( \mu_{ji} \) is the mean of jth evaluation index of fuzzy set, \( \sigma_{ji} \) is the variance of jth evaluation index of fuzzy set, the fuzzy evaluation matrix \( R_{mn} \) is obtained based on Eq. 8.

**Determining weight of evaluation index:** The evaluation system concludes n indexes and the corresponding collection is defined as U = \{u_1, u_2, ..., u_n\}. And the index
And the relative weight of evaluation index is expressed as follows (Parreiras et al., 2012):

$$
\bar{\omega}_i = \frac{\frac{1}{2} \sum_{i=1}^{q} \left[ b_{i}^{2} - a_{i}^{2} \right]}{\sum_{i=1}^{q} [b_{i} - a_{i}]} \quad (13)
$$

The normalization is applied to deal with relative weight of evaluation index $\omega_i$ and the corresponding expression is listed as follows:

$$
\omega_i = \frac{\bar{\omega}_i}{\sum_{i=1}^{q} \bar{\omega}_i} \quad (14)
$$

Weight vector of every evaluation index in evaluation system is expressed as follows:

$$
W = \{\omega_1, \omega_2, \ldots, \omega_q\} \quad (15)
$$

**STEPS OF EVALUATION FOR COMPETITIVE ABILITY OF VOLLEYBALL PLAYER**

According to the competitive ability of volleyball player, the evaluation concludes the following steps:

- Defining a multiple layer index system of the evaluation system of competitive ability of volleyball player
- Calculating the fuzzy evaluation matrix $R$ based on model based on fuzzy approach degree. The evaluation grades are set to “excellent”, “good”, “normal” and “bad”
- Calculating the relative weight of evaluation index according to Eq. 14, obtaining the relative weight vector $W$
- Using compositional operation of fuzzy matrix to obtain the comprehensive evaluation vector as shown in Eq. 16:

$$
B = W.R = \{b_1, b_2, \ldots, b_q\} \quad (16)
$$

Where:

$$
b_i = \bigvee_{r=1}^{q \times p} (w_r \cdot \lambda_r) \quad (16)
$$

"$\bigvee$" is choosing minimum value, "$\bigwedge$" denotes choosing maximum value. Let:

$$
\sum_{i=1}^{q} b_i = 1
$$

based on normalization.
• Confirming a score set \( S = \{ s_1, s_2, \ldots, s_i, \ldots, s_n \} \)
  where \( s_i \) is evaluation score of \( i \)th grade
• Calculating the evaluation result of this layer:

\[
I = BS
\]  
(17)

• Calculating the final evaluation result of the competitive ability of volleyball player

CASE STUDY OF EVALUATING THE COMPETITIVE ABILITY OF VOLLEYBALL PLAYER

In order to verify the effectiveness of the evaluation method, case study is carried out for woman’s 100 volleyball players and the average height of volleyball players is 178.31±6.32 cm, the average weight of volleyball players is 62.03±7.03 kg, the average age is 15.03±0.95 years old and the average training time is 3.25±1.09a.

The competitive ability of volleyball player can be measured the corresponding test indicator. Test projects conclude “running up to touch”, “30 meter race”, with “standing long jump”, “10s cross jump”, “20s repeated across” and so on.

The evaluation index system of competitive of volleyball player is shown in Table 1. The fuzzy evaluation matrices of bottom level are calculated according to Eq. 8:

\[
R_1 = \begin{bmatrix}
0.2 & 0.4 & 0.3 & 0.1 \\
0.3 & 0.4 & 0.3 & 0 \\
0.2 & 0.4 & 0.3 & 0.1
\end{bmatrix}
\]

\[
R_2 = \begin{bmatrix}
0.1 & 0.3 & 0.2 & 0.4 \\
0.2 & 0.2 & 0.4 & 0.2 \\
0.3 & 0.2 & 0.3 & 0.2
\end{bmatrix}
\]

\[
R_3 = \begin{bmatrix}
0.1 & 0.3 & 0.4 & 0.2 \\
0 & 0.5 & 0.3 & 0.2 \\
0 & 0.4 & 0.4 & 0.2
\end{bmatrix}
\]

\[
R_4 = \begin{bmatrix}
0.2 & 0.4 & 0.3 & 0.1 \\
0.4 & 0.2 & 0.1 & 0.3
\end{bmatrix}
\]

The relative weight vector of every level is calculated according to Eq. 14:

\[
W_1 = [0.225, 0.432, 0.342]
\]

\[
W_2 = [0.147, 0.385, 0.468]
\]

\[
W_3 = [0.325, 0.286, 0.389]
\]

\[
W_4 = [0.53, 0.47]
\]

\[
W = [0.25, 0.14, 0.32, 0.29]
\]

The fuzzy comprehensive evaluation vector is calculated according to the Eq. 16:

\[
B_1 = [0.145, 0.228, 0.384, 0.243]
\]

\[
B_2 = [0.093, 0.276, 0.501, 0.330]
\]

\[
B_3 = [0.124, 0.286, 0.376, 0.214]
\]

\[
B_4 = [0.094, 0.338, 0.136, 0.432]
\]

Score set is defined as \( S = [85, 70, 45, 20] \)

\[
I_1 = B_1 \cdot S = 50.425, I_2 = 47.825, I_3 = 51.75, I_4 = 46.41
\]

Finally, the comprehensive evaluation value of competitive ability for the volleyball players is obtained as follows:

\[
I = W_4 \cdot I = 45.815
\]

The final evaluation results show that this competitive ability of volleyball players is normal and the training plans should be amended in further study.

CONCLUSIONS

Evaluation of competitive ability is important for volleyball player and effective evaluation of competitive ability can reflect the advantages and disadvantages of volleyball players. According to the evaluation results the effective, training plan can be established. The fuzzy comprehensive evaluation and analytic hierarchy process are combined to evaluation the competitive ability of volleyball player and the fuzzy sets of evaluation index and weight are used in this study. Simulation analysis is carried out for 100 women’s volleyball players and the results show that this evaluation method can reflect the competitive ability of volleyball player and offer theoretical guidance for the training plans of volleyball player.

REFERENCES


