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Evaluation study on training of 100m sprint athletes based on improved D-S evidence theory

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ABSTRACT

In order to evaluate the training of 100m sprint athlete, the improved D-S evidence theory is applied in it. First, the basic characteristics of 100m sprint are analyzed. Second, the basic theory of D-S evidence theory is studied. Then, the analysis steps of improved D-S evidence theory are established. Finally, a case study of evaluation for 100m sprint training athletes is carried out based on improved D-S evidence theory, and results show that this evaluation results can obtain correct evaluation results.

Key words: improved D-S evidence theory; evaluation; 100m sprint

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INTRODUCTION

With the development of modern sports science, the sprint level improves constantly, and the athletes training method of 100m sprint is developed continuously with innovation. Chinese 100m sprint our national 100m sprint has lagged in the world. Although there are many reasons for poor sprint level in China, but the poor sprint level has something with poor physical function of athlete and recovery capability after the training [1]. The training is import factor for improving the speed and endurance of the athlete. Effective training method can improve the achievement of 100m sprint. Therefore it is necessary to evaluate pertinence, science and method of 100m sprint training, and the utilization of physical function of 100m sprint athlete can be improved, the comprehensive athletic ability of 100m sprint athlete can be exploited. The main attack way of 100m sprint athlete can be confirmed, and the physical function of 100m sprint athlete can be used. Then the good training method and system can be established. Therefore it is significant for 100m sprint to construct the evaluation model and standard of training, the training level can be evaluated correctly, and the existing problems in training can be improved. A good evaluation method must be used. Recently there are many evaluation methods, such as comprehensive fuzzy evaluation, expert investment method. These evaluation methods can get a comprehensive evaluation result, but the certainty and uncertainty of result can not be measured, therefore they have their limits. Improved D-S evidence theory is used in evaluating the athletes training of 100m sprint. Traditional D-S evidence theory is an uncertain reasoning method, which can grasp the uncertainty of problem relative to traditional probability theory [2]. And it has strong processing ability for uncertain information, which suits for evaluating the problem with human factors and uncertainties. Of course traditional D-S evidence theory still has deficiency, when the serious conflicts happen among evidences, and the evaluation results can not be applied. In order to deal with the disadvantages of traditional D-S theory, an improved D-S evidence theory is used in this research.

Basic characteristics of 100m sprint

100m sprint is a track and field event with shortest distance, fastest rate and greatest intensity. The essential feature of 100m sprint is listed as follows: it is a rolling and translating movement with high speed in the axle of hip. The kick is an extension of high speed rolling movement. The hip movement is a critical part of horizontal acceleration for athlete, and therefore the scientific, ideal and perfect 100 sprint technique should have strong hip muscles, rapid swing speed, and good speed of pawing movement [3]. During the procession of training of 100m sprint, the six

mistake way of running should be avoided which conclude slouching run, stomaching run, sitting run, jumping run, shaking run and curving run. 100m sprint training of athlete should be carried out from speed, technique and strength. Speed, technique and strength are closely connected, speed is core, strength is basis, and technique is carrier. Different special speed must require different special technique and strength.

Speed concludes acceleration ability, speed-endurance, absolute velocity, movement speed, speed ability [4]. For different speed, the corresponding training can be applied. Special technique concludes optimal special exercise, the training technique that can improve swing amplitude, the training technique that can improve swing ability. Strength concludes strength of hip muscle, strength of lumbar muscle, strength of lower limbs, the evaluation index system of 100m sprint training is established, which is shown in table 1.

Table 1 evaluation index system of 100m sprint training

Object level	first level	second level
Training effect of 100m sprint	sport quality	basic physical quality
		special physical quality
	physical function	maximum oxygen uptake
		diastolic pressure
		systolic pressure
		heart rate
	speed of athlete	acceleration ability
		speed-endurance
		absolute velocity
		movement speed
		speed ability
	special training technique	optimal special exercise
		training technique of swing amplitude
		training technique of swing ability
	strength of athlete	strength of hip muscle
		strength of lumbar muscle
		strength of lower limbs

Improved D-S evidence theory is used to carry out data fusion, and the evaluation efficiency of 100m sprint can be improved.

Basic theory of D-S evidence theory

D-S evidence theory is put forward by A.P. Dempster in1976, and is extended and developed for the next ten years.

(1) Basic conception

In D-S theory, a sample space is known as identification frame, which is expressed as Θ, it is a limited collection of possible answers about proposition, Θ is expressed as follows [5]:

$$\Theta = \{\theta_1, \theta_2, \cdots, \theta_i, \cdots, \theta_n\} \tag{1}$$

where θ_i $(1 \le i \le n)$ is a singleton of Θ.

If collection function $m: 2^{\Theta} \to [0,1]$ satisfies the expression (2), m is basic believe assignment on Θ, and $m(A)$ is a basic believe assignment of A.

$$m(\phi) = 0, \ \sum_{A \subset \Theta} m(A) = 1 \tag{2}$$

Set Θ as identification frame, $m: 2^{\Theta} \to [0,1]$ is a basic believe assignment on Θ, the validity function is expressed as follows [6]:

$$Bel(A) = \sum_{B \subset A} m(B), \ \forall A \subset \Theta \tag{3}$$

If $m(A) > 0$, then A is focal element of validity function Bel, all focal elements are named as core of validity function Bel.

(2) Combination of double validity functions

Setting Bel_1 and Bel_2 as two validity functions on the same identification frame Θ, m_1 and m_2 are the relating basic believe assignments, the corresponding focal elements are defined as $A_1, A_2, \cdots, A_n$ and

$B_1, B_2, \cdots, B_n$ respectively. If expression (4) is satisfied, then let $m = m_1 \dot{Y} m_2$.

$$K = \sum_{A_i \cap B_j} m_1(A_i) m_2(B_j) < 1 \tag{4}$$

The validity function defined by m is known as direct sum of Bel_1 and Bel_2, and the formulation of m is expressed as follows:

$$m(A) = \frac{1}{1-A} \sum_{A_i \cap B_j = A} m_1(A_i) m_2(B_j) \tag{5}$$

(3) Combination of multiple validity functions
Combination of multiple validity functions can be completed through multiple combinations of double validity functions based on the following characteristics:

Exchangeability: $m_1 \dot{Y} m_2 = m_2 \dot{Y} m_1$ (6)

Associability: $(m_1 \dot{Y} m_2) \dot{Y} m_3 = m_1 \dot{Y} (m_2 \dot{Y} m_3)$ (7)

Analysis steps of improved D-S evidence theory
Traditional D-S evidence theory is effective in information fusion of multiple data, but when the evidence information highly conflict, the evaluation conclusion contradicts intuition, therefore the traditional D-S evidence theory is improved. The improved D-S evidence theory is applied in evaluating the athlete training of 100m sprint.

The following mathematical signs are defined: S_i ($i = 1,2,\cdots,n$) is i th project, and I_i ($i = 1,2,\cdots,m$) is i th evaluation index, and the corresponding evaluation steps are listed as follows :

Step 1: The mass function is constructed. Score collection $S = \{s_1, s_2, s_3, s_4\}$, s_1 represents excellent, s_2 represents good, s_3 represents medium, s_4 represents poor. And the levels in score collection is defined, which is shown in table 2.

Table 2 Definition table of score collection

m_{Si}	1	2	3	4	5	6	7
s_1	1	0.85	0.55	0	0	0	0
s_2	0	0.15	0.75	0.5	1	0	0
s_3	0	0	0	0	0	1	0.15
s_4	0	0	0	0	0	0.25	0.75

The evaluation level is given according to fuzzy comment, which is expressed as $E = \{e_1, e_2, e_3, e_4, e_5, e_6\}$, e_1 represents 5 point, e_2 represents 4 point, e_3 represents 3 point, e_4 represents 2 point, e_5 represents 1 point, e_6 represents 0 point. And the corresponding evaluation level is shown in table 3.

Table 3 Definition table of evaluation level collection

E	1	2	3	4	5	6	7
e_1	1	0.85	0.25	0	0	0	0
e_2	0.15	0.55	1	0.25	0	0	0
e_3	0	0.35	0.75	0	0	0	0
e_4	0	0	1	0.85	1	0	0
e5	0	0	0	0.45	0	0.55	0
e6	0	0	0	0	0	1	0.75
e7	0	0	0	0	0	0	1

According to table 1 and table 2, the evaluation level can be reflect on the characteristic value based on maximum and minimum operation, and the basic validity grade assignment of characteristic value of every evaluation index is calculated according to the following expression [7]:

$$m_{\mathrm{j}}^{*}(s_k)=\frac{\sum_{i=1}^{7}(m_{ji},\wedge m_{A_k i})}{\sum_{i=1}^{7}(m_{ji},\vee m_{A_k i})},\ (k=1,2,3,4;\ j=1,2,3,4,5,6,7) \tag{8}$$

where $\wedge$ denotes minimum operation, $\vee$ denotes maximum operation. $0\le m_{\mathrm{j}}^{*}(s_k)\le 1$, normalization processing is carried out, which is expressed as follows:

$$m_{\mathrm{j}}^{'}(s_k)=\frac{m_{\mathrm{j}}^{*}(s_k)}{\sum_{i=1}^{4}m_{\mathrm{j}}^{*}(s_k)} \tag{9}$$

The original mass function is obtained according to the expression (6) and (7).

Step 2: The evidence combination is carried out. The mass functions $m_{\mathrm{j}}(s)$ are combined for all evidences, and the comprehensive validity of every evaluation index is obtained.

Step 3: The comprehensive score is calculated. According to the definition of characteristic collection, the score of s_1 is equal to 4.0, the score of s_2 is equal to 3.5, the score of s_3 is equal to 2.0, the score of s_4 is equal to 0.5, and the comprehensive score of every index is calculated according to the following expression [8]:

$$x_{ij}=4m^{(I_i)}(s_1)+3.5m^{(I_i)}(s_2)+2.0m^{(I_i)}(s_3)+0.5m^{(I_i)}(s_4) \tag{10}$$

Step 4: The approximation degree of every project is calculated. According to the comprehensive score, the original data matrix is obtained, which is defined as $X=\{x_{ij}\}_{n\times m}$. And the weighting decision matrix $D=\{d_{ij}\}_{n\times m}$ is calculated by the following expression:

$$d_{ij}=\omega_{ij}x_{ij} \tag{11}$$

where ω_{ij} denotes the weight of j th evaluation index.

Then the ideal project V^{+} and negative ideal project V^{-} are confirmed according to the following expressions:

$$V^{+}=\{v_i^{+}\} \tag{12}$$

$$V^{-}=\{v_i^{-}\} \tag{13}$$

where $v_i^{+}=\max(v_{1i},v_{2i},\cdots,v_{ni})$, $v_i^{-}=\min(v_{1i},v_{2i},\cdots,v_{ni})$.

The distance between the every project and $V^{+}(V^{-})$ is calculated according to the following expressions:

$$\delta_i^{+}=\sqrt{\sum_{j=1}^{m}(v_{ij}-v_j^{+})^2},\ i=1,2,\cdots,n \tag{14}$$

$$\delta_i^{-}=\sqrt{\sum_{j=1}^{m}(v_{ij}-v_j^{-})^2},\ i=1,2,\cdots,n \tag{15}$$

Then the approximation degree is calculated according to the following expression:

$$A_i^+ = \frac{\delta_i^-}{\delta_i^- + \delta_i^+},\ i = 1,2,\cdots,n \tag{16}$$

Finally the project is evaluated according to the sequence of approximation degree.

RESULTS AND DISCUSSION

In order to verify the effectiveness of the improved D-S evidence theory, 80 100m sprint athletes are used to carry out training evaluation. And the 12 training plans used to be evaluated. And the evaluation indexes are applied table 1. The data analysis is carried out by MATLAB programmer.

The expression (8) and (9) is applied to make the fuzzy comment and the characteristic value having the one to one relationship, and the original mass function is obtained, which is shown in table 4.

Table 4 Original mass function

Evaluation level	(s_1,s_2,s_3,s_4)
1	(0.914, 0.086,0.000,0.000)
2	(0.450, 0.400,0.150,0.000)
3	(0.085, 0.675,0.240,0.000)
4	(0.000, 0.145,0.680,0.175)
5	(0.000, 0.000,0.450,0.550)
6	(0.085, 0.675,0.240,0.000)

Using the evaluation index “sport quality” as example, the weights of three evidences obtained from the experts are 0.47, 0.32, 0.21 respectively, and the corresponding validity degrees are 1, 0.83, and 0.52 respectively. Then the final mass function of three evidences is shown in table 5.

Table 5 Final mass function of evaluation index “sport quality”

evidence	m(s_1,s_2,s_3,s_4,ϕ)
evidence 1	(0.000, 0.160, 0.690, 0.150, 0.000)
evidence 2	(0.058, 0.550, 0.124, 0.000, 0.268)
evidence 3	(0.350, 0.350, 0.000, 0.000, 0.300)

The mass function of other evaluation indexes is obtained according to the same calculating process. And then comprehensive validity of evaluation index to characteristic value based on the combination of evidences, the calculating results are shown in table 6.

Table 6 Comprehensive validity of evaluation indexes for training of 100m sprint athletes

evidence	m(s_1,s_2,s_3,s_4,ϕ)
sport quality	(0.000, 0.285, 0.520, 0.195, 0.000)
physical function	(0.000, 0.735, 0.265, 0.000, 0.000)
speed of athlete	(0.085, 0.680, 0.155, 0.100, 0.000)
special training technique	(0.065, 0.715, 0.220, 0.000, 0.000)
strength of athlete	(0.000, 0.714, 0.228, 0.058, 0.000)

The comprehensive score of evaluation indexes are calculated according to expression (10), and the corresponding results are shown in the following matrix:

$$X = \{x_{ij}\}_{12\times5} = \begin{bmatrix} 2.043 & 2.391 & 2.584 & 2.771 & 2.473 \\ 2.015 & 2.418 & 1.784 & 1.792 & 2.026 \\ 1.943 & 2.094 & 2.055 & 1.736 & 2.118 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 2.773 & 2.861 & 3.028 & 2.893 & 2.651 \end{bmatrix}_{12\times5}$$

The weighting decision matrix is calculated according to the expression (11), and the results are shown in the following matrix:

$$D = \{d_{ij}\}_{12\times5} = \begin{bmatrix} 0.390 & 0.435 & 0.413 & 0.536 & 0.257 \\ 0.336 & 0.446 & 0.289 & 0.554 & 0.294 \\ 0.337 & 0.381 & 0.447 & 0.514 & 0.448 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 0.495 & 0.482 & 0.553 & 0.684 & 0.388 \end{bmatrix}_{12\times5}$$

Then the ideal project V^+ and negative ideal project V^- are calculated according to expression (13), and the corresponding calculating results are shown as follows:

$$V^+ = \{0.559,0.668,0.682,0.896,0.583\}$$

$$V^- = \{0.285,0.316,0.305,0.412,0.227\}$$

Finally the approximation degree is calculated according to the expression (14)-(16), and the results are shown in table 7.

Table 7 Approximation degree of training plans

training plan	approximation degree	ranking
1	0.665	5
2	0.824	2
3	0.606	6
4	0.985	1
5	0.382	12
6	0.775	3
7	0.516	8
8	0.713	4
9	0.416	10
10	0.559	7
11	0.389	11
12	0.448	9

According to approximation degree, the training plan 4 is best for improving the achievement of 100m sprint athletes, and training plan 4 can be applied in the following training of 100m sprint.

CONCLUSION

Training is an important for improving the sport level of 100m sprint athletes, it can make the technique, strength and speed of athlete develop completely, then the good achievement can be obtained. The improved D-S evidence model is applied in evaluate the training level of 100m sprint, it can process the uncertain information well, and obtain the correct evaluation results.

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