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Molecular & Cellular Biomechanics 2024, 21(1), 149.
https://doi.org/10.62617/mcb.v21i1.149

Article

Prevention and rehabilitation measures for knee injuries during sports training

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CITATION

Xu H. Prevention and rehabilitation measures for knee injuries during sports training. Molecular & Cellular Biomechanics. 2024; 21(1): 149. https://doi.org/10.62617/mcb.v21i1.149

ARTICLE INFO

Received: 20 May 2024
Accepted: 15 July 2024
Available online: 24 October 2024

Abstract: In sports training, athletes often cause knee injury due to excessive exercise or inappropriate exercise habits, which increases inconvenience to the training life of athletes. In order to avoid the occurrence of knee injury, this article designed a knee joint injury warning system based on the neural network algorithm, which was used in the process of preventing athletes' movement damage and concluded. In the survey of pain scores, the measures for preventing athletes' knee damage in this article really played a role in alleviating the athlete's knee pain. In unstable scoring, the anxiety score of athletes has greatly improved after taking measures. In the survey of the lock -up score, the athletes' atresia feel was stable within 21 or above after taking measures. The athletes' swelling scores increased after taking measures. Athletes 6, 9, 13, 14, and 15 have reached full scores.

Keywords: sports training; knee injury; preventive measures; rehability measures

1. Introduction

Knee joint injury incidents occur from time to time. In people's past cognition, knee injuries are more likely to occur in elderly groups. However, the athlete group is ignored. Athletes often suffer knee injuries in sports training, causing athletes to suspend training to cooperate with doctors for recovery of sports injuries. Many athletes still have insufficient understanding of knee injuries and have not fully realized the importance and necessity of protecting knee joints in their sports career. In order to avoid the occurrence of knee injury, prevention should be placed in normal times. Only when the prevention work is in place, can the athlete's knee joint be protected. Therefore, research on knee injury is extremely necessary.

Knee injury in sports is a controversial topic. Scholars also have a profound research on it. Schnizer evaluated patients and surgical factors that may cause rigid patients and surgical factors after surgery that might cause polybrack knee injury [1]. Murmu et al. determined the accuracy of magnetic resonance imaging in diagnosis of knee injury [2]. Chauhan et al. compared the correlation of clinical, MRI and arthroscopy test results of patients with knee joint injury [3]. Figueeroa et al. explained that the knee joint multiple ligament damage [4]. Snoeker et al. estimated that the risk of clinical diagnosis of knee arthritis after the clinical diagnosis of different types of knee joint injury in young adults was estimated to be the risk of knee arthritis [5]. Bauer discussed the diagnosis and treatment plan of traumatic knee cartilage injury [6]. Godin et al. evaluated the results and failure rates of the patients after the reconstruction of the youth group after the re-reconstruction of the non-fixed-stage ligament [7]. The research on knee damage is mostly concentrated on the harm of knee damage and the risks it may encounter.

Sports training has great benefits to people, which affects all aspects of people's

lives. Calatayud et al. proved that high -intensity preoperative training had improved the physical and functional recovery of the whole knee joint replacement [8]. Zhou and Zhou studied the therapeutic effect of nano-ligament combined with motion rehabilitation training [9]. Fisher et al. evaluated the effect of motion training in the basic military training unit [10]. Ikeda and Ryushi conducted a 6-week study on knee extension muscle stretching and analyzed its effects [11]. Teichmann et al. tested the effectiveness of the accidental interference plan of the unilateral knee joint ligament damage in the early stage of rehabilitation [12]. Le et al. explored the impact of the activation of rope muscle activation in the knee angle to the long knee flexion and extension movement [13]. Kawama et al. described the different trends of bidding training and the biological adaptability of the body to the application pressure [14]. There are many research on sports training. However, at this stage, there are rare studies of knee injury prevention and rehabilitation during the process of raising and training.

In order to protect the athlete's knee joint, this article designed a knee injury warning system based on neural network algorithms, which was applied to the daily training of athletes. At the same time, the athlete's knee condition was detected by a scoring manner. This article investigated from four aspects: pain, uneasiness, atresia, and swelling. In contrast to the knee condition of the athletes before taking measures, the feasibility conclusion was obtained.

2. Athlete's knee injury during sports training

Knee injury is more prone to occur in sports training, which is called sports knee joint injury. Patients usually have clinical symptoms. If the scope of activity is limited, knee pain and swelling, who cannot participate in exercise. This has a negative impact on their quality of life and health [15]. Among the athletes, the number of knee injuries related to exercise is more, which seriously affects the athlete's daily life and training.

1) Basic situation of knee injury

In exercise and training, the physical condition of athletes is very different. If the training intensity is too large, or the training plan, training environment and training level are not adapted to the actual situation of the athletes, the athlete's body is prone to various injuries, which causes damage to tissue or organs. In severe cases, it also causes physiological disorders [16]. Studies have shown that there are different injuries between athletes. Fatigue and chronic injuries are more common, while severe and acute damage is not common. Knee injury is one of the most common damage among athletes. The most common knee joint injury is the inner-side ligament, half-moon plate, knee cross ligament and tendon strain, which not only interferes with normal exercise training, but also has a great negative impact on the health of the athletes. Therefore, the occurrence of these damage must be analyzed to reduce the occurrence of knee joint damage.

2) Types of knee injury

Common types of knee joint injury are: side-by-side ligament damage, anterior cruciate ligament (ACL) injury, meniscus injury, and bone damage. It can be seen in **Figure 1**.

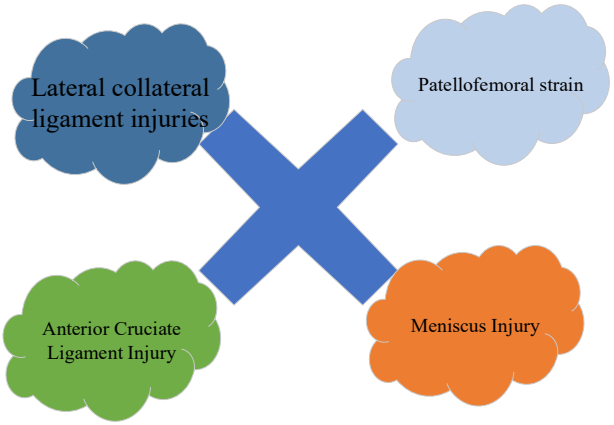

Figure 1. Types of knee injuries.

(1) Collateral ligament injury

Injury to the medial collateral ligament of the knee may occur when it is suddenly stretched outward by the abduction force of the tibia [17]. This may be due to the inability to move the body before cross country sports, the inability to control the power of the foot when the foot is in the air during the side kick movement, the loss of balance of the foot when jumping high on the obstacle course, a sudden turn during sports training, the ball being passed to a person during two-on-one football, etc.

(2) Anterior cruciate ligament (ACL) injury

The cruciate ligaments (called cruciate ligaments) of the knee joint are divided into two categories: the anterior cruciate ligament and the posterior cruciate ligament [18]. Injuries to the anterior cruciate ligament are more than twice as common as injuries to the posterior cruciate ligament. For example, in extreme training, the knee joint sharply rotates and bends inward due to the uneven surface, and the calf is placed under the body. In combat, the leg that attacks from the side misses the opponent, and the impact is too large. During wrestling training, they "tripped" each other; they lost weight by landing alternately with spin kicks and upper body kicks. Athletes squat on their calves and jump from a height in an obstacle course, throwing their feet off balance and falling. ACL injuries can result from tight turns during sports training, offense and defense while passing the ball in a football game, and other mechanisms that can lead to an injury to the medial collateral ligament. Additionally, an ACL injury can be caused by a sudden impingement on the front of the thigh, which may be active or passive, with the knee flexed about 90 degrees.

(3) Meniscus damage

The meniscus is located on the medial and lateral condyles of the tibia and consists of medial and lateral menisci, which are made of fibrocartilage. For example, in a fight, both knees are bent and the menisci immediately collide with each other. During sports or agility training, the meniscus may suddenly stop or flip over and fall. During various jumps, the meniscus may sway from side to side due to the loss of weight during a hasty landing on the last 1–2 m forward jump. During various types of training and sports, the orientation of the body changes between jumping and landing. During leg movement, the knee joint is constantly flexed and straightened. In addition, while climbing up and down, there is a gradual, although not acute, injury to the meniscus.

(4) Patellar strain

The main causes of patellar strain are multiple local small friction injuries over a period of time, as well as local impact and traction injuries [19]. Without scientifically justified training, a single or prolonged session of overloading the knee can cause patellar strain.

3) Causes of knee injury

The causes of knee joint injuries in sports are mainly related to high-intensity and high-load sports, such as jumping, acrobatics, and sprinting. It is easy to cause knee joint injury and impact, and also easy to cause knee joint wear and tear. In addition, most people are more focused during exercise and training and cannot take care of themselves. In the event of an accident, it is easy to cause knee injury [20,21]. In the event of an accident, the knee joint is prone to injury. Second, the knee joint is structurally fragile because it is relatively heavy and not as stable as the rest of the body. It can be affected by forces from different directions, as shown in **Figure 2**.

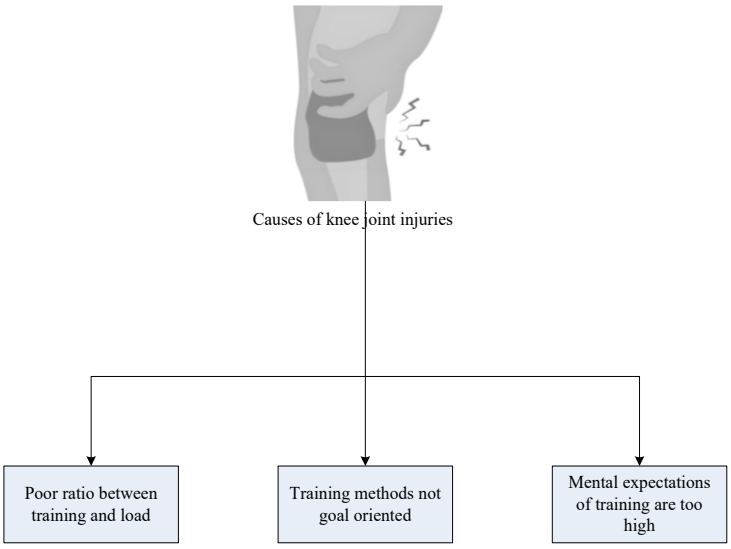

Figure 2. Causes of knee injuries.

(1) Poor ratio between training and loading

If certain sports require athletes to have good endurance, the training program should increase aerobic activity. If training time is continuously increased, the development of physical function and the training load are unbalanced, leading to a high risk of overload and muscle breakdown. If the purpose of training is to develop explosive power, the athlete must apply high-explosive muscle force, which causes compression of the limb joints. This excessive load also leads to sports injuries. In addition, in some technical skills training, when the body is under high load or muscle tissue is inflexible and must perform more complex movements, it can stimulate the weight-bearing joints and cause injury [22].

(2) Training methods are not goal-oriented

The purpose of physical training is to improve the physical fitness of athletes. The most common training programs are balance, technique, explosiveness, and other types of training. Currently, this is mainly seen in athletes who have not fully recovered from previous injuries. Athletes who engage in long-term physical activity

tend to suffer from sports injuries of varying degrees.

(3) The psychological expectations of training are too high

The objective causes of sports injuries are related to training methods and training tasks. In addition to objective reasons, there are psychological aspects of training. To reduce the risk of sports injuries, a solid training program should be developed. However, athletes often overestimate their athletic ability and do not take a step-by-step approach to training. When training alone, some movements may not be directly seen by the trainer, which may deviate from the norm and increase the risk of injury [23]. Therefore, overestimation of individual ability and training alone is one of the reasons for knee injuries in athletes.

3. Knee joint injury early warning algorithm

In sports training, it is very important to effectively prevent and recover from knee joint injuries. In this paper, a combination of wearable devices, motion sensors and clinical trials is used to collect the physiological parameters, training load, exercise mode, and force state of the knee joint of athletes. Through cleaning, normalization, and division into training samples and test samples, the data is preprocessed. Convolutional neural network is used as the neural network architecture of this paper. The input layer of the model accepts the preprocessed data, the hidden layer performs feature extraction and pattern recognition, and the output layer gives the prediction result, that is, the risk probability of knee injury.

On the basis of establishing a neural network, the next step is to train the model of the neural network. The learning process is divided into two stages: forward and reverse. On this basis, a method based on forward propagation is established, which can effectively improve the robustness of the model. The loss function and optimization algorithm used in the training process. In the training process, a data enhancement method is used to improve its promotion performance and avoid overfitting. The model can monitor the athlete's exercise status in real time and predict the dangers that occur. During training and competition, through the analysis of the sports information obtained in real time, behaviors that may cause knee load and inappropriate pressure are identified and warned. The model can also be used to formulate personalized training and rehabilitation programs, according to the individual conditions of athletes, put forward targeted prevention and rehabilitation opinions, adjust training intensity, change training methods, and strengthen specific parts of training. In the long run, this intelligent monitoring and feedback system of neural networks is of great practical significance for reducing knee injuries, improving training effectiveness, and prolonging sports life. The use of neural network methods in sports training can not only accurately predict the risk of knee injury, but also provide a scientific basis for the prevention and treatment of diseases and rehabilitation, so as to effectively protect the physical health of athletes. The neural network structure of this article is shown in **Figure 3**:

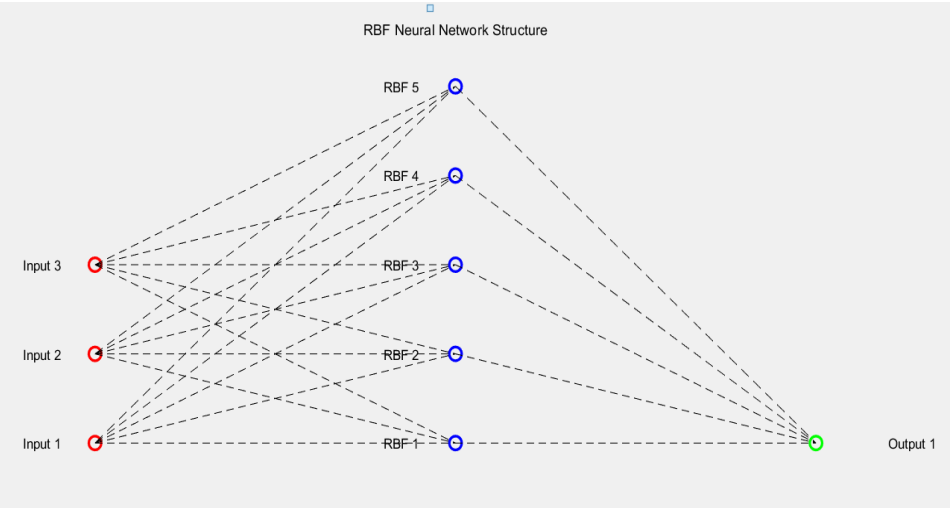

Figure 3. Neural network structure in this article.

1) Selection of basis functions

The Gaussian function is selected as the activation function of the hidden layer unit:

$$R_j(x) = e^{\frac{\|x-c_j\|}{2\sigma_j^2}} \tag{1}$$

Among them, $R_j(x)$ is the output of the j-th hidden node, c_j is the kernel function center vector of the j-th hidden layer node, and the network output is defined as:

$$y_j = \sum_{j=1}^{k} \omega_{ij} R_j(x) \tag{2}$$

$$i = 1,2,\ldots,m \tag{3}$$

Among them, w_{ij} is the connection weight from the j-th hidden layer node to the i-th output layer node.

2) Update of radial basis function center, width and weights to the output layer

The radial basis function center and other parameters undergo a learning process. The error correction learning process is usually used, and the gradient descent method is applied, as follows:

Assuming there are N sample inputs, for all input samples, the error function is defined:

$$\xi = \frac{1}{2}\sum_{q=1}^{N} e_q^2 \tag{4}$$

Among them, e_q is the error, which is defined as follows:

$$e_q = d_q - y(x_q) = d_q - \sum_{j=1}^{3} \omega_{1j} R_j(x_q) = d_q - \sum_{j=1}^{3} \omega_{1j} e^{-\frac{\|x_1-c_j\|^2}{2\sigma_j^2}} \tag{5}$$

Among them, d_q is the value of the required type of the sample x_q.

3) Iterative process of each free parameter

(1) The weight of the output unit

$$\frac{\partial \xi(n)}{\partial \omega_{ij}(n)} = -\sum_{q=1}^{n} e_q(n) R_j(x_q) = -\sum_{q=1}^{n} e_q e^{-\frac{\|x_q-c_j\|^2}{2\sigma_j^2}} \tag{6}$$

$$\omega_{ij}(n+1) = \omega_{1j}(n) - \eta_1 \frac{\partial \xi(n)}{\partial \omega_{ij}} \tag{7}$$

Among them, n represents the current value of the variable, and $n + 1$ represents

the value after iterative correction.

(2) Hidden unit center

$$\frac{\partial \xi(n)}{\partial c_j(n)} = -\sum_{q=1}^{n} e_q R_j(x_q) = -\sum_{q=1}^{n} e_q \frac{\omega_{1j(n)}}{\sigma_j^2} e^{-\frac{\|x_q - c_j(n)\|^2}{2\sigma_j^2}} \left(x_q - c_j(n)\right) \tag{8}$$

$$c_j(n+1) = c_j(n) - \eta_2 \frac{\partial \eta(n)}{\partial c_j} \tag{9}$$

(3) Function height

$$\frac{\partial \xi(n)}{\partial \sigma_j(n)} = -\sum_{q=1}^{n} e_q \frac{\omega_{1j}(n)}{\sigma_j^3(n)} \|x_q - c_j\|^2 R_j(x_q) \tag{10}$$

$$\sigma_j(n+1) = \sigma_j(n) - \eta_3 \frac{\partial \xi(n)}{\partial \sigma_j(n)} \tag{11}$$

Among them, η_1, η_2, η_3 are learning efficiency, which can be constants or variables.

4) Correlation between neurons

$$\rho_{X,Y} = \frac{\mathrm{cov}(X,Y)}{\sigma_x \sigma_y} \tag{12}$$

The connection strength between each node in the weight graph G is defined as:

$$a_{i,j} \begin{cases} |z(i,j)||z(i,j)| \geq T \\ 0 \qquad \text{other} \end{cases} \tag{13}$$

The global efficacy of a neural network, Eglobal, is defined as the reciprocal (harmonic inverse) of the harmonic mean of the shortest path lengths between any two nodes in the network. This parameter is a global indicator used to measure the speed of information transmission in the network:

$$E_{\text{global}} = \frac{1}{N(N-1)} \sum_{i \neq j \in A} \frac{1}{L_{i,j}} \tag{14}$$

Through the global performance index of the network, the network vulnerability V_i of the i-th node is defined as the i-th node. After the edges between all nodes directly connected to it are removed, the resulting new network is compared with the original network in the proportion of the decrease in the global efficiency index:

$$V_i = \frac{E_{\text{global}} - E_{\text{global}}^i}{E_{\text{global}}} \tag{15}$$

4. Prevention and rehabilitation measures for knee injury

1) Preventive measures for knee injury

For conventional knee injuries, the main thing is to change the training method. In daily training, movements that can prevent knee injuries are added to the training. For anterior cruciate ligament injury, meniscus injury and hip bone injury, methods such as squatting against the wall, static contraction exercises, front and rear lunges and squatting can be used for prevention. However, lateral lunges and lateral decubitus gluteus Medius exercises can be performed for medial collateral ligament injuries to avoid sports injuries [24]. The prevention of knee joint injury can be supplemented by the knee joint early warning system constructed by the algorithm proposed in this paper to detect the knee joint injury and issue an alarm in time. According to the hazard level, different alarms are issued, which allows athletes to have certain psychological

expectations, so as to avoid the occurrence of knee joint injuries.

2) Rehabilitation measures for knee injuries

For mild to moderate injuries, the primary goal of conservative treatment is to relieve or prevent symptoms. According to this principle, the rehabilitation of knee injuries is divided into different therapies: exercise therapy, physiotherapy and traditional Chinese medicine. Exercise therapy includes ankle pumps, leg lifts, knee stretches, half-leg wall lifts, stair climbing, balance and proprioceptive training [25]. Physiotherapy includes ultrasonic therapy, infrared therapy, intermediate frequency pulse current therapy, transcutaneous electrical nerve stimulation therapy, etc. TCM treatments include acupuncture, cupping therapy, and massage. In general, different treatment methods should be selected according to the different conditions of athletes. The different treatments are summarized in **Figure 4**.

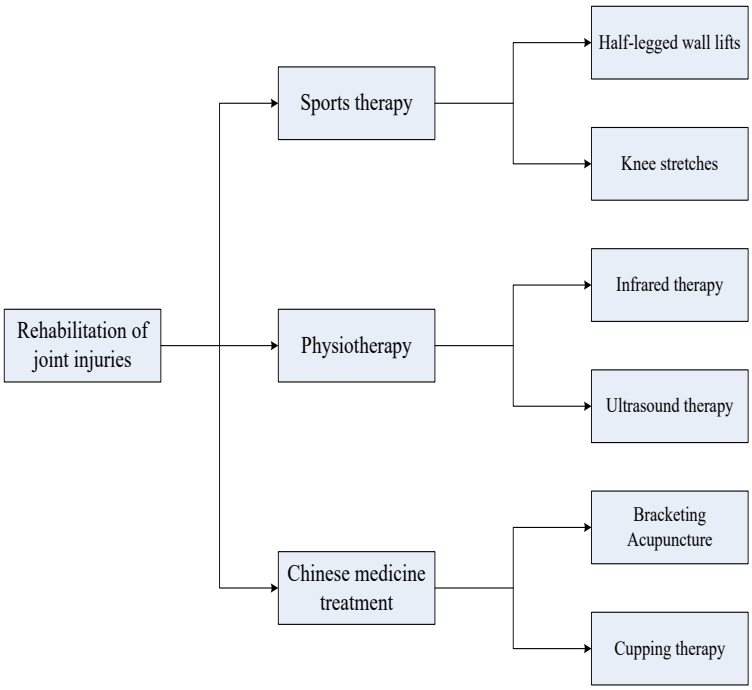

Figure 4. Rehabilitation measures for knee injuries.

3) Measures to improve the condition of the knee joint

In the process of sports training, various comprehensive interventions should be adopted for the prevention, treatment and rehabilitation of knee joint injuries to ensure the recovery of their normal physiological functions and functions. Be prepared to prevent knee injuries. Warm-up exercises can raise joint body temperature, promote blood circulation, and reduce the risk of injury. Stretching exercises can enhance muscle flexibility, but also improve the range of motion of the joints. It is very important to exercise the muscle strength of the muscles around the knee. Through targeted training of the quadriceps, hamstrings, adductors, extensors, etc., the stability of the knee joint is improved, the load on the joint is reduced, and the wear and tear of the joint is reduced. Proper movement posture and skills are also very important. Athletes must be guided by a professional trainer to practice in the correct posture to prevent knee injuries caused by improper posture.

For the injured knee joint, methods such as ice application, compression, and

elevation of the affected limb can be used to relieve swelling and pain. After that, functional recovery training should be carried out gradually. At the beginning, do some minor activities, weight-free joint range training, exercise in water, etc., and then gradually move to muscle-strengthening and flexible exercise. In the later rehabilitation process, balance and coordination exercises can be used to help rebuild knee function and stability.

Physical therapy also has a great impact on the rehabilitation of the knee joint. Physical therapy is mainly through massage, ultrasound therapy, laser therapy and other methods to accelerate tissue repair, so as to achieve the purpose of relieving pain and inflammation. Targeted training programs should start from the nature of the injury, the severity of the injury, and the characteristics of the athlete himself in order to ensure the scientific and effective training. Athletes should pay attention to step-by-step recovery to prevent secondary injuries caused by overtraining. At the same time, maintaining a good attitude and actively performing rehabilitation exercises are of great significance to improve the efficacy of rehabilitation. Through the comprehensive prevention and treatment of the above aspects, it will play a positive role in improving the physical fitness of athletes, reducing the occurrence of sports injuries, promoting the recovery of sports functions, and returning to the competition as soon as possible.

5. Prevention and recovery effects

In order to avoid the occurrence of knee joint injury, this paper analyzes the prevention and rehabilitation effects of athletes' knee joint injury. Fifteen members of a training team with a history of sports knee injuries are investigated. The basic information of these players is recorded in **Table 1**.

Table 1. Basic information about the patient.

Gender	**Male**	**Female**
Number of people	10	5
Age	26.45 ± 6.24	25.34 ± 4.37
Height/cm	178.5 ± 2.6	167.3 ± 3.7
Body weight/kg	76.5 ± 6.2	55.4 ± 4.5

In order to make a fair evaluation of the prevention and rehabilitation effects of athletes, this paper uses the Lysholm Knee Score to evaluate the condition of the knee before and after the measures are taken. It is mainly evaluated from four aspects: pain, instability, lock-in, and swelling. The maximum score for each item is 25 points, out of 100 points. The higher the score, the better the knee joint condition of the respondents. In order to exclude the influence of gender on the experiment, the survey subjects are marked 1 to 15 respectively.

Statistical analysis: The data analysis was conducted using SPSS 22.0; Use mean ± standard deviation (± s) to express measurement data that conforms to a normal distribution, and use p-value (a parameter used to determine hypothesis test results) between groups for comparison. $P < 0.05$ indicates that the difference is statistically significant.

1) Pain score

Pain is a major cause of motion in the knee joint. For ordinary people, if the pain is unbearable, they cannot walk, which affects their normal life. However, pain is life to movement. If an athlete cannot train properly, his career is ruined. Based on this, this paper scored the pain, and compared the pain scores before and after the measures are taken. The results are recorded in **Figure 5**.

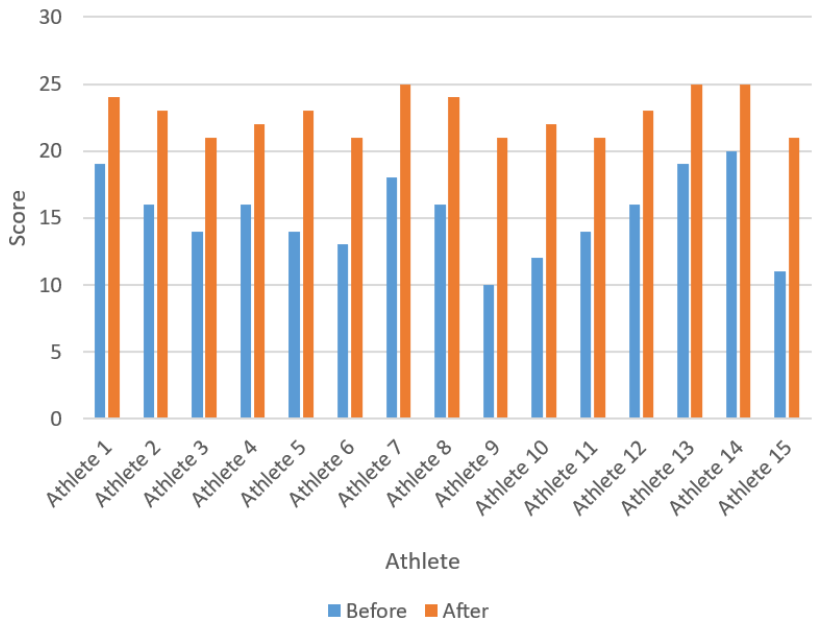

Figure 5. Athlete pain scores.

The athlete's pain score was centered on a 10- to 20-point scale before taking action. Only athletes No. 1, No. 13 and No. 14 had higher pain scores, indicating that pain was an important factor affecting the movement of the knee joint of athletes before taking measures. However, all athletes' pain scores remained above 20 after the measures were taken. The pain scores of athletes No. 7, No. 13 and No. 14 can all reach the highest level. It shows that the measures proposed in this paper to prevent knee injury in athletes have actually played a role in relieving knee pain in athletes, which has brought positive effects to athletes.

2) Instability score

If the athlete cannot control his own behavior, it not only brings great inconvenience to the training, but also affects the normal life of the athlete. In this paper, the anxiety scores of athletes before and after taking measures are recorded in **Figure 6**.

According to **Figure 6**, the anxiety scores of athletes 1, 5, 10, and 15 before taking measures were 15, 14, 16, and 20 points, respectively; After taking measures, the anxiety scores of athletes 1, 5, 10, and 15 were 22, 24, 21, and 25 points, respectively. It can be seen from this that after using the method proposed in this article, the anxiety of athletes has been significantly alleviated, and their instability has also been significantly improved. This indicates that this article can optimize the physical condition of athletes after sports injuries, enable them to better control their own behavior, reduce obstacles in sports training, and ensure that athletes can better train

and live normally.

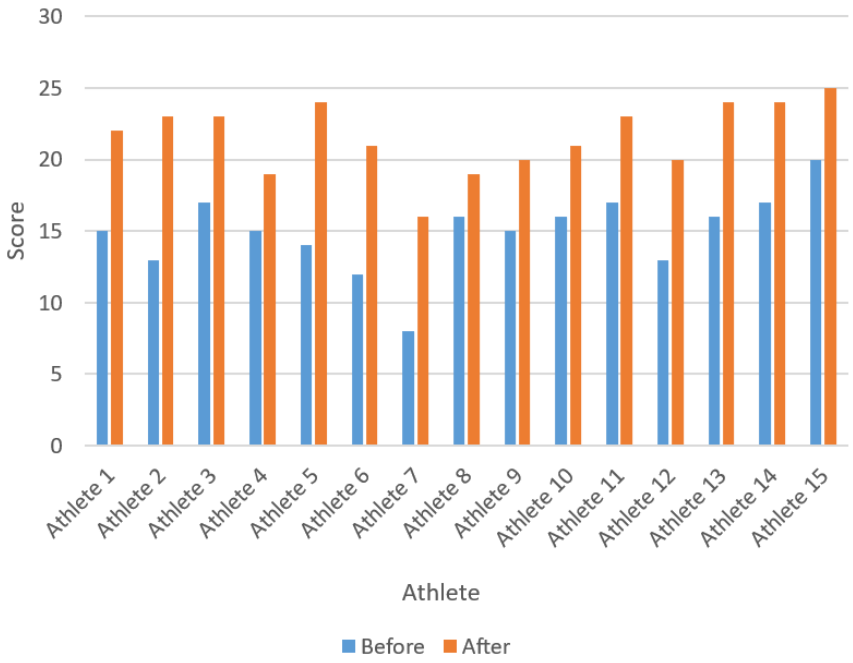

Figure 6. Unsettledness score.

3) Locking feeling score

Locking feeling mainly refers to the phenomenon that the knee is stuck and cannot move, and the knee cannot straighten or bend back. If the athlete often feels a locking sensation in the knee joint, this affects the athlete's control of the knee. It also has more serious consequences, which seriously affect the training situation and mentality of the athlete. Based on this, this paper investigates the knee lock feeling of athletes. The results are recorded in **Figure 7**.

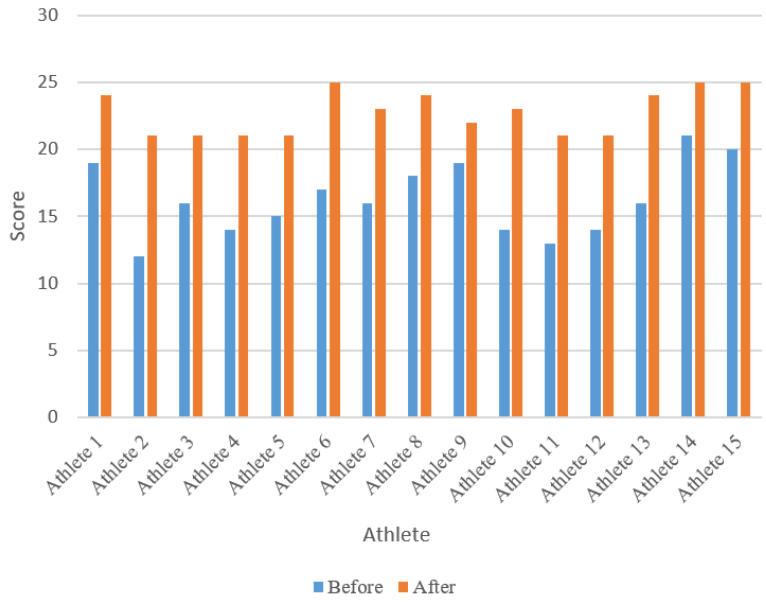

Figure 7. Occlusion score.

After the measures were taken, the athletes' lock-in scores were all stable within

the range of 21 points and above. It shows that the athletes all feel that the knee joint has no sense of locking, and they can control their own knee joint freely.

4) Swelling score

Swelling of the joints can interfere with muscle strength and training, and can also make walking very uncomfortable. This paper investigates the swelling scores of athletes. The results are recorded in **Figure 8**.

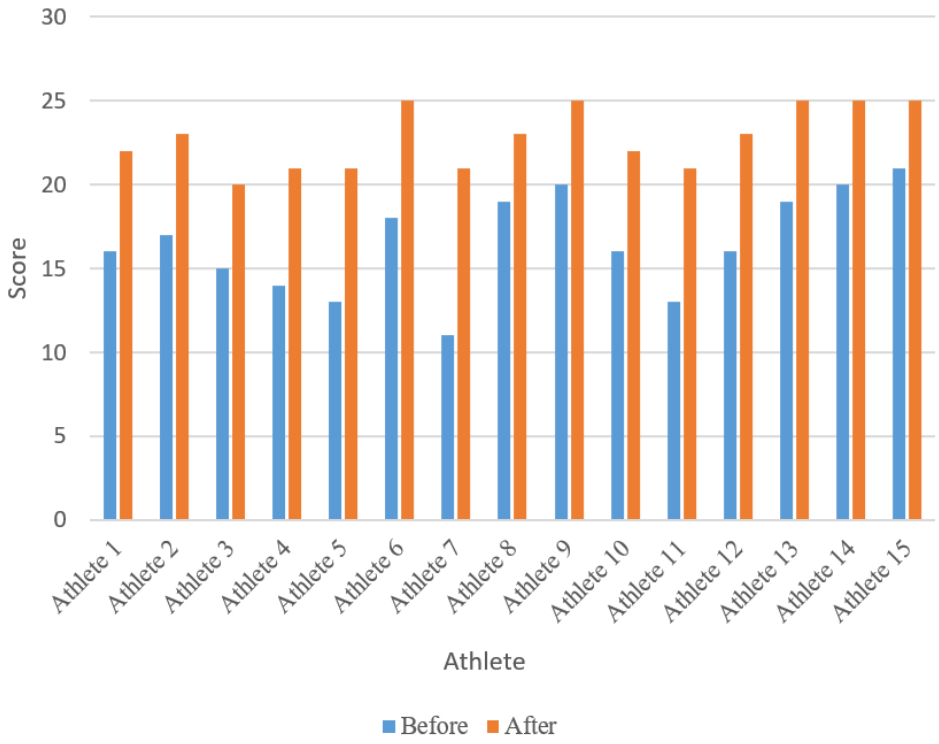

Figure 8. Swelling score.

As shown in **Figure 8**, after using the method proposed in this article, the swelling score of athlete 1 increased from 16 before use to 22; The swelling score of athlete 5 increased from 13 before use to 21; The swelling score of athlete 10 increased from 16 before use to 22; The swelling score of athlete 15 has increased from 21 before use to 25. It can be seen from this that after using the method proposed in this article, the joint swelling of athletes has significantly improved, which means that the method proposed in this article can better promote joint recovery and ensure better training for athletes.

Finally, this article used descriptive statistics to calculate the pain, instability, lock-in, and swelling scores of 15 participants before and after taking measures, using mean and standard deviation methods. The results are shown in **Table 2**:

Table 2. Descriptive statistical results.

Test item	Before taking	After taking	*P* value
Pain	15.2 ± 3.27	22.73 ± 4.18	0.012
Unstable	14.93 ± 2.96	21.6 ± 3.11	0.006
Lock	16.27 ± 3.25	22.73 ± 4.29	0.032
Swelling	16.53 ± 3.86	22.8 ± 4.77	0.036

According to **Table 2**, the scores of pain, instability, locking, and swelling before taking the measures were significantly higher than those after taking the measures, and the differences were statistically significant ($P < 0.05$).

6. Conclusion

This article first introduced the basic situation of knee joint injuries, and explained the common types of knee joint injuries and their causes. Prevention and rehabilitation strategies were proposed for existing knee injuries. Finally, the proposed countermeasures were analyzed for their effects. The Lysholm Knee Score was used to rate the condition of the athlete's knee before and after the measures were taken, and the conclusions were drawn. After taking the measures, the athlete's pain, instability, lock-in and swelling have been greatly improved, which has played a positive role in avoiding knee injury.

Availability of data and materials: The data and materials of this study are available from the corresponding author.

Ethical approval: Not applicable.

Conflict of interest: The author declares no conflict of interest.

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