SIN-CHN
SCIENTIFIC PRESS PTE.LTD.

*Molecular & Cellular Biomechanics* 2024, 21(1), 183.
https://doi.org/10.62617/mcb.v21i1.183

Article

# Rehabilitation training of hamstring injury in athletes training hamstrings based on BP neural network algorithm

**Yukun Chu**[1], **Jia Xu**[2,*]

[1] Department of Physical Education and Research, Harbin Finance University, Harbin 150030, China
[2] Department of Basic Courses, Wuhan Qingchuan University, Wuhan 430204, China
*** Corresponding author:** Jia Xu, 18162665507@163.com

**CITATION**

Chu Y, Xu J. Rehabilitation training of hamstring injury in athletes training hamstrings based on BP neural network algorithm. Molecular & Cellular Biomechanics. 2024; 21(1): 183. https://doi.org/10.62617/mcb.v21i1.183

**ARTICLE INFO**

Received: 4 June 2024
Accepted: 24 June 2024
Available online: 13 September 2024



**Abstract:** Athletes are prone to injury during daily training and competition. In order to achieve better results, they are subjected to heavy training every day, who challenge the limits of their bodies. Excessive exertion, inattention, and irregular movements may all lead to muscle strains in athletes. The hamstrings, consisting of the biceps, semitendinosus, and semimembranosus, are susceptible to injury. Traditional research on hamstring injury rehabilitation training focuses on the prevention of muscle strains and the restoration of muscle elasticity. However, traditional training methods are often unable to make targeted adjustments to each athlete's specific situation. The actual application effect is not good. In order to improve the effectiveness of rehabilitation training for hamstring injury, this paper has introduced the BP neural network algorithm model. Based on the BP (Back Propagation) algorithm model, this paper has conducted an in-depth analysis of the causes of muscle strain in athletes. The results showed that the average accuracy of the algorithm was 97.83%, which had a high accuracy for the analysis of the cause. Muscle strain rehabilitation training methods were further analyzed. Research showed that the BP neural network algorithm could optimize up to 31%, and the effectiveness was above 96%. In the comparison of these two methods, it can be clearly seen that the algorithm in this paper is more scientific and efficient, which is conducive to better and faster recovery of the injured hamstrings of athletes.

**Keywords:** BP neural network algorithm; hamstring injury; rehabilitation training research; mean squared error; topology model

## 1. Introduction

In sports competitions, athletes often have higher requirements for speed and explosiveness. Athletes need to perform high-intensity training day after day in order to improve their professional requirements. However, if the training intensity is too high, it is easy to be in a state of fatigue all the time, causing damage to the hamstrings. The hamstrings are very prone to injury. The research of hamstring injury rehabilitation training is crucial for injured athletes, which is of great significance for athletes to achieve better performance and prolong sports life. Traditional rehabilitation training is often targeted training for the hamstrings, which mainly adopts resistance training or passive training. Ultimately, the goal of rehabilitating muscle groups is achieved through training. This method tends to ignore the differences between athletes. It cannot adjust the training method flexibly in time and has poor adaptability. BP neural network algorithm can make up for the shortcomings of traditional rehabilitation training. It has a high degree of self-learning, self-adaptation and certain fault tolerance.

With the deepening of the society's emphasis on sports and the increase of athletes' injuries, the research on the rehabilitation of athletes' training for hamstring injuries is also more in-depth. Wang and Li used sports anatomy analysis and other means to study preventive measures, treatment methods, rehabilitation methods and analysis [1]. Guided by the multidisciplinary nursing model of sports injury rehabilitation, Clement and Arvinen-Barrow's research provided support for the utilization of the multidisciplinary nursing model of sports injury rehabilitation for high school athletes [2]. Gao et al. reported the application of isokinetic strength training methods to the rehabilitation of athletes after anterior cruciate ligament injury [3]. Liu et al. explored the effect of isokinetic training of thigh muscle groups on the posterior displacement and remodeling of knee anterior cruciate ligament (ACL) reconstruction. He also summarized relevant rules to guide clinical practice [4]. Balci et al. suggested that lower extremity injuries might be associated with proximal muscle weakness and decreased motor control. Research focused on examining knee flexor and extensor strength in athletes with and without trunk muscle asymmetry [5]. These rehabilitation training studies have really worked well for the physical recovery of athletes. However, due to the differences in physical fitness, physical fitness and recovery speed among athletes, the methods of rehabilitation training methods for athletes training hamstring injuries need to be updated in time, so as to make more adaptive and differentiated changes. The training research based on BP neural network algorithm can effectively solve these problems.

The BP neural network algorithm is a multi-layer feedforward network trained according to the error back-propagation algorithm, which minimizes the sum of squared errors of the network through back-propagation. Li et al. identified different wireless channels by establishing feature vector sets of wireless channels for training back-propagation (BP) neural networks. The experimental results showed that the algorithm could accurately identify different wireless channels, and the accuracy rate could reach 97.59% [6]. Ma et al. established a BP neural network prediction model to measure the heat transfer coefficient of supercritical water. The prediction result showed that the maximum error was 16.06332%. The trained BP neural network prediction model could better predict and understand the heat transfer coefficient of supercritical water [7]. Gao et al. proposed an AACMM (Articulated Arms Coordinate Measuring Machines) modeling and error compensation method based on BP neural network, which optimized the structure and parameter settings of the neural network, and improved the prediction accuracy and training speed. Experimental research validated that propo became something Rithm and neural network compensation. This showed that 97% of the errors of AACMM could be eliminated after compensation. These experimental results verified the effectiveness of the proposed AACMM modeling and compensation method [8]. Zhang et al. experimentally investigated the effect of temperature on the monitoring of steel cable force with an intelligent elastic magnetoelectric (EME) sensor. A back-propagation (BP) neural network method was proposed. Based on the experimental results, an improved BP neural network model was established. The experimental results showed that the maximum relative error of force measurement was within ±0.9% in the temperature range of about 10 ℃ to 60 ℃ [9]. From a macro point of view, BP neural network algorithm has been widely used. It has played a special role in face recognition, housing price prediction, location tracking, etc. However, there is less connection with athletes' injury rehabilitation training, and research in sports is relatively lacking. In order to improve the traditional athlete training hamstring injury rehabilitation training, the introduction of BP neural network algorithm is particularly important.

In this paper, BP neural network algorithm was used to deeply study the rehabilitation training of athletes training hamstring injuries. 100 typical samples were selected to form a five-layer topology model. The model used 3 hidden layers. After several trial runs, the algorithm had an accuracy rate of 97.83% in judging the cause of the damage to the hamstrings of the athlete. In the study of muscle injury rehabilitation training, the rehabilitation effects of traditional rehabilitation training and BP neural network algorithm on samples were calculated separately. Traditional training methods could only achieve a maximum recovery effect of 85% for athletes. The recovery effect of the algorithm in this paper was all over 96%, and the highest was 98%. Therefore, the BP algorithm can provide a more accurate and effective method for rehabilitation training.

## 2. Rehabilitation training for athletes training hamstring injuries

### 2.1. Causes of hamstring injury

In sports training, especially in sports that require high speed and explosive power, such as sprint, long jump, athletes often experience hamstring strains [10]. The injury of the hamstrings not only affects the daily systematic training, but even some athletes miss the golden age of sports because of the slow recovery speed after injury, which seriously affects their own development prospects. In order to reduce the occurrence of sports injuries, in the early stage, the focus should be on understanding the overall situation of the athletes and finding out the reasons, so as to actively explore ways to avoid injuries.

This article sends out 1000 questionnaires in 2021 to students of the Sports Academy and some athletes participating in the games. The following figures are obtained by collating the valid forms recovered.

**Table 1.** Questionnaire for the causes of hamstring injuries.

| **Questionnaire on the causes of hamstring injuries** | |
|---|---|
| **Cause of injury** | **Visits** |
| 1) No warm-up or insufficient warm-up | 342 |
| 2) Poor strength and flexibility, insufficient strength of the hamstrings | 218 |
| 3) Fatigue or injury training | 237 |
| 4) Incorrect movement skills | 104 |
| 5) Psychological pressure and nervousness during training or playing games | 201 |
| 6) Seasonal climate and temperature effects | 82 |
| 7) Others | 17 |

These collected data in **Table 1** reflect the main reasons for the injury of the hamstrings of athletes are lack of warm-up activities, poor physical fitness, and fatigue. The specific analysis is as follows:

(1) Poor psychological quality

Poor psychological quality is a subjective cause of hamstring strain in athletes during training. Athletes have greater psychological pressure in daily training due to poor movement completion or unsatisfactory performance, resulting in depression and other negative emotions. This produces boredom and fear of training. The lack of concentration during training leads to muscle strain [11]. In addition, there are still some athletes lack of awareness of the harm of hamstring injury. In order to achieve good results in competitions, athletes deliberately conceal their injuries and increase their training intensity. Eagerness for success leads to irregular movement skills or excessive force, which aggravates the injury.

(2) Insufficient warm-up activities

Many athletes don’t understand the importance of warm-up activities and even think it’s just a waste of time. During training and pre-competition preparations, athletes are perfunctory, resulting in insufficient muscle relaxation. The tightness and stiffness of the muscles have a certain impact on the standardization and completion of the athlete’s movements. Intense exercise with uncoordinated movements can easily lead to strain of the hamstrings [12]. It should be noted that the content and form of warm-up activities for different sports also vary. For example, in the anaerobic exercise represented by sprinting, the warm-up activities should focus on promoting blood circulation and increasing muscle temperature. The warm-up activities of aerobic exercise represented by swimming should focus on mobilizing all organs of the body into a state of motion and flexibility exercises.

(3) Unreasonable training arrangements

Scientific sports arrangements are not only conducive to improving training levels, creating better results, but also preventing sports injuries. Some training methods are often used for more than ten years and have not been updated in time. It may actually work at first and improve the performance of the athlete. However, sport is a competitive game. In the case of the opponent’s innovation and progress, standing still only gradually lags behind. The dull and monotonous training and excessive exercise make athletes lose their enthusiasm for sports and complete exercise arrangements mechanically. Long-term repetitive training can easily cause muscle fatigue, beyond the pressure of the hamstrings.

(4) Seasonal reasons

During the season exchange period, if athletes cannot quickly adapt to the external environment, their inherent coordination would be destroyed, which is likely to cause traumatic accidents [13]. In winter or rainy weather, athletes may be slack in the preparatory activities, and the warm-up activities are often insufficient. In summer and some climates with high air humidity, athletes tend to sweat easily after doing some simple warm-ups, which makes them mistakenly believe that the preparation activities are effective. In fact, the muscles are not fully exercised. During formal training, the high-intensity load causes huge pressure on local muscles, resulting in muscle damage.

(5) Physical reasons for athletes

Generally speaking, the golden age of athletes is around 25 years old. Long-term repetitive training and many intense competitions consume athlete’s physical strength and energy. In particular, heavy practice and the accumulation of injuries can reduce athlete’s physiology, with a corresponding decrease in concentration and muscle elasticity. Irregular movements or the lack of muscle relaxation can lead to excessive muscle contraction, which can easily lead to passive strain [14]. There are also some athletes with weaker physical fitness, poor explosiveness and durability, who usually need to spend more time for more training. This is also one of the reasons for muscle strain is to ignore the situation in order to catch up with the progress.

## 2.2. BP neural network algorithm

The BP neural network algorithm is to obtain the proxy weight by arbitrarily selecting a set of weights to establish a linear formula system. Convergence is faster and easier to understand than traditional methods. In fact, the BP neural network algorithm adjusts its own connection weights and activation thresholds through the learning of input samples. Then, the output is performed according to the expected input value. The nonlinear classification function of the neural network is obtained.

**Figure 1** shows the transmission model of the BP neural network.

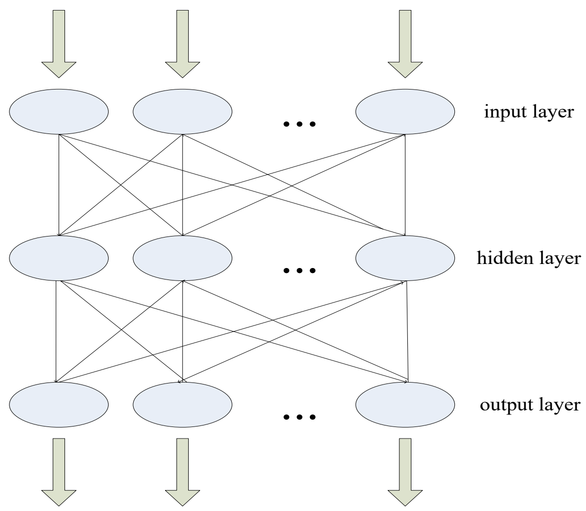


**Figure 1.** Three-layer BP neural network topology.

From the three-layer BP neural network topology in **Figure 1**, it can be known that its specific process is as follows:

(1) The sample is selected. From the database, $x$ input samples are arbitrarily selected, and corresponding numerical expectations are output. The number and representativeness of the selected samples must be strictly screened, and data cannot be simply input. Generally speaking, the more sample data, the more comprehensive the situation is considered, and the smaller the error of the results obtained. However, excessive and cluttered data not only affects the convergence speed, but also affects the fitting accuracy. The lack of a representative sample can also affect the algorithm's calculation results on the research subjects. Therefore, when the initial sample is selected, representative data should be selected. The maximum value should be included as much as possible.

(2) The input and output values are calculated. From the perspective of improving the performance of neural networks, the data must first be preprocessed. Because of the complexity of real life, each sample data is disturbed by multiple factors. The value range between elements cannot be exactly the same. This brings great challenges to

the network algorithm, and the fluctuation of elements can easily lead to the failure of the algorithm. Therefore, it is necessary to preprocess the input and output values to speed up the algorithm.

Equation (1) is the input value of $k_{bk}(x)$ for the hidden layer. Equation (2) is the output value $k_{ak}(x)$. Equation (3) is the input value $y_{bk}(x)$ corresponding to the output layer. Equation (4) is the output value $y_{ak}(x)$.

$$k_{bk}(x) = \sum_{k=1}^{n} w_{bk}\, x_i(x) - b_k, k = 1,2,\dots,n \tag{1}$$

$$k_{ak}(x) = f(k_{ak}(x)), k = 1,2,\dots,n \tag{2}$$

$$y_{bk}(x) = \sum_{h=1}^{n} w_{ko}\, h_{ak}(x), o = 1,2,\dots,n \tag{3}$$

$$y_{ak}(x) = f(y_{ia}(x)), o = 1,2,\dots,n \tag{4}$$

Equation (5) is the partial derivative of the error function of the neurons in the output layer. Equation (6) is the partial derivative of the error function of the neurons in the hidden layer.

$$z_a(j) = (d_o(j) - y_o(j))y_o(j)(1 - y_o(j)) \tag{5}$$

$$z_k(j) = [\sum_{o=1}^{q} \alpha_o\,(j)w_{ko}]v_k(j)(1 - v_k(j)) \tag{6}$$

Equation (7) is modified by $\alpha_o(j)$ and $v_h(j)$ to the connection weight $w_{ko}$. Equation (8) is a correction to the threshold value $f$.

$$w_{ko}^{n+1}(j) = w_{ko}^{n}(j) + \lambda\alpha_o(j)v_h(j) \tag{7}$$

$$f^{n+1}(j) = f^{n}(j) + \lambda\alpha_o(j) \tag{8}$$

The learning rate of the above equations is $\lambda \in (0,1)$.

Equation (9) is modified with $\alpha_h(j)$ and $v_i(j)$ for the connection weight $w_{ih}$. Equation (10) is corrected for threshold $\theta$.

$$w_{ih}^{n+1}(j) = w_{ih}^{n}(j) + \lambda\alpha_h(j)v_i(j) \tag{9}$$

$$\theta^{n+1}(j) = \theta^{n}(j) + \lambda\alpha_h(j) \tag{10}$$

Equation (11) calculates the global error $E$.

$$E = \frac{1}{2m}\sum_{k=1}^{m}\sum_{o=1}^{q}(d_o(j) - y_o(j))^2 \tag{11}$$

(3) According to the result of $E$, it is decided whether or not to end the algorithm. If $E < \varepsilon$ or the tester's practice of the content exceeds the set maximum number of times, the algorithm would automatically end. Otherwise, it is entered into step (1) to randomly sample and then learn [15].

### 2.3. Rehabilitation training algorithm model for posterior femoral muscle injury

In order to restore the hamstrings of the athletes better and faster, the BP neural network algorithm is introduced. The specific operation process is shown in the **Figure 2**.

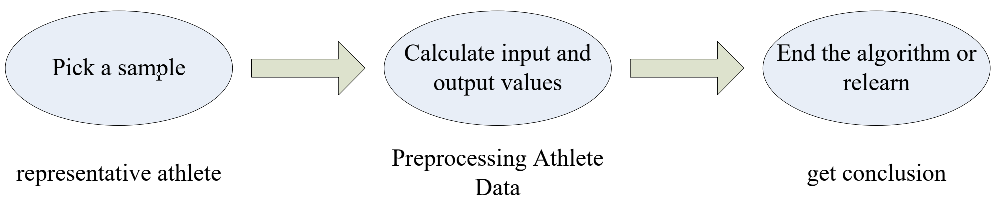


**Figure 2.** BP neural network algorithm operation flow.

According to the flowchart in **Figure 2**, a representative sample of athletes should be selected first. In 2021, the questionnaires sent to the students of the Sports Academy and some athletes participating in the games are compiled. According to whether there is a risk of straining the hamstrings, the athletes can be divided into track and field, gymnastics, swimming, ball and other categories according to sports. The specific data are shown in **Table 2**.

**Table 2.** Injury questionnaire of posterior femoral muscle group in different sports.

| Project | Visits | Proportion |
|---|---|---|
| Track and field | 653 | 68.2% |
| Gymnastics | 102 | 10.6% |
| Swim | 79 | 8.2% |
| Ball | 71 | 7.4% |
| Other | 54 | 5.6% |
| Total | 959 | 100% |

In **Table 2**, track and field athletes have the most hamstring strains and the greatest risk of muscle strains [16]. Track and field sports can be divided into sprint, high jump, long jump, shot put, javelin and other competitions. The injury of the hamstrings caused by track and field sports is shown in **Table 3**.

**Table 3.** Track and field hamstring injury questionnaire.

| Project | Visits | Proportion |
|---|---|---|
| Sprint | 326 | 49.9% |
| High jump | 105 | 16.1% |
| Long jump | 88 | 13.5% |
| Shot put | 54 | 8.3% |
| Javelin | 47 | 7.2% |
| Other | 33 | 5.0% |
| Total | 653 | 100% |

The data in **Table 3** reflect that sprinting in track and field has the most injuries to the hamstrings of athletes. Next, the hamstring strain in the sprint event is analyzed. The information in the questionnaire is organized to obtain the following data.

**Table 4.** The time of hamstring strain in the sprint event questionnaire.

| Time | Visits | Proportion |
|---|---|---|
| Train | 103 | 31.6% |
| Contest | 96 | 29.4% |
| Morning warm up | 67 | 20.6% |
| After school exercise | 60 | 18.4% |
| Total | 326 | 100% |

**Table 4** shows that athletes in sprinting events account for up to 61% of injuries during training and competition. The muscle strain caused by the morning warm-up accounts for 20.6%. The muscle strain caused by after-school training accounts for

18.4%. Training and competition time are the main time points for hamstring injuries in sprinters. Whether it is the athletes themselves or schools and coaches, they should pay attention to this.

100 typical cases are selected from 326 sprinters with hamstring injuries and substituted into the BP neural network model. A topology model with a five-layer structure can be obtained, as shown in **Figure 3**.

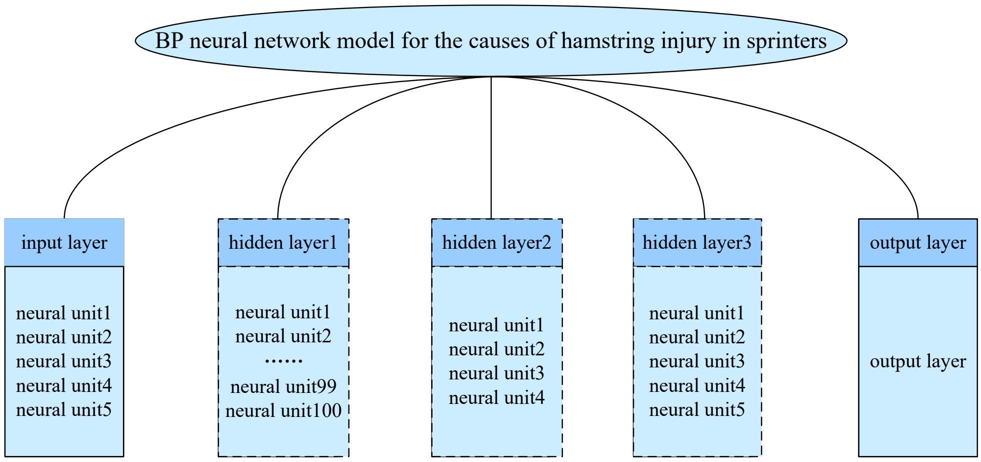


**Figure 3.** BP neural network structure model.

In order to more accurately find out the cause of the hamstring strain in sprinters, three hidden layers are used after many trials. The BP neural network model of the sprinter's hamstring injury in **Figure 3** is a five-layer topology of 5 × 100 × 4 × 5 × 1. 5 neural units constitute the input layer. 100 neural units form the first hidden layer. 4 neural units form the second hidden layer. 5 neural units form the third hidden layer. The output layer is 1 neural unit. Any number of hidden layers can be inserted between the input layer and the output layer of the BP neural network model. The hidden layer is internally budgeted according to the established algorithm within the model. Its number is inversely proportional to the model convergence rate.

## 3. Neural network validation of the rehabilitation of the hamstring injury of athletes

The selected 100 sprinters are used as sample data to run the BP neural network algorithm. The first 40 samples are set as the control group, and the last 60 samples are used as the test group. The last 60 samples are divided into three hidden layers. 20 sample data is inserted into each hidden layer. The mean square error equation is used to calculate the accuracy of the neural network:

$$\mathrm{MSE}(a, a') = \frac{1}{n}\sum_{i=1}^{n}(a_i - a_i')^2 \tag{12}$$

In Equation (12), $a_i$ represents the expected output of the sample data. $a_i'$ represents the actual output of the sample data. The calculation of the mean square error can reflect the fitting accuracy of the BP neural network algorithm to the actual situation [17].

The termination condition $E$ of the algorithm model is set to $E < 10^{-10}$ or the mean square error is less than $10^{-10}$. During the training process of inputting the damage of the hamstrings of sprinters, the model can continuously adjust the connection weights and thresholds of the model, thereby realizing the nonlinear classification function of distinguishing different causes of the damage of the hamstrings of athletes. $\mathrm{MSE} = 1.79^{-16}$ can be calculated. The number of iterations of the training results is 7 and the search gradient is $8.62^{-7}$. The selected 20 groups of muscle strain athletes' data are brought into the algorithm prediction model to calculate. The running results are shown in **Table 5**.

**Table 5.** Analysis score table of the main causes of damage.

| Data serial number | Expected output | Actual output |
|---|---|---|
| 1 | [0 1 0 0 0 0] | [0 1 0 0 0 0] |
| 2 | [0 1 0 0 0 0] | [0 1 0 0 0 0] |
| 3 | [0 1 0 0 0 0] | [0 1 0 0 0 0] |
| 4 | [0 1 0 0 0 0] | [0 1 0 0 0 0] |
| 5 | [0 1 0 0 0 0] | [0 1 0 0 0 0] |
| 6 | [0 1 0 0 0 0] | [0 1 0 0 0 0] |
| 7 | [0 1 0 0 0 0] | [0 1 0 0 0 0] |
| 8 | [0 1 0 0 0 0] | [0 1 0 0 0 0] |
| 9 | [0 1 0 0 0 0] | [0 1 0 0 0 0] |
| 10 | [0 1 0 0 0 0] | [0 1 0 0 0 0] |
| 11 | [0 0 1 0 0 0] | [0 1 0 0 0 0] |
| 12 | [0 0 1 0 0 0] | [0 0 1 0 0 0] |
| 13 | [0 0 1 0 0 0] | [0 0 1 0 0 0] |
| 14 | [0 0 1 0 0 0] | [0 0 1 0 0 0] |
| 15 | [0 0 1 0 0 0] | [0 0 1 0 0 0] |
| 16 | [0 0 1 0 0 0] | [0 0 1 0 0 0] |
| 17 | [0 0 1 0 0 0] | [0 0 1 0 0 0] |
| 18 | [0 0 1 0 0 0] | [0 0 1 0 0 0] |
| 19 | [0 0 1 0 0 0] | [0 0 1 0 0 0] |
| 20 | [0 0 1 0 0 0] | [0 0 1 0 0 0] |

Among the 20 groups of data in **Table 5**, only the 11th group of data has a prediction error. The 20 sets of data are run repeatedly to make 1000 predictions. The validity of the BP algorithm model is judged by calculating the accuracy of the arithmetic mean of the algorithm model. Through calculation, the average accuracy of the algorithm is 97.83%. It shows that the algorithm has high reliability and accuracy in judging the cause of the injury of the hamstrings of the athlete training.

The traditional rehabilitation training methods for the hamstrings mainly include resistance training, which is divided into glute bridge training, passive training and PNF training methods.

Glute bridge training refers to the state where the athlete lies on the back and keeps the waist close to the ground. The thighs are folded, and the feet are close to the ground. The hips and waist are gradually raised. When doing glute bridge training, it needs to pay attention to the size and order of muscle force. With the torso and thighs in a straight line, the glutes and biceps should be naturally tightened. After 5 s, it returns to normal in order. The recovery should be carried out in the order of the waist falling and then the buttocks falling. It is necessary to be careful not to push too hard both when starting the movement and when resuming it. It needs to be done slowly to avoid secondary injury to the muscles. Under the condition that the basic training achieves a certain effect or the athlete's muscle recovery is good, the intensity of the glute bridge training can be increased, such as single-leg training, increasing body weight, etc.

Passive training is the opposite of glute bridge training. In passive training, the athlete only needs to lie prone and keep the knee flexed at 90°. Afterwards, when assisting teammates in training, the athlete's ankle joint should be forced to perform auxiliary confrontation training. One group lasts for 15 s. It should be noted that the athlete should try to keep the position and state of the knee joint unchanged during the confrontation. The point of application should be consistent. After training, muscles need to be relaxed by massaging or rubbing sore muscles. It can speed up the metabolism of acidic substances in muscles and improve muscle elasticity, so as to achieve the purpose of restoring muscle groups.

PNF training refers to the athlete remaining supine. The athlete grasps the fixed object with both hands, which help train the teammates to keep the other leg fixed when they lift one leg for 15 s. Rubber bands can also be used for training. The elasticity of the rubber band can achieve the effect of muscle contraction resistance training. The specific mode of PNF training can be adjusted, and the duration and interval of training can be selected according to their own differences [18].

20 representative sprinters are selected and adopted different rehabilitation training methods according to their muscle strain degree [19]. The prediction results are shown in **Figure 4**.

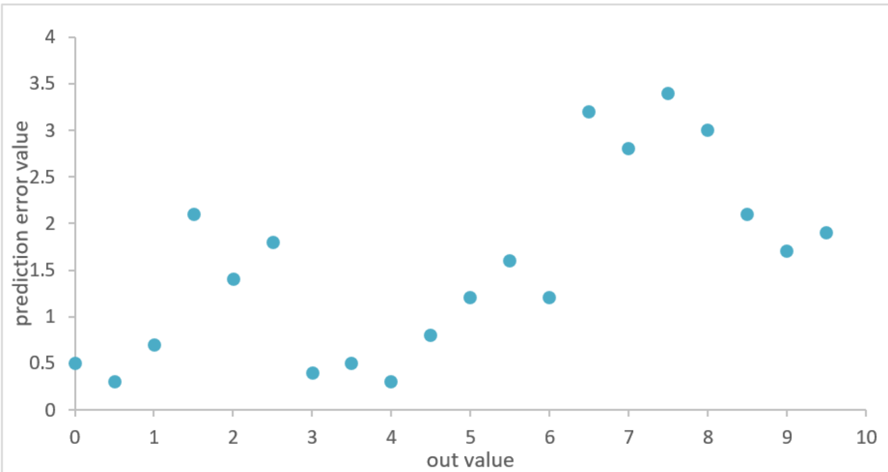


**Figure 4.** BP neural network prediction results.

The *X*-axis in **Figure 4** is the output value of the neural network training method. The *Y*-axis is the experimental value of the rehabilitation training method. There is the following relationship between the degree of damage to the hamstrings and the effect of rehabilitation training methods:

$$S = \frac{X - Y}{Y} \times 100\% \tag{13}$$

The data in **Figure 4** shows that the prediction errors are all less than 3.5%. The minimum error is 0.3%, and the maximum is 3.4%. That is to say, the prediction model can more accurately predict the matching rehabilitation training method according to the athlete's muscle damage.

The traditional athlete's hamstrings rehabilitation training is largely arranged by the coach. The athlete's rehabilitation training method is selected based on the coach's subjective judgment and years of experience. However, individual choice cannot accommodate multiple athletes. Each athlete's own quality, degree of muscle damage and suitable training methods are different. Uniform training methods have limited impact on athlete rehabilitation. Even sometimes, the secondary injury of the muscle is caused by inadvertent improper operation or excessive force [20]. The algorithm in this paper can analyze, learn and continuously adjust the specific conditions of the input athletes. **Figure 5** is the comparison between the traditional training method and the BP network algorithm on the muscle rehabilitation effect of athletes.

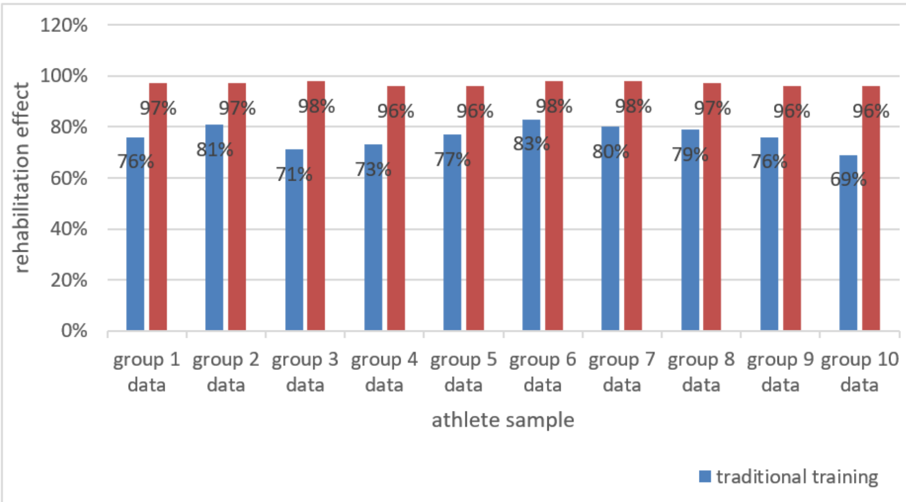


**Figure 5.** Comparison of traditional training and neural network training for sprinters.

**Figure 5** selects 10 sprinters as sample data. The comparison of the histograms reflects that the overall rehabilitation effect of the algorithm training in this paper on the sprinter who has strained the hamstrings is higher than that of the traditional rehabilitation training method. The best rehabilitation effect that the traditional training method can achieve is 83%, which is much lower than the 98% of the network algorithm.

**Figure 6** is a comparison between the rehabilitation effects of 10 high jumpers. In the fifth set of data, the network algorithm is up to 31% better than the traditional training effect. In the 8th set of data, the lowest can be optimized by 13%.

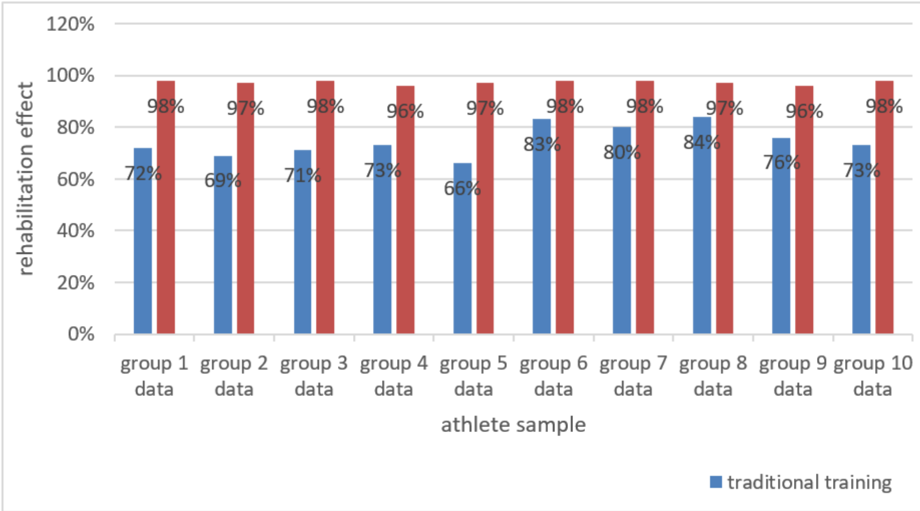


**Figure 6.** Comparison of traditional training and neural network training for high jumpers.

**Figure 7** shows data for 10 shot putters with hamstring strains. The rehabilitation effect of traditional rehabilitation training on hamstring injuries varies between 68% and 85%. The rehabilitation effect that the BP network algorithm can achieve is higher than 96%.

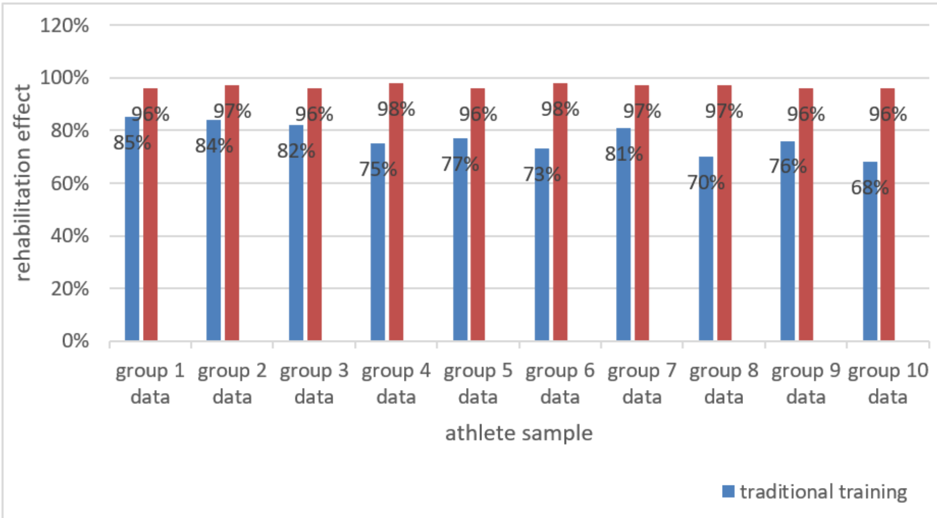


**Figure 7.** Comparison of traditional training and neural network training for shot put players.

To sum up, it can be seen that the rehabilitation effect of traditional training methods on these 30 athletes fluctuates greatly. The lowest can only reach 66%, the highest is 85%. The effect that the BP network algorithm can achieve is relatively stable. The effect on all samples is above 96%, and the highest can reach 98%. Therefore, the neural network algorithm is more accurate and scientific than the traditional method, which can optimize up to 31%. There is a big difference in the effect that each athlete can achieve according to the traditional rehabilitation training method. Each athlete's physical function, overall state, and degree of muscle strain are difficult to fully consider in traditional training methods. In response to these problems, the neural network algorithm can flexibly adjust the learning method and training strategy. The actual situation of each sample is analyzed, which generates more targeted and effective rehabilitation training methods.

## 4. Conclusion

At present, the application of neural network algorithms in the field of sports is not common. Most areas and projects still use the school or coach-led method for sports training, However, the training plan formulated with experience and subjective thinking can improve the performance of athletes and the rehabilitation of injured muscles, which has a limited effect. Based on the BP neural network topology model, this paper conducted an in-depth analysis of the causes of the hamstrings strained athletes and the training methods that could achieve the best recovery effect. It has found a matching rehabilitation training method, which could better solve the problem of rehabilitation of athletes' posterior femoral muscle group injury in real life. After the introduction of the algorithm, the effect of rehabilitation training for athletes' muscle strains has been greatly improved, but there are still errors in the prediction of sample data, and the algorithm needs to be optimized and improved. In future research, it would be continued to improve research methods. It is necessary to learn from other advanced experiences to reduce prediction errors. More scientific and efficient rehabilitation training plans for the hamstrings of athletes are also needed to be formulated.

**Author contributions:** Conceptualization, YC and JX; methodology, YC; software, JX; validation, YC; formal analysis, JX; investigation, YC; resources, JX; data curation, YC; writing—original draft preparation, YC; writing—review and editing, JX; visualization, JX; supervision, YC; project administration, JX; funding acquisition, YC. All authors have read and agreed to the published version of the manuscript.

**Ethical approval:** Not applicable

**Conflict of interest:** The authors declare no conflict of interest.

## References

1. Wang W, Li Y. Study on treatment and rehabilitation training of ligament injury of javelin throwers based on sports biomechanics. Measurement. 2021; 171: 108757. doi: 10.1016/j.measurement.2020.108757
2. Clement D, Arvinen-Barrow M. An Investigation into Former High School Athletes' Experiences of a Multidisciplinary Approach to Sport Injury Rehabilitation. Journal of Sport Rehabilitation. 2021; 30(4): 619-624. doi: 10.1123/jsr.2020-0094
3. Gao Z, Cheng L, Zhou J, et al. Study of isokinetic strength training's rehabilitating effects on elite athletes after knee joint ACL reconstruction surgery. International Journal of Experimental and Computational Biomechanics. 2018; 4(2/3): 209. doi: 10.1504/ijecb.2018.092267
4. Liu H, Lu W, Liang D. Effect of isokinetic training of thigh muscle group on graft remodeling after anterior cruciate ligament reconstruction. Journal of Reparative and Reconstructive Surgery. 2019; 33(9): 1088-1094.
5. Balci A, Ünüvar E, Akınoğlu B, et al. Investigation of knee flexor and extensor muscle strength in athletes with and without trunk muscle strength asymmetry. Advances in Rehabilitation. 2021; 35(1): 1-8. doi: 10.5114/areh.2021.102314
6. Li D, Wu G, Zhao J. Wireless Channel Identification Algorithm Based on Feature Extraction and BP Neural Network. Journal of Information Processing Systems. 2017; 13(1): 141-151.
7. Ma D, Zhou T, Chen J, et al. Supercritical water heat transfer coefficient prediction analysis based on BP neural network. Nuclear Engineering and Design. 2017; 320: 400-408. doi: 10.1016/j.nucengdes.2017.06.013

8. Gao G, Zhang H, San H, et al. Modeling and Error Compensation of Robotic Articulated Arm Coordinate Measuring Machines Using BP Neural Network. Complexity. 2017; 2017: 1-8. doi: 10.1155/2017/5156264
9. Zhang R, Duan Y, Zhao Y, et al. Temperature Compensation of Elasto-Magneto-Electric (EME) Sensors in Cable Force Monitoring Using BP Neural Network. Sensors. 2018; 18(7): 2176. doi: 10.3390/s18072176
10. Yu B, Liu H, Garrett WE. Mechanism of hamstring muscle strain injury in sprinting. Journal of Sport and Health Science. 2017; 6(2): 130-132. doi: 10.1016/j.jshs.2017.02.002
11. Meyer VM. Sport Psychology for the Soldier Athlete: A Paradigm Shift. Military Medicine. 2018; 183(7-8): e270-e277. doi: 10.1093/milmed/usx087
12. Cunniffe B, Ellison M, Loosemore M, et al. Warm-up Practices in Elite Boxing Athletes: Impact on Power Output. Journal of Strength and Conditioning Research. 2017; 31(1): 95-105. doi: 10.1519/jsc.0000000000001484
13. Bauman JE, Hendrix S, Bullock GS, et al. Changes in Functional Movement Patterns and Injuries for In-season Division III Women. Medicine & Science in Sports & Exercise. 2017; 49(5S): 372. doi: 10.1249/01.mss.0000517901.44564.b7
14. Jansen van Rensburg A, Janse van Rensburg D, Van Buuren H, et al. The use of negative pressure wave treatment in athlete recovery. South African Journal of Sports Medicine. 2017; 29(1): 1-7. doi: 10.17159/2078-516x/2017/v29i1a2929
15. Zhang D, Lou S. The application research of neural network and BP algorithm in stock price pattern classification and prediction. Future Generation Computer Systems. 2021; 115: 872-879. doi: 10.1016/j.future.2020.10.009
16. Ruan M. “Excessive muscle strain as the direct cause of injury” should not be generalized to hamstring muscle strain injury in sprinting. Journal of Sport & Health Science. 2017; 6(01): 127-128.
17. Li K, Li R, Huang W, et al. Modeling Prediction and Research on Leaf Moisturizing Effect of Tobacco Redrying. Journal of Physics: Conference Series. 2021; 2068(1): 012050. doi: 10.1088/1742-6596/2068/1/012050
18. Arazi H, Eghbali E, Karimifard M. Effect of creatine ethyl ester supplementation and resistance training on hormonal changes, body composition and muscle strength in underweight non-athlete men. Biomedical Human Kinetics. 2019; 11(1): 158-166. doi: 10.2478/bhk-2019-0022
19. Arvinen-Barrow M, Clement D. Preliminary investigation into sport and exercise psychology consultants’ views and experiences of an interprofessional care team approach to sport injury rehabilitation. Journal of Interprofessional Care. 2016; 31(1): 66-74. doi: 10.1080/13561820.2016.1235019
20. Chen F. Athlete muscle measurement and exercise data monitoring based on embedded system and wearable devices. Microprocessors and Microsystems. 2021; 82: 103901. doi: 10.1016/j.micpro.2021.103901