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Risk early warning safety model for sports events based on back propagation neural network machine learning

Haijun Zhang[a], Yuanle Li[b,*], Haili Zhang[c]

[a] Physical Education College, Hunan First Normal University, Changsha, China
[b] Physical Education Institute, Hunan University, Changsha, China
[c] Physical Education College, Hunan University of Arts and Science, Changsde, China

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ABSTRACT

In order to ensure the smooth progress of sports events and reduce the possibility of risk accidents, a risk early warning safety model of sports events based on BP neural network and fuzzy theory is established, which has great advantages. The establishment of the model is divided into five steps: (1) using BP neural network as the basic network structure to obtain the fuzzy data; (2) using fuzzy theory to form the eigenvalue matrix; (3) optimizing the evaluation of the early waiting warning data; (4) determining the model; (5) determining the comprehensive numerical value of sports events risk according to the weight and threshold range of the obtained fuzzy optimized BP neural network, alarm based on relevant indicators. In the empirical analysis, the appropriate sample data was selected, the BP neural network topology structure was construct, the simulation training was carried out, the training error results of the input neural network nodes were calculated. Bying comparing the output data of the neural network with the theoretical data it is found that this risk early warning safety model has certain validity and reliability, and can achieve better early warning effect.

1. Introduction

Sports events are an important part of the development of sports industry. Sports events have obvious advantages for urban development. Therefore, in recent years, many government departments and enterprises have actively invested in the preparation for sports events. Most cities hope to promote the city's economic development by holding sports events. However, the preparation and hosting for sports events is not an easy task. Sports events, especially large-scale or international events, have a long period of time, high cost, high requirements for external hardware facilities, there are many units and departments related to various interests. and a variety of comprehensive environmental impacts at home and abroad. Therefore, there are many unstable factors in the operation for sports events, which leads to huge risks in the holding for sports events (Li and Liu, 2016). To successfully hold a sports events, it is necessary to predict the unstable factors in advance so as to reduce the influence of relevant factors on the holding for sports events and the threat of uncertain factors. It is necessary to carry out scientific and effective risk early warning for sports events. Therefore, a risk early warning safety model for sports events is established in this paper based on back propagation neural network machine learning (BP neural network for short) according to the relevant literature of risk early warning for sports events and the index system of risk early warning for sports events, and an empirical study on the risk early-warning safety model is also made in the back part.

2. Methodology

2.1. Risk early warning index system

At present, most experts use one-time function smoothing method and multivariate Logic reasoning method to establish the risk early warning index system for sports events (Zhang and Wang, 2017). Although these methods are simple in calculation, easy to understand and implement, they obviously cannot meet the actual requirements for the Olympic level sports events, and have greater limitations. The limitations of the traditional risk early warning index system for sports events are as follows:

(1) For large-scale sports events such as the Olympic Games and the World Championships, there are many qualitative indicators in the

* Corresponding author at: Physical Education Institute, Hunan University, Address to No. 2 Lushan South Road, Yuelu District, Changsha City, Hunan Province, China.
E-mail address: zhhj1488@sina.com (Y. Li).

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Table 1
Risk Early warning Index System for sports events.

The first level index	The second level index	The third level index
Risk early warning index System for sports events	Natural environmental risk	Climatic conditions; geographical location; natural disasters
	Events management risk	Competition athlete quality; competition organization; competition management system; competition information release; competition emergency management measures; competition management requirements
	Social environmental risk	Political elements; economic development; humanistic conditions

risk early warning index system (Hong, 2014). The evaluation of the qualitative indicators is a non-linear and fuzzy one. The accuracy and objectivity of the qualitative indicators cannot be guaranteed by the traditional risk early warning index system, which reduces the reliability of risk early warning.

(2) The influencing factors for sports events are often changeable. The traditional risk early warning index system has a threshold range for influencing factors. It does not have certain timeliness and dynamics, lacks the self-adaptability of risk early warning index system, and can not adapt to contemporaneously complex and changeable sports events.

Therefore, this paper will dynamically and flexibly realizes the risk early warning for sports events based on BP neural network. The specific risk early warning index system for sports events is shown in Table 1.

The risk early warning index system of sports event should be based on scientific monitoring of sports event risk (Ren, 2015). BP neural network is widely used in monitoring and control management system because of its fuzziness. BP neural network can adopt parallel decentralized processing pattern to improve the accuracy of pattern recognition and enhance the logic robust fault tolerance rate. It is a prediction method with strong adaptability. It can overcome the limitations of traditional methods and deal with the complex index system of sports event risk early warning accurately (Hu et al., 2015).

2.2. Risk early warning safety model for sports events based on BP neural network

BP neural network model is a complex network system composed of a large number of simple processing units. BP network is a one-way multi-layer antecedent network with three or more layers of neural network, including input layer, hidden layer and output layer. If the number of nodes in the input layer is n and the number of nodes in the output layer is m, the network will be mapped from n-dimensional Euclidean space to m-dimensional Euclidean space. Because there is no coincidence between the same-layer nodes, the output of each layer node will only affect the output value of the next layer node, where each node represents a neuron, and its corresponding transfer function is usually of Sigmoid type. By adjusting the structure of BP network, the problem of non-linear classification can be realized, and any non-linear function can be approached with any accuracy. When the structure of BP neural network is determined, the input and output sample sets are used to train the network, that is, the threshold and weight of the neural network are learned and adjusted, so as to realize the mapping relationship between input and output given by the network.

risk early warning for sports events needs to set up a supervisory authority, which is responsible for data analysis of all sports events, dynamic monitoring of the whole process for sports events operation, obtaining warning signals of sports event risk, and then the events risk management personnel need to deal with the risk items urgently to ensure the smooth progress for sports events. The realization process of risk early warning safety model for sports event based on BP neural network is shown in Fig. 1.

Through the process of information search shown in Fig. 1, the construction of index system above, risk early warning, risk synthesis and alarming, the established goal of risk early warning can be well accomplished, and the possibility of risk incidents occurring in the operation for sports events can be reduced.

Therefore, the main advantages of using BP neural network to fuzzy risk early warning for sports events are summarized as follows:

(1) The original set is replaced by a fuzzy set. Because there are many sports events, management is difficult, there are greater complexity and multilateral, and there are many risk factors. Therefore, the use of fuzzy sets can manipulate sports events risk items, facilitate the quantification and identification of fuzzy information, ensure the objectivity of risk information, and make the early warning results more reasonable.

(2) The early warning function is dynamic and time-varying. BP neural network has strong self-adaptability. It can self-study and train according to the existing information and data. At the same time, it can revise the original data to ensure the accuracy of the data space, so as to cope with the complex and changeable external risk environment.

(3) Realize the transition from single early warning to combined early warning. The fuzzy function of BP neural network can improve the expression function of the neural network, make the fuzzy membership function automatically generated, optimize the decision process of the fuzzy function, and have greater operation space.

The key steps of risk early warning safety model for sports events based on BP neural network are as follows:

Step 1: With BP neural network as the basic network structure, the traditional risk early warning data for sports events are fed into the network for data learning and training. After training, the obtained early warning data are fed into BP neural network again to obtain the fuzzy data.

Step 2: Using the fuzzy theory, the relative membership function is calculated according to the fuzzy data. The eigenvalue matrix composed of m early warning indicators of n Waiting warning data is as formula (1):

$$\begin{bmatrix} X_{11}\ X_{12}\ \ldots\ \mathrm{X}_{1n} \\ X_{21}\ X_{21}\ \ldots\ \mathrm{X}_{2n} \\ \vdots\ \vdots\ \ddots\ \vdots \\ X_{\mathrm{m}1}\ X_{\mathrm{m}2}\ \cdots\ X_{mn} \end{bmatrix} = (\mathrm{X}_{\mathrm{ij}}) \tag{1}$$

Among them, X_{ij} for eigenvalue matrix of the early warning indicators "i" of Waiting warning data "j". i = 1, 2 …, m; j = 1, 2…, n.

By standardizing all the data in the matrix, the larger the eigenvalue, the greater the risk for sports events. Then, the larger eigenvalues are treated according to formula (2) and the smaller eigenvalues are treated according to formula (3).

$$r_{ij} = \frac{\mathrm{x_{ij}} - \min(\mathrm{x_{ij}})}{\max(\mathrm{x_{ij}}) - \min(\mathrm{x_{ij}})} (\mathrm{i} = 1, 2, \cdots, \mathrm{m}) \tag{2}$$

$$r_{ij} = \frac{\max(\mathrm{x_{ij}}) - \mathrm{x_{ij}}}{\max(\mathrm{x_{ij}}) - \min(\mathrm{x_{ij}})} (\mathrm{i} = 1, 2, \cdots, \mathrm{m}) \tag{3}$$

After the processing is completed, the formula (1) is normalized to obtain a relative membership matrix R, such as formula (4).

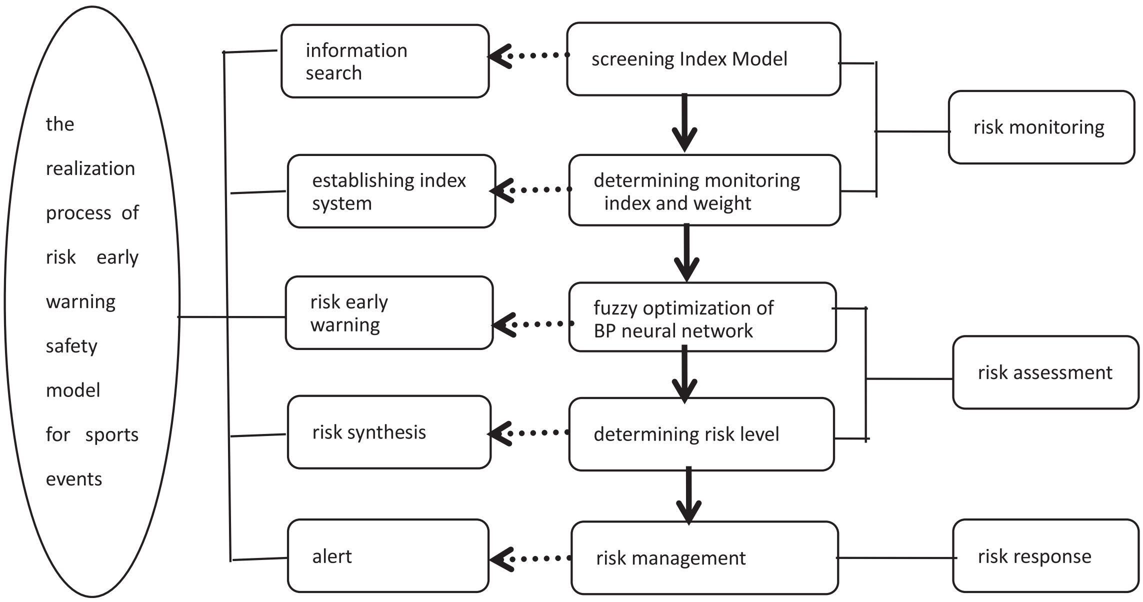

Fig. 1. The realization process of risk early warning model of sports events based on BP neural network.

$$R = \begin{bmatrix} r_{11} & r_{12} \cdots r_{1n} \\ r_{21} & r_{22} \cdots r_{2n} \\ \vdots & \vdots \ddots \vdots \\ r_{m1} & r_{m2} \cdots r_{mn} \end{bmatrix} \tag{4}$$

Among them, i = 1, 2..., m; j = 1, 2..., n. $0 < r_{ij} < 1$.

Step 3: Optimize the evaluation of "n" waiting warning data, set the maximum risk relative optimization vector for sports events as g:

$$g = \begin{pmatrix} g_1 \\ g_2 \\ \cdots \\ g_m \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \\ \cdots \\ 1 \end{pmatrix} \tag{5}$$

The minimum risk relative optimization vector is b:

$$b = \begin{pmatrix} b_1 \\ b_2 \\ \cdots \\ b_m \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ \cdots \\ 0 \end{pmatrix} \tag{6}$$

According to the theory of fuzzy optimization, formula (7) shows that the greater the value of u_j, the greater the risk of u_j.

$$u_j = \frac{1}{1 + \left\{ \frac{\sum_{i=1}^{m} [w_i (g_i - r_{ij})]^p}{[w_i (r_{ij} - b_i)^p]} \right\}^{\frac{2}{p}}} \tag{7}$$

Among them, p is the distance parameter, it is Hamming distance when p = 1, and it is Euclidean distance when p = 2.w_i is the weight value of the "i" index.

Step 4: Determine the risk early warning safety model for sports events based on BP neural network as shown in Fig. 2.

The relative optimization r_{ij} of all the indices of the fuzzy optimization are taken as the sample space of BP neural network. The sample learning space of three-layer BP neural network is constructed to collect all index data and loss function information that the risk of previous sports events occurs for learning and training. Let vector S_1 (1, 0, 0, 0) be normal output state, vector S_2 (0, 1, 0, 0) be low risk output state, vector S_3 (0, 0, 1, 0) be medium risk output state, and vector S_4 (0, 0, 0, 1) be high risk output state. When the actual output of BP neural network is close to the expected output, it can be considered that the training of input data is over, and the weight and threshold range of BP neural network with fuzzy optimization are obtained.

Step 5: the comprehensive numerical value for sports events risk is determined according to the obtained weights and thresholds of the fuzzy optimized BP neural network, and an alarm is given according to relevant numerical indicators.

3. Results and discussion

3.1. Sample data selection

In this paper, the sample data of risk early warning safety model for sports events based on BP neural network are obtained by questionnaire survey and other ways. 20 groups of sample evaluation data came from the summary of statistical questionnaire survey results, and 6 risk early warning indicators were set. 20 groups of risk early warning evaluation data were used as input values, and corresponding risk early warning index levels were used as output values. specific sample data are shown in Table 2.

The sample data in Table 2 are used to train the neural network, and the training times are gradually increased in order to reduce the evaluation error caused by the small number of samples(Yang and He, 2017). After the training of sample data, 8 groups of data are selected as the test data of risk early warning safety model for sports events, and the validity of the risk early warning safety model is tested.

3.2. Topological structure design of BP neural network

According to the risk early warning safety model for sports events shown in Fig. 2, the BP neural network topology structure is designed, which includes the input end, the implied end and the output end. In BP neural network, BP neural network with a single implied end can approximate any function without breakpoints. Therefore, for a simple BP neural network with only 3 layers of input, implied and output, it can be realized by using many-to-many mapping relationship (Chen and He, 2015).

For the input neural network, the number of risk early warning indicators is usually regarded as the number of ganglion points at the input end of the neural network. Therefore, according to Table 2, the number of ganglion points at the input end of this paper is 6.

The number of output neural nodes depends on the situation. Generally speaking, for a classification evaluation problem, the number of output neural nodes is mainly determined by the predictable network parameters of the neural network, but the number of output neural nodes is not less than the number of target objects to be evaluated. The

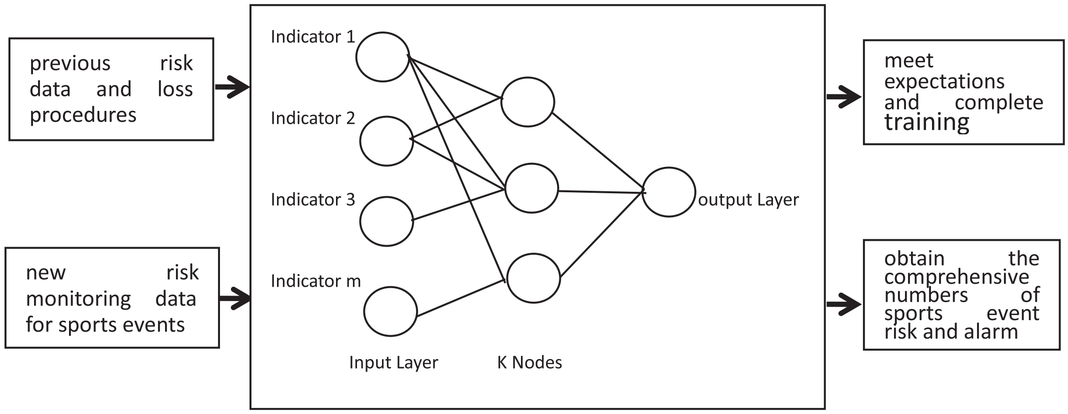

Fig. 2. The risk early warning safety model for sports events based on BP neural network.

Table 2
Sample data of risk early warning safety model of sports event.

Group number	11	12	13	14	15	16	Comprehensive risk assessment
1	4	2	24	4	5	3	Medium
2	4	1	4	2	2	3	High
3	1	4	2	3	2	1	Low
4	1	4	1	1	1	3	Low
5	3	2	5	1	2	3	High
6	4	2	5	2	1	3	Low
7	3	3	2	2	4	4	Medium
8	4	2	5	1	4	4	High
9	5	3	1	2	4	4	Medium
10	4	2	5	2	2	2	Low
11	5	1	4	1	2	2	Low
12	4	3	4	4	3	4	Medium
13	2	4	2	5	2	2	Low
14	2	1	5	1	3	2	High
15	1	5	1	4	1	2	Low
16	1	4	2	5	2	3	Low
17	2	5	1	5	4	1	Low
18	5	4	3	5	5	3	Medium
19	2	5	1	4	3	1	Low
20	2	5	1	4	2	2	Low

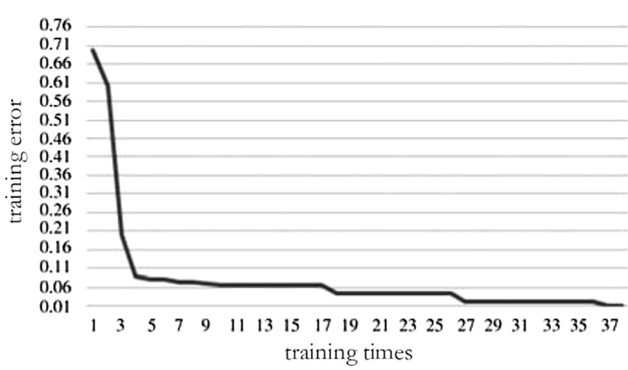

Fig. 3. Training error results of neural network node at input.

essence of the risk early warning safety model for sports events discussed in this paper is a problem of classification and evaluation. The comprehensive risk early warning evaluation results can be divided into 3 levels: high, medium and low. According to the number of output neural nodes, the number of three output neural nodes is designed. Its structure model is (high, medium and low). The results of risk comprehensive early warning evaluation for high, medium and low risk are mathematically expressed as follows: high (1 0 0), medium (0 1 0) and low (0 0 1). That is to say, if the result of risk comprehensive early warning evaluation is high, the "high" position in the output node

Table 3
Comparison of output data of neural network with theoretical data.

Test sample data number	Expected theoretical output result	Actual output result			Risk level
1	100	0.9834	0.0254	0.0000	High
2	001	0.0045	0.1476	1.0000	Low
3	001	0.0003	0.1647	0.9943	Low
4	001	0.0007	0.1558	0.9924	Low
5	001	0.0003	0.1845	0.9723	low
6	100	0.9813	0.0274	0.0000	High
7	010	0.0069	0.9723	0.1392	Medium
8	010	0.9837	0.1834	0.0002	High

number structure model is "1". Correspondingly, if the result of risk comprehensive early warning evaluation is medium or low, the "high" or "low" position in the output node number structure model are "1". Therefore, there is only one "1" in the number structure model of output nodes.

In addition, the design of the number of ganglion points at the implied end is more complex. The number of implied end and the number of implied end nodes directly determine the scale of BP neural network (Huo et al., 2014). In order to effectively control the scale of BP neural network, it is necessary to control the number of ganglion points in the implied end within a reasonable range. The excessive number of ganglion points at the implied end would enlarges the scale of the neural network, increases the training time of the network nodes, weakens the generalization ability of the network, and directly reduces the accuracy of the prediction results of the neural network. However, too few ganglion points at the implied end will reduce the scale of the neural network, resulting in inadequate model construction and inaccurate recognition of network classification patterns. Therefore, it is necessary to carefully select the number of ganglion points at the implied end, and select a relatively compact topological structure of the implied end ganglion points to minimize the number of the implied end ganglion points under a certain scale of the neural network (Shi and Huo, 2017). The formula for setting the number of ganglion points at the implied end is shown in formula (8):

$$n_1 = \sqrt{n + m + t} \tag{8}$$

Among them, m is the number of nerve nodes at the output end, n is the number at the input end, and t is a constant ranging from1 to 10.

3.3. BP neural network simulation training

The simulation training of risk early warning safety model for sports events based on BP neural network adopts Matlab software(Shi, 2016). The simulation test toolbox of BP neural network is included in the Matlab software. There are corresponding predictors and constructed

Table 4
disposal schemes of risk early warning for sports events.

Risk categories	Risk level		
	Low	Medium	High
Natural environmental risk	Risk acceptance, risk monitoring	Risk transfer, risk avoidance	Risk avoidance, risk transfer
Event management risk	Risk acceptance, risk monitoring	Risk mitigation	Risk transfer, risk avoidance
Social environmental risk	Risk acceptance, risk monitoring	Risk mitigation, risk transfer	Risk transfer, risk avoidance

function in the toolbox. The BP neural network sample data are trained by constructing predictors and function(Zhang et al., 2013). Since the output result vector element is 0–1 variable, the constructing function of the output neural nodes can choose logarithmic function. The number constructor of the implied end ganglion points is tangent function. The training function of the input node of the neural network is TRAINLM, and the training times are 2000. The training error is not higher than 0.01. After many training, the number of ganglion points at the input end is 7, and the training error meets the set requirements. The training error results of the input neural network nodes are shown in Fig. 3.

3.4. Simulation results analysis

8 groups of risk prediction test sample data for sports events were trained by neural network. After several training it meets the training error requirements, they were brought into the input end of BP neural network model. The output data of the neural network were calculated and compared with the theoretical data. The results are shown in Table 3.

By comparing the actual output results with the theoretical output data, the validity of the actual output risk early warning results is tested with the theoretical data results of (1, 0, 0), (0, 1, 0) and (0, 0, 1) totally three categories of data. The actual risk categories are classified according to 3 groups of actual output data according to the classification model. For example, for the test sample data numbered 1, the actual output results of the 3 groups are 0.9834, 0.0254 and 0.0000 respectively, which are more in line with the (1, 0, 0) classification model. According to the classification rules formulated above, the risk category of the sample is set to be high. The risk categories of other test sample data are determined according to this method.

Bying verify the robustness of the risk early warning index system for sports events proposed in Table 1, the risk treatment schemes of natural environmental risk, events management risk and social environmental risk under different risk levels are summarized. The results are shown in Table 4.

The occurrence and development of risks in the course of the event are not fixed, so we should monitor the risk situation in real time. For the medium-risk situation, the common risk coping strategies are risk mitigation and risk transfer. Of course, event managers can also take other measures such as risk avoidance according to the actual situation of the event; according to the high-risk situation in the event, event managers can use the pre-prepared program measures to transfer the risk. If the risk occurs in a high probability and the event manager is unable to cope with and bear the consequences of its occurrence, the termination of the game can be considered.

The validity of risk early warning safety model for sports events based on BP neural network proposed in Fig. 2 is verified. In the simulation process of BP neural network, only 1 group of 8 test samples shown in Table 3 is false prediction. The error rate of risk early warning safety model based on BP neural network is 12.5%, and the accurate prediction rate of samples is 87.5%. Therefore, the risk early warning safety model for sports events based on BP neural network has certain validity and reliability.

3.5. Coping strategies after risk early warning of sports events

The coping strategies after risk early warning of sports events should meet the actual requirements of sports events. Generally, the following aspects should be done well: (1) By consulting literature, consulting experts and on-site investigation, the main risks of sports events should be identified as comprehensively and accurately as possible; (2) the main risks identified should be effectively assessed; (3) the risk warning level should be reasonably classified and clearly expressed through different ways. (4) Mobilizing the enthusiasm of the whole team, risk response needs the participation of all members. According to the results of the above risk early warning, different measures should be taken to deal with the social environmental risk, event management risk and natural environmental risk in large-scale sports events.

4. Conclusion

The risk early warning of sports events is some ways to warn and deal with all kinds of risk accidents that may occur in the process of sports events. There are many unstable factors in the operation of large-scale or international sports competitions, which cause great risks in holding sports competitions. To successfully hold a sports event, it is necessary to predict the unstable factors in advance so as to reduce the influence of relevant factors on the holding of sports events and the threat of uncertain factors. Therefore, it is necessary to carry out scientific and effective risk early warning for sports events. Based on BP neural network, the risk early warning safety model of sports events solves the limitation of traditional risk early warning. In the empirical analysis, the appropriate sample data are selected, and the BP neural network topology structure including the input end, the hidden end and the output end is constructed. The BP neural network simulation training is carried out, and the training error results of neural network nodes of input end are calculated. By comparing the output data of the neural network with the theoretical data, it is found that the risk early warning safety model of sports events based on BP neural network proposed in this paper has certain validity and reliability, and can achieve better early warning effect.

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