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Retraction

Retracted: Training Fatigue and Recovery of Throwing Athletes Based on the Comprehensive Environmental Test of the Field

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] K. Peng, "Training Fatigue and Recovery of Throwing Athletes Based on the Comprehensive Environmental Test of the Field," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 7993666, 10 pages, 2022.

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Research Article

Training Fatigue and Recovery of Throwing Athletes Based on the Comprehensive Environmental Test of the Field

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Exercise-induced fatigue is a common phenomenon during exercise, and its mechanisms mainly include peripheral and central mechanisms. This article discusses the causes of the throwing athletes' fatigue and the effective recovery methods used, in order to have a certain reference value for making throwing training plans more scientifically and rationally and participating in competitions. Central fatigue will seriously affect the athletic state of athletes, and environmental factors are one of the important factors affecting the central fatigue of athletes. Because the influence of central fatigue and environmental factors on throwing athletes is more prominent, the correlation between environmental factors and central fatigue in throwing sports is studied, and a general prediction model and grouping prediction model of athletes' central fatigue under various environmental factors are established based on ANN. Experiments show that the established general prediction model of central fatigue of throwing athletes has good performance, and the correlation coefficient between the prediction results and the actual measured value is 0.68; for different groups of athletes, the established prediction model of central fatigue of throwing athletes has better performance. The prediction accuracy is high, and the correlation coefficient between the prediction result and the actual measurement value is higher than 0.70.

1. Introduction

In the context of the continuous development of science and technology, countries have improved their competitiveness in throwing events through naturalization policies and hiring elite coaches. Among them, veteran throwing powers such as the United States and Poland still win gold steadily [1]. At the same time, Croatia, Cuba, and other countries have also cultivated strong young throwing athletes [2]. Throwing events include shot put, discus, javelin, and hammer. So far, track and field has been known as the theme of the modern Olympic Games. It is the event with the most gold medals in the Olympic Games, with a total of 46 gold medals, of which throwing events account for 8. China has a glorious history in the men's and women's javelin and women's shot put events. In the 24th, 25th, 26th, and 28th Olympic Games, China won a total of two silver, two bronze, and four Olympic medals. Throwing, as an advantageous event in my country's track and field, is more necessary to strengthen relevant research and achieve breakthroughs in historical achievements on the basis of consolidating advantages [3]. This article compares and analyzes the development trend of throwing athletes' performance between international and domestic throwing athletes and provides relevant references for related research and scientific formulation of athletes' training and preparation plans [4].

The recovery quality of the body after exercise is the key to whether the functional level is improved and whether the training can continue. The training effect is also obtained in the recovery period. The training process consumes a lot, and the fatigue of the body, including the nervous system, will be deeper, which requires us to train in a good physical state. Only when the body is in good condition can we get the "benign fatigue" we need. People have realized that after the athlete training, if effective and reasonable recovery methods can be adopted in time, the training performance will be further improved, and the incidence of athlete injuries can also be avoided [5]. Therefore, experienced coaches pay special attention to the recovery of athletes after training. So how to improve the sports performance of throwing athletes and cultivate reserve talents for the country is an important issue we are currently facing [6]. In addition to the correct training methods and means to improve sports performance, it is also necessary to pay attention to the recovery of fatigue after training [7]. Through more than ten years of practice and investigation, and on the basis of consulting relevant literature, the author studies and summarizes the causes and recovery methods of fatigue after training for juvenile throwers [8].

Exercise-induced fatigue is a common phenomenon during exercise, and its mechanisms mainly include peripheral and central mechanisms [9]. Central fatigue is a protective inhibition of the central nervous system; the purpose is to prevent excessive functional failure of the body [10]. It is known that central fatigue can be affected by many factors and there are significant individual differences, and the environment is one of the main factors [11]. Studies have found that ambient temperature has a significant effect on the occurrence of central fatigue in athletes, and a variety of neurotransmitters that can clearly lead to central fatigue, such as serotonin, dopamine, and norepinephrine, are all related to thermoregulation and control [12]. Some scholars believe that exercise-mediated body temperature increase is related to central fatigue, and the thermal storage of overheated brain may be the basic factor of central fatigue [13]. Although there is no relevant research on the effect of other environmental factors on central fatigue except for ambient temperature, some studies have shown that ambient sound can significantly affect the psychological fatigue of individuals in the environment, causing symptoms such as tension, anxiety, and irritability and causing individual discomfort, and other environmental factors, such as temperature, humidity, and illumination, can work in concert with ambient sound.

2. State of the Art

2.1. Causes of Fatigue. The decline of muscle movement ability is the basic sign and essential characteristic of exercise-induced fatigue. Since this century, researchers have conducted a large number of studies on exercise-induced fatigue from different perspectives and proposed that the negative effect of exercise-induced stress metabolism may be the root cause of exercise-induced fatigue, such as the depletion of metabolic matrix, the accumulation of metabolites, and the acidification of metabolic environment. They may cause changes in the structural integrity of muscle fibers, energy supply, neurohumoral regulation, etc., through a variety of channels, leading to motor muscle contraction and relaxation dysfunction. Therefore, the decline of exercise ability, that is, fatigue, is the inevitable result. As we all know, the generation of fatigue is a complex process [14]. The motor function is dominated by the motor center. The higher the excitability of the motor center, the more agile its response, and thus, the higher the motor function level [15]. Every action of people in sports is made by the corresponding muscles, and the work of muscles is directed by the movement center [16]. When a certain part of the human body feels slow movement and heavy weight after a certain load, it is the inhibitory reflection of the fatigue of the motor central nervous system [17]. When an athlete is fatigued, it is generally manifested as slow reflection, inattention, and muscle movement perception, and accurate sense of rhythm, speed, distance, and spatial orientation is weakened [18]. At this time, the concept of various actions has certain difficulty and fuzziness, and exhaustion is the expression of its accuracy [19]. The generation of fatigue can be roughly divided into three types: one is physical fatigue; the other is pathological fatigue; and the third is psychological fatigue [20–22].

(1) Physical fatigue is caused by overworked muscles, causing carbon dioxide and lactic acid to accumulate in the blood, slowly weakening the body's strength. This is due to the large amount of exercise and exercise intensity load during training. For example, in the initial stage, some athletes just came in and suddenly participated in systematic training, and the various functional levels of the body are still at the original stage, and it is difficult to suddenly improve. However, because they have not mastered the amount of exercise and load intensity, the training volume is large and the time is very long, and they have not made necessary adjustments after training for a period of time. At this time, the athletes began to have bad reactions, but they still insisted on the original plan training. Therefore, the energy has been consumed, resulting in physical fatigue

(2) Pathological fatigue is the result of pathological changes due to physiological dysfunction. It is manifested in illness, injections, medication, and even surgery. Diseases that easily lead to fatigue include diabetes, thyroid dysfunction, liver and kidney function damage, and cardiac function decline. It is necessary to clarify the causes and treat these diseases. In life, we should pay attention to the combination of work and rest. Exercise moderately and improve physical fitness, and you can also take some traditional Chinese medicine as appropriate

(3) Psychological fatigue is mainly caused by mental state and emotion. Junior shot put players are usually busy with cultural lessons and training, so although they feel very fulfilled in life, they are also under a lot of pressure. In many years of practice, there is a thrower like this. He always trains in his spare time every day and works very hard. Because he really wants to get good results in the provincial youth competition, he does his best to complete the training task with good quality and quantity in every training class, regardless of his physical condition. He does not ask for leave when he is injured or sick. Due to psychological factors, it did not achieve good results. It can be seen that psychological fatigue also has a great impact on training and competition

2.2. Classification of Fatigue

2.2.1. Mild Fatigue. It usually occurs after muscle work, or even after training with low volume and intensity, and manifests in the form of fatigue. This type of fatigue generally does not reduce training capacity.

2.2.2. Acute Fatigue. It is a characteristic that occurs when one-time extreme physical load occurs. Frailty appears on the surface, with a marked decrease in training ability and muscle strength. When performing functional tests, the response of the cardiovascular system is abnormal. This type of fatigue tends to occur in poorly trained athletes. The clinical manifestations of acute fatigue are pallor and tachycardia.

2.2.3. Excessive Tension. An acute state that occurs after a one-time extreme training or competition load on the basis of poor physical function. This state is more common in elite athletes who have strong willpower and can carry out heavy-duty training on the basis of fatigue. The clinical manifestations are general weakness, dizziness, sometimes fainting, dyskinesia, palpitations, liver pain, etc.; the cardiovascular system does not respond normally to the load. This type of fatigue can last from days to weeks and needs attention.

2.2.4. Overtraining. This is a state that occurs when the athlete's training and rest structure is unreasonable. The main reason is that the long-term overload is too large and the training methods and methods are monotonous. It is characterized by marked neuropsychological changes, decreased athletic performance, disorganized cardiovascular activity, and decreased body resistance to infection.

2.2.5. Excessive Fatigue. This is a physical pathological state often manifested in neurological diseases. Usually, the nervous system is unstable, and emotionally sensitive athletes are prone to this state when the training load is heavy. The clinical manifestations are more than excessive fatigue. The training is obvious, the athlete's mood is cold, the sports performance is not interested, and the digestive function is impaired.

2.3. Methods and Means of Fatigue Recovery. Fatigue in sports training is normal. Without fatigue, there will be no recovery and improvement of athletic ability; without intense training, it is impossible to have excessive recovery; without fatigue recovery, it is impossible to improve the level of sports training. This is dialectical. Only by scientifically and objectively judging the appearance and degree of fatigue and using effective methods to recover athletes can further improve their sports performance.

The factors that affect the speed of recovery should be understood. (1) Age: athletes of different ages have different recovery times after training with the same load. (2) Degree of training: the improvement of athletic ability and training performance is essentially a balance between various factors and new levels on the basis of scientific training, which is manifested as adaptation. Athletes with higher training levels have less response to the stimulation brought about by training, adapt faster, and thus recover faster. (3) Gender: the recovery speed of female athletes is slower than that of male athletes, and this difference is determined by the unique physiological characteristics of women themselves.

2.4. The Following Methods Can Be Used for Physical Fatigue. First, get enough sleep. Teenagers are busy studying every day and want to get good grades, and they are physically exhausted. Therefore, they should strictly abide by the work and rest time system and improve the quality of sleep. Some data show that a person's sleep time of about 10 o'clock every night to 2 o'clock in the morning is the best time to restore physical strength. Sleep is a static rest. After a large amount of exercise and a high-intensity load, it is impossible to restore the functions of various organs without sufficient sleep. Therefore, we must ensure the quality of sleep.

Second, use active rest and try to use active finishing activities at the end of each training session. The so-called active rest refers to other activities during rest, also known as active rest. After local muscle fatigue, you can use another muscle without fatigue to carry out some appropriate activities, so as to promote the whole-body metabolic process and accelerate the recovery of fatigue. When the whole body is tired, you can also speed up the elimination of muscle metabolism through some light and high interest physical activities. For example, I personally experienced when I was an athlete. After a large amount of exercise, the coach asked me to jog on the venue to relax and press my legs, but I was lazy and tired, so I did not follow the teacher's request. In the next training, I feel leg muscle soreness, while other teammates are less so. In this training, I followed the teacher's arrangement and used active rest, which made me feel much better than the last training session. Therefore, the use of active rest is very helpful for physical recovery.

Third, take a bath. This method is a simple and easy way to eliminate fatigue. If the water temperature is suitable, it can speed up the body's metabolism and regulate the body to make it excited. Some people abroad have tested that after a day of training, athletes have an average of 30 mg of lactic acid per 100 mg of blood before bathing. At the same time, athletes who soaked in warm water at 43 degrees for 5 minutes have little change in the concentration of lactic acid. After 10 minutes of washing, the lactic acid in the blood drops to 7-8 mg; after 30-60 minutes of soaking, the lactic acid in the blood returns to the level before fatigue. Of course, each person's ability to adapt to water temperature is different, and appropriate control should be carried out according to their own specific circumstances.

Fourth is nutrition. Nutrition is one of the important factors for athletes to create performance. Therefore, nutritional factors should be scientifically used to supplement the substances consumed by training, repair the nutritional structure in the body, help eliminate the fatigue of the body, and promote the improvement of sports performance. The throwing events we are engaged in have high requirements on muscle mass and need to increase the supply of protein, preferably high-quality protein, so as to improve athletic performance more effectively.

2.5. Recovery Methods for Pathological Fatigue. Young athletes are still in the growth stage, and they receive this kind of quasiprofessional training after entering the school. Sometimes they are easily injured or strained due to excessive intensity of the activities; there are also colds caused by the unsuitable climate, which can lead to muscle strains, etc. In response to these phenomena, acupuncture, massage, and other means should be used for treatment. After a large amount of exercise, you can perform self-massage or massage between athletes, depending on the fatigue. The whole-body massage generally first press the thigh, then press the calf, and then massage the buttocks, lower back, upper limbs, and other parts in turn. This is because massage can improve the function of the nervous system, improve functions such as breathing and circulation and material metabolism, increase muscle tissue nutrition, promote metabolism, relieve muscle tension after load, strengthen local blood supply, and improve nerves, muscles, and the activity of the organs, thereby accelerating the elimination of fatigue.

2.6. Recovery Methods for Psychological Fatigue. Psychological fatigue has no certain early warning. It is unconsciously hidden around people but accumulated a little. When the accumulation reaches a certain time and a certain amount of “fatigue,” it will cause disease, so it is often easy to be ignored by people. To eliminate psychological fatigue, music therapy can be taken to reduce irritability. This is because the nerve consumption is greater than the physical consumption during training. In the long run, the energy will be unconcentrated, resulting in emotional irritability, which will have a certain impact on sports performance. Especially the throwing project, because of its technical complexity, mental and physical strength is indispensable. At this time, music therapy is used to relax the tension as much as possible, so that the fatigue of the central nervous system can be relieved, and it has a good effect of sedation and memory enhancement. The author suggests that our coaches should strengthen the training of athletes’ psychological quality in their usual training.

3. Methodology

The mainstream prediction methods are divided into artificial intelligence-based prediction methods and statistics-based algorithms. The former includes support vector machines, Bayesian networks, and artificial neural networks (ANN) and the latter such as sequential logistic regression models. Different from previous theoretical derivation formulas, ANN can summarize the relationship between research objects and influencing factors by analyzing and learning a large number of existing evaluation data and predict unknown results from these “relationships.” In the development of more than 60 years, constantly improving and adding a variety of algorithms, it is widely used for identification and prediction in many fields such as industry, medicine, and commerce. Many prediction models established by this technology have an accuracy rate of more than 70%. According to the different learning strategies and connection modes of the interconnection mode, ANN is divided into various types, and the BP (back propogation) neural network has the advantages of strong universality and clear operation process compared with other neural networks and is especially suitable for solving complex internal mechanisms.

3.1. LSTM Neural Network. Short- and long-term memory neural network (LSTM) is a special kind of recurrent neural network (RNN). During the training of the original RNN, with the extension of the training time and the increase of the number of network layers, it is easy to have the problem of gradient explosion or gradient disappearance, resulting in the inability to process a long sequence of data and thus unable to obtain the information of long-distance data. In order to solve this problem, its improved scheme, namely, LSTM neural network, is proposed. LSTM is a temporal recurrent neural network, which is a special type of recurrent neural network (RNN). After long-term research, LSTM has been proven to effectively alleviate this series of problems when inputting long-term sequences. Figure 1 shows the LSTM neural network structure diagram.

The specific structure diagram is as follows:

$$\begin{aligned} i_t &= \sigma\left(W_t[h_{t-1}, x_t]^T + b_i\right), \\ f_t &= \sigma\left(W_t[h_{t-1}, x_t]^T + b_f\right), \\ o_t &= \sigma\left(W_o[h_{t-1}, x_t]^T + b_o\right), \\ c_t' &= \tan h(W_c[h_{t-1}, x_t] + b_c), \\ c_t &= f_t \cdot c_{t-1} + i_t \cdot c_t', \\ h_t &= o_t \cdot \tan h(c_t). \end{aligned} \tag{1}$$

There are mainly three stages in LSTM: forgetting, selecting memory, and outputting. The forgetting stage is to selectively forget the state passed in from the previous node $ct-1$, “forget the unimportant, remember the important”; this work is completed by forgetting gate ft; the selection stage is mainly to selectively memorize the input xt in the current state, and this stage of work is completed by the input gate it; in the output stage, this stage will decide which will be regarded as the current state. In the output of the state, this stage is completed by the output gate ot.

$$P\left(A_i, B_j\right) = \begin{cases} 1, A_i = B_j, \\ 0, A_i \neq B_j. \end{cases} \tag{2}$$

The main activation functions used in the LSTM neural network are Sigmoid and Tanh.

The activation function is introduced in detail:

The specific mathematical form of the sigmoid function is:

$$f(z) = \frac{1}{1 + e^{-z}}. \tag{3}$$

Among them, z represents the original value processed by the activation function, and the value covers the entire real number field; $f(z)$ represents the output value after the activation function, and the range will be between 0 and 1.

The main function of the sigmoid activation function is to transform the continuous real value of the input between 0 and 1. If there is a positive or negative number with a very large absolute value, the output will be converted to 1 or 0, respectively. It is used so far. The most extensive type of activation function can be expressed as a certain probability or normalized data. The specific mathematical form of the Tanh function:

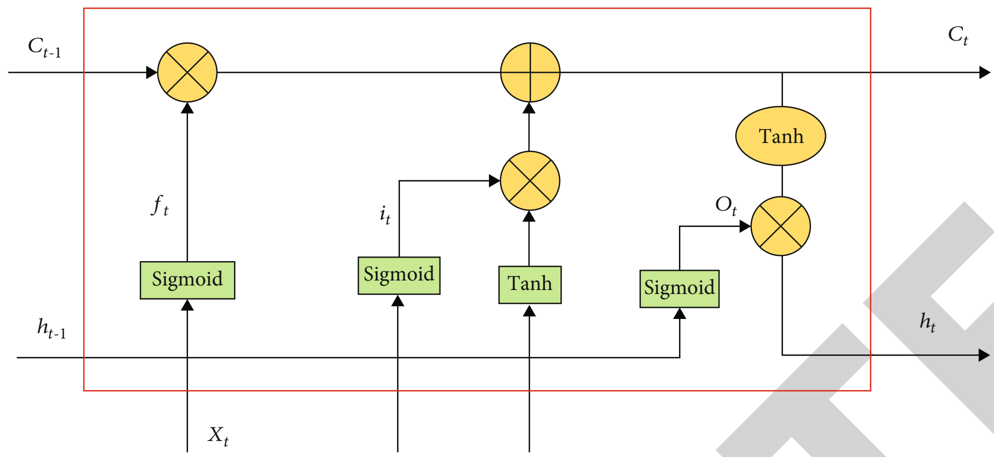

Figure 1: LSTM neural network structure diagram.

$$\tan h(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}}. \quad (4)$$

Among them, x represents the original sample processed by the activation function, and the value covers the entire real number field; $\tan h(x)$ represents the output value after the activation function, and the range will be between -1 and 1.

The number of neurons in each layer of the neural network, that is, the number of data variables processed by each layer, in practical problems, and the number of neurons in the input layer and the output layer, can be determined in advance. The number cannot be directly determined and generally needs to be determined according to the empirical formula combined with the step-by-step trial and error method. The specific empirical formula is as follows:

$$q = \sqrt{a+b} + c. \quad (5)$$

The mean square error (MSE) loss function is the most widely used loss function at present, and the specific mathematical form is as follows:

$$MSE = \frac{1}{N}\sum_{i=1}^{N}\left(y_i - \hat{y}_i\right)^2. \quad (6)$$

3.2. BP Neural Network Algorithm. A common neural network consists of an input layer, an output layer, and several hidden layers. Its activation function is

$$y = f\left(\sum_{i=1}^{N} w_i x_i - \theta\right). \quad (7)$$

Yi is the output of the ith neuron.

In actual operation, the number of nodes in the input layer is the number of input neurons; the number of nodes in the output layer is based on the analysis situation. If it is a classification problem, the number of nodes is equal to the number of classifications. If it is a regression problem, the number of nodes is generally 1. If the number of hidden layers and the number of nodes in the hidden layer are too large, the model will be overly flattered by the training set, and overfitting will easily occur. Academia has not yet accurately determined the number of hidden layer nodes, and the specific number of hidden layer nodes can be determined with reference to empirical formulas.

$$\begin{aligned} l &< n, \\ l &< \sqrt{n+k} + i, \\ l &= 2\sqrt{n}. \end{aligned} \quad (8)$$

l is the number of nodes in the hidden layer; n is the number of nodes in the input layer; k is the number of nodes in the output layer; i is an arbitrary constant between 0 and 9.

4. Result Analysis and Discussion

4.1. Experimental Data and Environment. The prediction accuracy of an ANN model is related to several factors, including the preprocessing of the input data, the number of hidden layers, the number of hidden nodes in each layer, the preset of weights, the number of network training, the structure of the hidden layer, and the excitation function. In the process of constructing the ANN model in this paper, we comprehensively consider the above-mentioned various influencing factors in order to construct an ANN model with the best prediction accuracy.

In the process of ANN model design, the first thing to consider is the structural complexity of the model, because the computing power of ANN is closely related to its structural complexity. The more complex the ANN model, the stronger the computing power and the higher the prediction accuracy. However, the complex model structure requires a large amount of training sample data to match with it; otherwise, overfitting will easily occur, which will not only increase the prediction accuracy of the model but will reduce the prediction accuracy. The research has found that in the BP neural network, when the number of hidden layers is 1 or 2 layers, various existing classification problems can be solved. Consider the limited sample data collected in this study, in order to avoid the phenomenon of overfitting. In this paper, the classic three-layer ANN model is used, that is, an input layer, a hidden layer, and an output layer. The input layer, hidden layer, and output layer are fully linked. In addition, the structural complexity of the ANN model also involves the number of hidden layer nodes. Considering that the dimension of the input variable in this paper is between 12 and 15, in order to avoid overfitting caused by too many hidden layer nodes, the number of hidden layer nodes in this paper is designed to dynamically change from 5 to 35. For the rest, according to different calculation goals, the number of input layer nodes will be consistent with the attribute dimension of the input data. The number of output layer nodes will be consistent with the attribute dimension of the output data. Considering the obvious nonlinear relationship between the environmental variables studied in this paper, the subjective feeling variables of athletes and the central fatigue, in the design of the ANN model in this paper, and the excitation function of our hidden layer and output layer nodes adopts the S-shaped Sigmoid function.

In the process of ANN model training, the ANN model is trained by two methods of fixed number of iterations and cross-validation, and the model parameters with the best prediction accuracy are selected as the final prediction model. According to the amount of existing data, we set the training times of the network to be between 100 and 3000 times during the training process with a fixed number of iterations. The dataset is divided into training set and test set, in which 80% of the data is used for training and 20% of the data is used for testing. In the training process of the cross-validation method, we set 5-fold cross-validation. The dataset is divided into three groups: training set, validation set, and test set, of which 72% of the data is used for training, 18% of the data is used for validation, and 10% of the data is used for testing. In addition, in order to make the prediction model more optimized, in the model training stage, we compare the prediction results calculated by the model with the actual evaluation results of the athletes' central fatigue, and consider two optimization measures, the root mean square error and the correlation coefficient.

According to the above design principles, we implemented the ANN model designed in this paper under MATLAB. First, the number of iterations of network training is fixed, and different numbers of hidden layer nodes are tried to find the optimal value.

4.2. Experimental Results and Analysis. Figures 2 and 3 show the changes of the root mean square error and the correlation coefficient of the model output when the number of iterations is 1000 and the number of nodes in the hidden layer is different. In this set of experiments, we examine the output results on two different datasets, the training set and the validation set, respectively. As can be seen from Figure 2, when the number of hidden layer nodes varies from 5 to 35, the root mean square error of the model output generally decreases with the increase of the number of nodes, indicating that the increase of the number of hidden layer nodes increases the computing power of the model, so that the prediction error can be continuously reduced. However, it can also be seen from the figure that when the number of hidden layer nodes increases to a certain level, the prediction error on the training set no longer decreases but remains basically unchanged, while the prediction error on the validation set does not decrease, but there was a slight rise. This is because in the case of limited training data, a certain amount of hidden layer nodes can fit the given training data well.

When the number of nodes reaches an optimal value and then continues to increase, overfitting will occur, which is more clearly seen from the output results of the validation set data. Figure 3 shows the model test results when the correlation coefficient is used as the optimization metric, from which we can see similar results; that is, with the increase of the number of hidden layer nodes, the model computing power is enhanced, and the fitting results become better. That is, when the number of hidden nodes increases from 5 to 25, the correlation coefficient of the test group increases from 0.54 to 0.69; when the number of nodes reaches the optimal value, if the number of nodes continues to increase, the fitting result will become worse. That is, when the number of hidden nodes continues to increase from 25 to 35, the correlation coefficient of the test group decreases from 0.64 to 0.60. Through this set of experiments, it can be determined that under the existing dataset, the optimal number of hidden layer nodes is 25.

The number of iterations is another important parameter that affects the prediction accuracy of the BP artificial neural network model. Increasing the number of iterations of network training can reduce the training error of the network, but too many iterations can also cause overfitting. In order to determine the influence of the appropriate number of iterations on the prediction effect of the network, this group of experiments studied the training iterations 100 times, 200 times, 300 times, 400 times, 500 times, and 600 times, respectively, under the condition that the number of nodes in the fixed hidden layer remained unchanged. 700 times, 800 times, 900 times, 1000 times, 2000 times and 3000 times, root mean square error and correlation coefficient of ANN model output on training set and validation set under different training times.

It can be seen from Figure 4 that on the training set, the root mean square error of the model output continues to decrease as the number of iterations increases. However, on the validation set, the output error of the model first decreases with the increase of the number of iterations, and when it reaches a minimum value, it increases with the increase of the number of iterations, indicating that too many iterations will also lead to the model's failure. This is more clearly seen in Figure 5. In Figure 5, the correlation coefficient of the test group is the lowest when the number of the training is 100, which is only 0.39. With the increase of the number of training, the correlation coefficient of the test group gradually improves and reaches 0.67-0.67 when the number of training increases to 400-800, a good level of 0.69. However, when the training times continued to increase from 900 to 3000, the correlation coefficient of the test group no longer increased but gradually decreased from 0.67 to 0.58. This is because the number of iterations of the network is too large, which leads to the "overfitting" of the network, which reduces its generalization ability; that is, the network changes from "flexible understanding" to "simple memory," which reduces the accuracy of

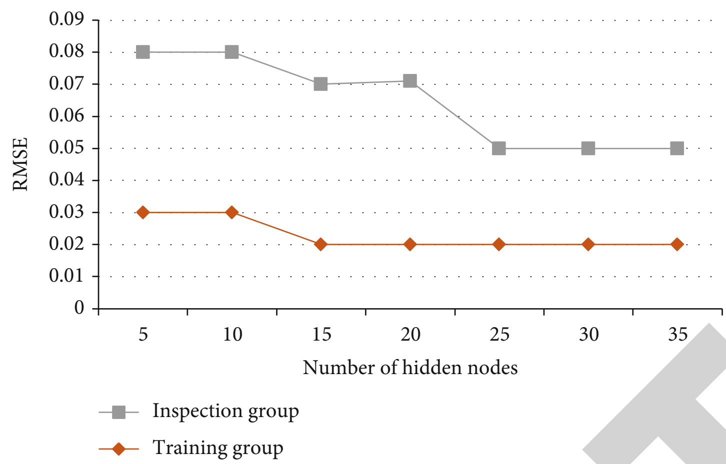

Figure 2: Errors of training and testing groups in the 3-layer ANN model.

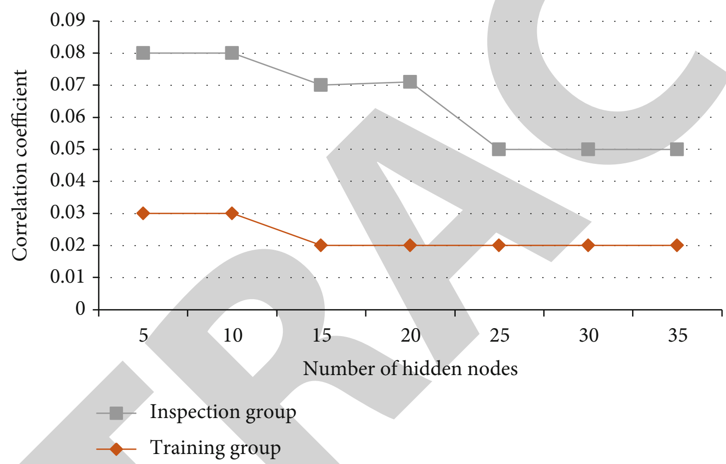

Figure 3: Correlation coefficients of training and test groups in the 3-layer ANN model.

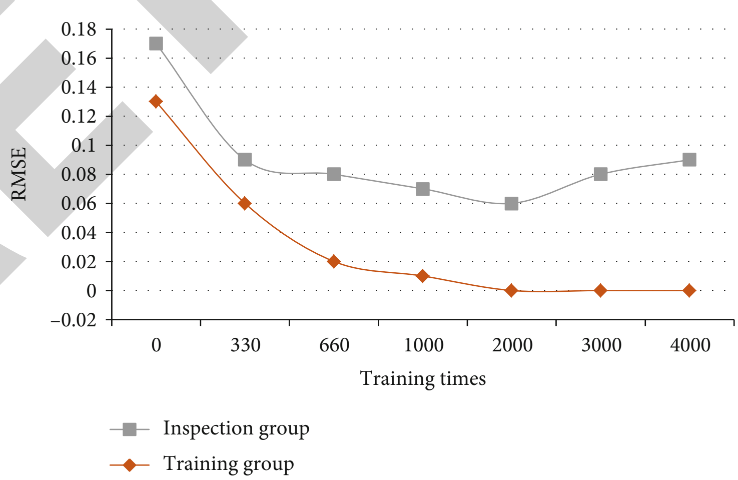

Figure 4: Errors of training and testing groups in the ANN model under different training times.

prediction. Through this set of experiments, we selected 800 iterations as the optimal training times for the ANN model for model building.

Due to the large number of parameters of the ANN model, its optimization function is a complex hypersurface with many local minima. Therefore, the solution process of ANN cannot guarantee to obtain the optimal solution of the model but is likely to fall into a certain optimal solution. In order to find a local suboptimal solution that better approximates the global optimal solution, many methods have been tried. One type of

Figure 5: Correlation coefficients of training and test groups in the ANN model under different training times.

Figure 6: Errors of training and testing groups in the ANN model under different training functions.

approach is to use different ways of model training. But all of these model training methods are "application dependent." For different application data, different model training methods will show different performance. For this problem, MATLAB's neural network toolbox provides a variety of functions to achieve different model training. In the specific construction process of the ANN model in this paper, we examine three classic MATLAB training functions, namely, the Levenberg-Marquardt training function (TRAINLM), the one-step tangent training function (TRAINOSS), and the Powell-Beale connection gradient training function (TRAINCGB). Figures 6 and 7 show the experimental results of using these three training functions, respectively, when the number of nodes in the fixed hidden layer is 25 and the number of training iterations is 800.

It can be seen from Figures 6 and 7 that, whether in the training set or the validation set, when the training function TRAINCGB is selected, the prediction error of the model is the smallest, while the prediction error of the model is the largest when the training function TRAINM is selected. As can be seen from Figure 6, using the TRAINCGB training function, the correlation coefficient of the output result of the ANN model on the validation set is 0.72, which is the best. Therefore, for the research object of this paper, the TRAINCGB training function shows better performance. In the following model building process of this paper, we will use the TRAINCGB training function to build our ANN prediction model.

In order to further improve the network performance and optimize the network parameters, we compared the fixed training times and cross-validation two network training methods based on the above experimental results. In this comparative experiment, the parameters are set to the optimal values of the above experimental results; that is, the number of hidden layer nodes in both methods is set to 25, the training function adopts TRAINCGB, and the number of iterations of the fixed training number method is 800 times. Table 1 presents the experimental results of the two training methods, from which it can be seen that for the test set data, the cross-validation training method has a smaller

Figure 7: Correlation coefficients of training and testing groups in ANN models under different training functions.

Table 1: Errors and correlation coefficients of training and testing groups in the ANN model with/without validation tests.

Condition	RMSE			Correlation coefficient		
No verification	Training group	Inspection group		Training group		Inspection group
	0.01	0.04		0.81		0.72
With verification	Training group	Inspection group	Training group	Inspection group	Training group	Inspection group
	0.02	0.04	0.03	0.82	0.70	0.74

root mean square error and a higher correlation coefficient. Therefore, on this dataset, the cross-validation training method has a better prediction effect.

5. Conclusion

The study summarizes the causes and recovery methods of fatigue in juvenile throwers after training. The reasons for the fatigue of throwing athletes and the effective recovery methods and methods are discussed, in order to have a certain reference value for making throwing training plans more scientifically and rationally and participating in competitions. Central fatigue will seriously affect the athletic state of athletes, and environmental factors are one of the important factors affecting the central fatigue of athletes. Because the influence of central fatigue and environmental factors on throwing athletes is more prominent, the correlation between environmental factors and central fatigue in throwing sports is studied, and a general prediction model and grouping prediction model of athletes' central fatigue under various environmental factors are established based on ANN. Experiments show that the established general prediction model of central fatigue of throwing athletes has good performance, and the correlation coefficient between the prediction results and the actual measured value is 0.68; for different groups of athletes, the established prediction model of central fatigue of throwing athletes has better performance. The prediction accuracy is high, and the correlation coefficient between the prediction result and the actual measurement value is higher than 0.70.

Data Availability

The figures and tables used to support the findings of this study are included in the article.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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