Scholar Publishing Group
International Journal of Sports Technology
https://doi.org/10.38007/IJST.2023.040104
ISSN 2789-7141 Vol. 4, Issue 1: 49-62

Prediction of Spinal Cord Injury in Basketball Sports Based on Machine Learning and Rehabilitation Treatment Effect of Upper Limb Dyskinesia

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Keywords: Prediction of Spinal Cord Injury, Upper Extremity Dyskinesia, Machine Learning, Rehabilitation Treatment

Abstract: As a team sport, basketball has the characteristics of strong antagonism, appreciation and skill. In basketball, players usually have to face the huge pressure from many parts of the body, especially in the attack, defense, sudden action. In particular, the athletes need to be very professional in taking off, defending, breaking through and breaking into the basket. At the same time, because basketball has the characteristics of fast, quiet and accurate, the probability of upper limb movement disorder after injury is relatively high. Basketball is widely loved by young people today. With the progress of society, basketball has entered the life of the public, but there is also spinal cord injury. Spinal cord injury is a serious disease that cannot be cured at present, with a high disability rate and relatively serious consequences. For spinal cord injury, regular exercise rehabilitation training is a very effective treatment. Therefore, this paper proposed to use machine learning algorithm to predict spinal cord injury in basketball sports and analyzed the effect of rehabilitation treatment of upper limb motor disorders. The research shows that under the same other conditions, when FMS (Functional Movement Screen) $\geq$ 14 points, the injury rate of athletes is higher, and when FMS $\leq$ 14 points, the injury rate of athletes is lower. It shows that machine learning can effectively predict spinal cord injury in basketball.

1. Introduction

Spinal cord injury is a serious disability, which can lead to the loss of normal sensory, motor, autonomic nerve and urination functions, thus adversely affecting the patient's body, psychology, family and society. After spinal cord injury, almost all organs would be affected, and there are many complications. Its treatment is complex, difficult, long time, high cost and poor effect.

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Therefore, it is necessary to carry out early exercise rehabilitation and proper exercise. At present, there is no radical cure for spinal cord injury in the world. Many studies show that sports rehabilitation training can significantly improve the curative effect of spinal cord injury. Physical rehabilitation training can effectively activate the potential of patients, thereby significantly reducing and preventing complications and disabilities of patients. It is necessary to restore the patient's physiological function as soon as possible, so that the patient can return to normal social life. Sports rehabilitation is of great significance to the recovery of spinal function in patients with spinal cord injury. With the rapid development of science and technology, the continuous improvement of sports rehabilitation equipment has provided great help for the rehabilitation treatment of patients with spinal cord injury. Comprehensive adjustment should be made according to the patient's gender, age, physical condition, injury location, injury degree, mental status and other factors to achieve the best sports rehabilitation effect.

Based on this, this paper would use the linear regression analysis algorithm in machine learning to analyze the prediction of basketball spinal cord injury and the rehabilitation treatment effect of upper limb movement disorder, and study the relationship between them.

2. Related Work

Spinal cord injury is a serious disability, which can lead to the loss of normal sensory, motor, autonomic nerve and urination functions, thus adversely affecting the patient's body, psychology, family and society. In this context, more and more scholars have studied it. Wu F's research found that the application of isokinetic training in the walking function of basketball players with thoracolumbar spinal cord injury can significantly improve the therapeutic effect, actively improve the walking function of patients, and promote rehabilitation [1]. Hupp M neurophysiological assessment improved the prediction of functional prognosis after traumatic cervical spinal cord injury, and suggest using neurophysiology to optimize patient information, rehabilitation, discharge plan and design of future clinical trials [2]. Gruener H found that the pathological pain of central nervous system after SCI makes people weak and has a great impact on individuals [3]. However, the above researches are all theoretical researches on spinal cord injury, lacking scientific methods.

In view of the above situation, the use of machine learning to analyze spinal cord injury began to be noticed, and gradually launched in-depth research. The goal of Fallah N was to develop and validate a prediction tool that can predict the mortality after traumatic spinal cord injury based on machine learning technology [4]. DeVries Z showed that machine learning algorithms use acute demographic and neural information to predict the rehabilitation of patients with traumatic spinal cord injury [5]. Inoue T found that extreme gradient enhancement based on machine learning algorithm can accurately predict the changes of nervous system in cervical spine SCI patients [6]. These studies all illustrate the adaptability of machine learning in the field of spinal cord injury, and lay a foundation for its application in the prediction of spinal cord injury in basketball sports and the analysis of the effect of rehabilitation treatment of upper limb motor disorders.

3. Prediction of Spinal Cord Injury in Basketball Based on Machine Learning and Construction of Rehabilitation Training Methods for Upper Limb Motor Disorders

Machine learning is a multi-disciplinary interdisciplinary, including probability theory, statistics, convex analysis, etc. [7]. Machine learning algorithm is an algorithm to predict unknown data through automatic analysis of data and design of rules [8-9]. The process of machine learning is shown in Figure 1:

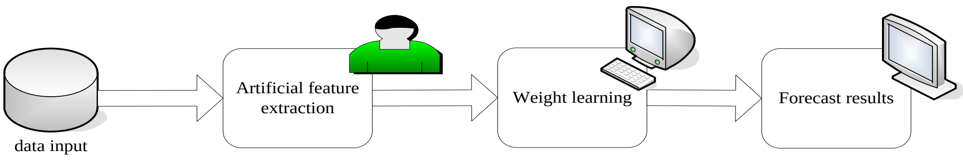


Figure 1. Machine learning flow chart

Machine learning technology has been widely used in various fields, such as data mining, computer vision, natural language processing, speech recognition, and games [10]. Its application fields are shown in Figure 2:

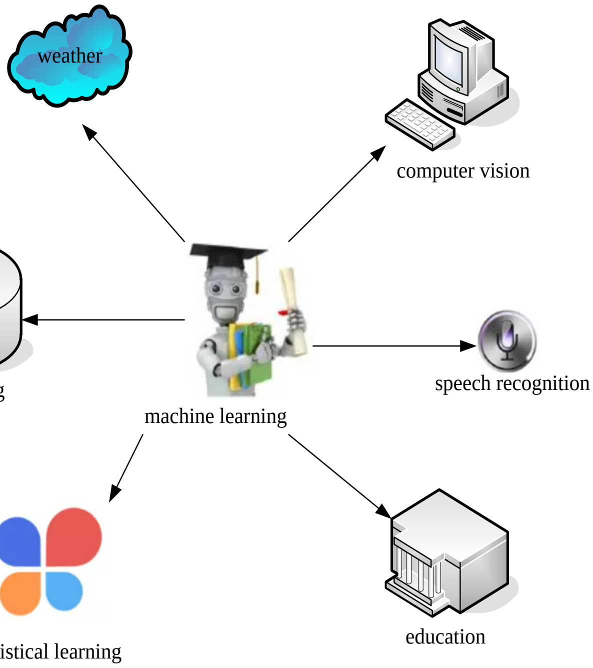


Figure 2. Application fields of machine learning

3.1. Spinal Cord Injury in Basketball

In basketball, the incidence rate of spinal cord injury is 6.0%, accounting for about 2.0% of the total death toll of basketball players [11]. From the clinical study of Chinese basketball, it can be found that most spinal cord injury patients occur 3 to 5 days after sports injury [12]. Among them, sports injuries that occur between the spine and spinal cord axons and spinal spinous processes are also called disabling spinal cord injuries. The damage of the anterior and posterior horn of the spinal cord would lead to instability of the anterior horn of the spinal cord, and would cause corresponding nerve damage [13-14]. The main manifestations of the injury were local muscle strength decline, muscle atrophy, disappearance of the posterior horn of the spinal cord, swelling or atrophy of the central area of the spinal cord, disappearance of kyphosis, instability of the transverse process of the spinal cord, and forward or backward protrusion of the posterior edge of the transverse process of the spinal cord. If an athlete encounters an opponent's impact or body collision in the course of sports, the anterior horn of the spinal cord would be damaged or even the spinal cord would be injured [15].

3.2. Machine Learning Based Rehabilitation Training Method for Upper Limb Motor Disorders

Although the neural network is usually used in the research of sports injury models in relevant studies, the types of upper limb movement disorders such as the weakening or weakness of upper limb muscle strength after the injury of athletes' muscles, tendons and joints, and the pain after the injury of lower limb muscles, tendons and joints have not been clearly reported [16-17]. In addition, most of the existing studies use functional recovery therapy to improve symptoms and functional recovery, such as exercise control, balance ability and other training programs, and exercise rehabilitation training programs aimed at improving upper limb pain and movement disorders. However, these methods have some limitations, resulting in poor recovery of upper limb function after upper limb injury. Therefore, some scholars proposed a method based on machine learning technology to predict athletes' upper limb movement disorder status and motion control level, so as to achieve the goal of improving the muscle endurance and motion control ability of patients with upper limb movement disorder, improving the level of motion control, upper limb movement function status and patients' quality of life [18]. This paper constructs and evaluates the model by analyzing the factors such as athletes' movement control after injury, the status quo of upper limb movement disorder and the existing problems. It extracts feature parameters according to the model construction feature values, uses linear regression analysis algorithm to analyze the training and prediction effects of the data, and uses machine learning technology to build a training model to detect its effects [19].

3.3. Regression Algorithm Based on Machine Learning

Algorithm principle of spinal cord injury prediction in basketball

In practical problems, it is often necessary to analyze a phenomenon and its most important influencing factors. In basketball games, there are many factors affecting spinal cord injury, and FMS score is one of the main factors affecting spinal cord injury [20]. This study focuses on the correlation between basketball spinal cord injury and FMS score, and by observing a large number of real values between them, the correlation between them can be obtained. Based on the FMS score, basketball spinal cord injury can be predicted. The univariate linear regression model can better reflect the uncertain relationship between the two variables. The general method is to represent the spinal cord injury and FMS in basketball with B and A respectively, and corresponding to the actual observation value, and generate B and A scatter plots in the plane coordinate system. If the scatter plot is basically on a straight line, it means that there is a strong linear relationship between the two variables. People score A for each FMS and build a straight line. It is expected that through this fitting straight line, the spinal cord injury corresponding to each FMS score can be predicted. The least squares method is used to observe by constructing a straight line. In this way, the line should minimize the sum of all observed true values and the vertical deviation of the line.

Let any straight line $b=\chi_0+\chi_1 a$, where χ_0 and χ_1 are to be determined. When $a=a_0$, the ordinate of this line is $\chi_0+\chi_1 a$. The vertical distance between point (a_o,b_o) and it can be shown as:

$$\left|b_o-(\chi_0+\chi_1 a_o)\right| \tag{1}$$

To fit m points into a straight line, P is the sum of the vertical distances of m points, then:

$$P=\sum_{o=1}^{m}\left[b_o-\left(\chi_o+\chi_1 a_o\right)\right]^2 \tag{2}$$

The least squares method can be used to determine the value of χ_0 and χ_1 that must be selected to minimize the value of P.

It is not difficult to minimize the value of P by considering χ_0 and χ_1. It can use:

$$\frac{\alpha P}{\alpha \chi_0}=-2\sum_{o=1}^{m}\left(b_o-\chi_o-\chi_1 a_o\right) \tag{3}$$

$$\frac{\alpha P}{\alpha \chi_0}=-2\sum_{o=1}^{m}\left(b_o-\chi_o-\chi_1 a_o\right)a_o \tag{4}$$

If formulas (3) and (4) are equal to 0, it can get:

$$\chi_0 m+\chi_1\sum_{o=1}^{m}a_o=\sum_{o=1}^{m}b_o \tag{5}$$

$$\chi_1\sum_{o=1}^{m}a_o+\chi_1\sum_{o=1}^{m}a_o^2=\sum_{o=1}^{m}a_o b_o \tag{6}$$

Let formulas (5) and (6) be the normal formulas of χ_0 and χ_1. By considering the second order partial derivative of P, it can be proved that the values of $\hat{\chi}_0$ and $\hat{\chi}_1$ satisfying the normal formula are the values that minimize the sum of squares P in formula (3). If these values are represented by $\hat{\chi}_0$ and $\hat{\chi}_1$, the linear formula obtained by the least square method can be obtained as follows:

$$b=\hat{\chi}_0+\hat{\chi}_1 a \tag{7}$$

This line is called the least squares line.

Let $\bar{a}_m=\left(1/m\sum_{o-1}^{m}a_o\right)$ and $\bar{b}_m=\left(1/m\sum_{o-1}^{m}b_o\right)$, for χ_0 and χ_1, by solving formulas (5) and (6), it can get:

$$\hat{\chi}_1=\frac{\sum_{o=1}^{m}a_o b_o-m\bar{a}_m\bar{b}_m}{\sum_{o=1}^{m}a_o^2-m\bar{a}_m^2} \tag{8}$$

$$\hat{\chi}_0=\bar{b}_m-\hat{\chi}_1\bar{a}_m \tag{9}$$

Now let's look at the algorithm of multiple linear regression. Multivariate linear regression is based on the univariate linear regression, and variables affecting b are added to fit the following multivariate linear functions:

$$b=\chi_0+\chi_1 a_1+\wedge+\chi_l a_l \tag{10}$$

Under this condition, the value of $\chi_0,\ldots\ldots,\chi_l$ is calculated by the least square method, and the algorithm principle is basically consistent with the linear regression of one variable. In fact, nowadays, computer statistical software can quickly calculate the least squares regression line.

4. Experimental Analysis on Prediction and Treatment of Spinal Cord Injury in Basketball

4.1. Prediction of Spinal Cord Injury in Basketball

(1) Research object

Taking 70 basketball majors of 2019, 2020 and 2021 levels in a sports university as the objects, the FMS scores were investigated. The average age, height and weight of the subjects in this study are 20.03 cm, 186.90 cm and 81.19 kg respectively, including one national master, four first class athletes, 51 second class athletes and 14 non second class athletes. The training period is divided into four in 11 years, five in 10 years, eight in 8 years, ten in 6 years, 14 in 5 years, five in 4 years and 24 in 3 years, as shown in Table 1:

Table 1. Basic information of subjects

	Male
Age	20.04±2.54
Height	186.37±6.59
Weight	79.82±9.29
Years of exercise	5.44±2.52

(2) Experimental methods

FMS tester was used to test the subjects, and the procedure is as follows:

Before the experiment: the testers can be trained to make them familiar with the content and scoring conditions of the test, and try to do the best demonstration. Before the test, the test content, scoring criteria and questions shall be briefly introduced, and then the printed scoring form shall be sent to the tester, who shall fill in the name, gender and date of birth. After filling in, the test shall be carried out in sequence according to the serial number.

In the experiment, the order of the test is seven clockwise movements. After completing one item, this paper would give the corresponding score in the examinee's scoring table according to the scoring criteria. During the test, an examiner took a camera to take a picture of it, recorded the experimental results, and evaluated the experimental results.

Experimental requirements: The subjects wore loose sportswear and sports shoes, and then carried out pre competition preparation activities.

Experimental observation stage: the experiment lasted for eight weeks from the winter league match of a sports university to the last round of the first round of group match (October 13-December 7). The team of the subject was monitored, tracked and recorded the occurrence and location of sports injuries, and recorded the time loss caused by any injury defined as musculoskeletal injury (excluding contusion).

Test score: Seven simple screening actions can be used for grading. In each project, when a person finishes an action, if there is pain in one place, the test would be deducted points, and the pain location would be recorded. If the subject is unable to complete the specified exercise according to the exercise specification, or there is movement deviation in multiple positions during the examination, the item would be scored 1 point. Subjects can complete the screening, but some part of their body would compensate during the screening. This score is 2. The subjects completed the action in accordance with the screening code of conduct, and the score of this item is 3 points. The total score of FMS is the total score of 7 actions, and the score of each action is the highest score of the project. In addition, there are three injury examinations, namely shoulder, body control push ups and rotary exercises. This is an injury examination of the shoulder, spine and spine.

The subjects had no pain when completing the exercise test, the test result of this item was negative, and the score was recorded. If people feel pain when they finish the exercise test, the item would be judged as positive and would not be scored.

(3) Analysis of experimental results

Correlation between motor function screening score and early injury:

According to the motor function examination, 62 people were injured. The average score, standard deviation, 95% confidence interval and proportion of these people were 15.74, 2.64, 15.07-16.40 and 88.58% respectively. The number of people without injury is 8, and their data are 17.14, 1.27, 16.19-18.08 and 11.42%, as shown in Table 2:

Table 2. Results of motor function screening and pre injury

	History of damage	No damage history
N	62	8
Mean ± standard deviation	15.74±2.64	17.14±1.27
95% confidence interval	15.07-16.40	16.19-18.08
Percentage(%)	88.58	11.42

Table 2 is used to check the square difference, and one degree of freedom (df) is 1, 68, and the total df is 69. Sum of squares of deviations: the sum of squares of deviations between groups is 13.872, the sum of squares of deviations within groups is 431.214, the average variance is 13.872, and the average variance within groups is 6.341. F is 2.188, P=0.144>0.05, indicating that there is no significant difference between them.

According to the retrospective investigation on the injury status of the subjects before the experiment, the injured parts mainly occurred in the knee joint, ankle joint and waist, as shown in Figure 3:

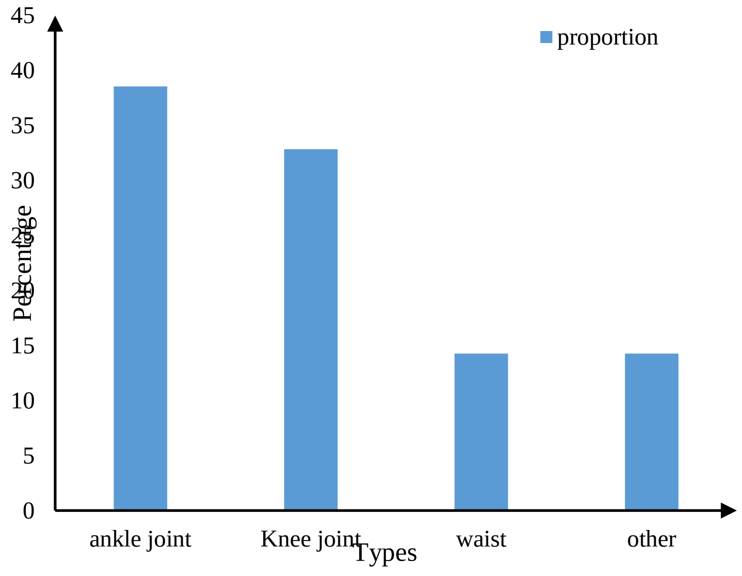


Figure 3. Damaged parts

It can be seen from Figure 3 that the ankle joint accounts for 38.58%, the knee joint 32.87%, the waist 14.28% and others 14.27%.

It can be seen from the above research results that the injured parts of basketball athletes in Beijing Sports School are mainly concentrated in the knee joint, ankle and waist. There was no significant difference between FMS score and early injury score (P=0.144.>0.05). All participants were not affected by any pain, which indicated that any individual comparison could be made without pain.

Relationship between motor function screening score and body symmetry:

The study found that there were 23 participants with symmetry, and their average score, quasi deviation, 95% confidence interval and proportion were 17.33, 1.30, 15.95-17.71 and 32.87% respectively. There are 47 people with asymmetry, and their values are 12.97, 3.42, 12.17-13.76 and 67.13%, as shown in Table 3 for details:

Table 3. Results of motor function screening and body symmetry

	History of damage	No damage history
N	23	47
Mean ± standard deviation	17.33±1.30	12.97±3.42
95% confidence interval	15.95-17.71	12.17-13.76
Percentage(%)	32.87	67.13

The FMS scores of symmetry and asymmetry in Table 3 were tested by one-way ANOVA. The df was 1 and 68, and the total df was 69. Sum of squares of deviations: the sum of squares of deviations between groups is 27.557, the average square within groups is 417.531, and the mean square between groups is 27.557, and the average square within groups is 6.141. F value was 4.489, P=0.038<0.05, the difference was statistically significant.

The results showed that there was a significant difference in FMS scores between symmetrical and asymmetrical groups (P=0.038<0.05). There are symmetrical movements such as deep squats and push ups with stable body, and the other five are hurdles, squats, shoulders, flexibility and rotation of lower limbs. These five asymmetrical movements are carried out in two different directions. When a person's body is asymmetrical, the movement ability of one part of his body would be reduced, and there would be no high-level movement. The score of FMS would also be reduced when performing motion function screening.

Analysis of the effect of action limitation and asymmetric performance on the prediction of basketball injury are as follows: before the winter training in a sports university and after the last round (8 weeks) of the group competition, the team of the subjects carried out injury monitoring, tracking and recording, and defined all injuries as muscle and bone injuries (excluding contusion) and injury locations. Among the people with new injuries, there are 6 people with FMS ≤ 14, 6 people with FMS>14, 3 people with symmetrical injuries, and 9 people with asymmetrical injuries.

The relationship between asymmetry performance and the appearance of new injuries during the observation period is shown in the Figure 4.

It can be seen from Figure 4 (a) that the number of people with symmetrical body injury is 3, the number of people without injury is 13, the number of people with asymmetrical body injury is 9, and the number of people without injury is 45. It can be seen from Figure 4 (b) that the incidence of symmetrical body injuries is 18.75%, and the incidence of asymmetrical body injuries is 16.67%. It can be seen from Figure 4 that the incidence of symmetrical body injuries is higher than that of asymmetrical body injuries.

Chi square test (N=70) was carried out for new damage and asymmetry during the observation period, and the results are shown in Figure 5.

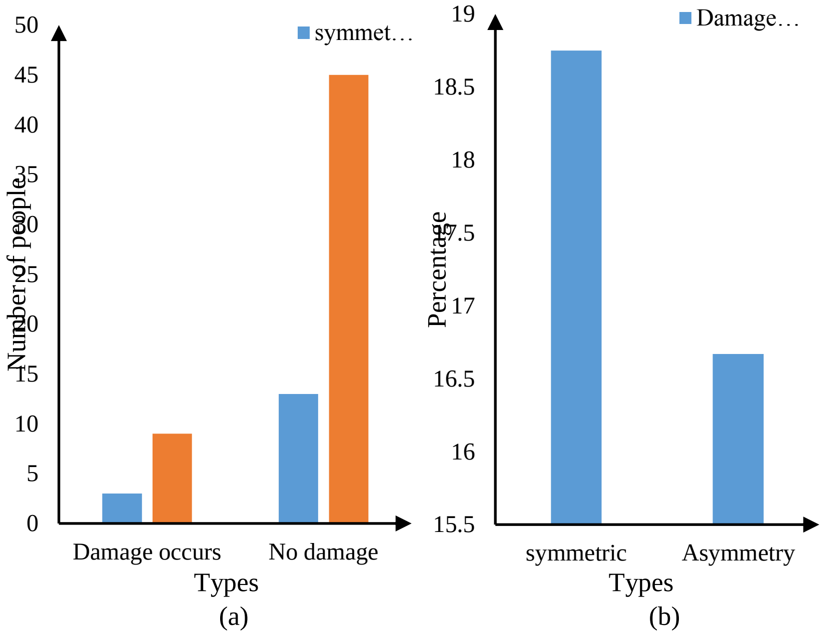


Figure 4. The relationship between asymmetry and new injuries in the observation period

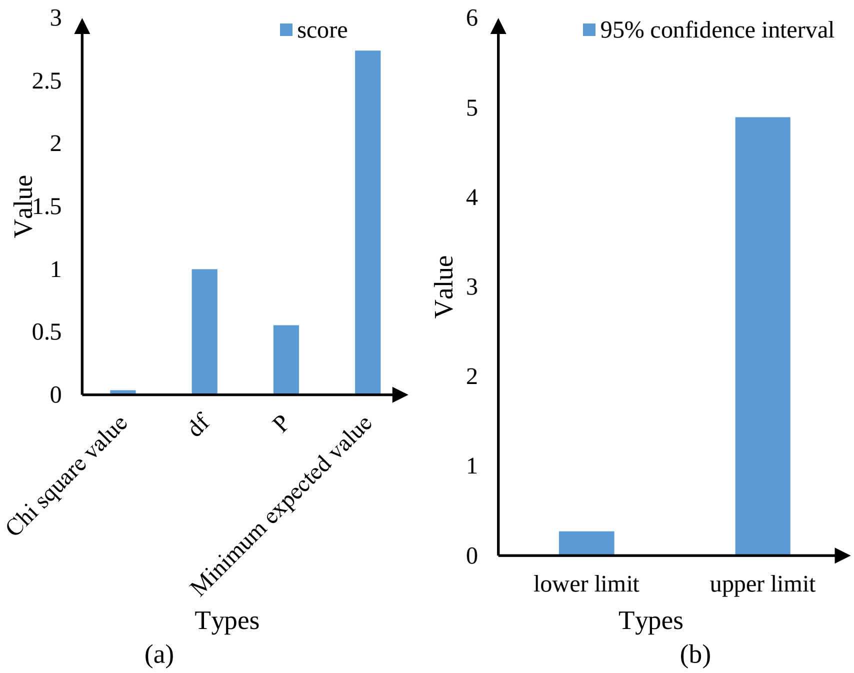


Figure 5. Chi square test of asymmetric performance and new damage in the observation period

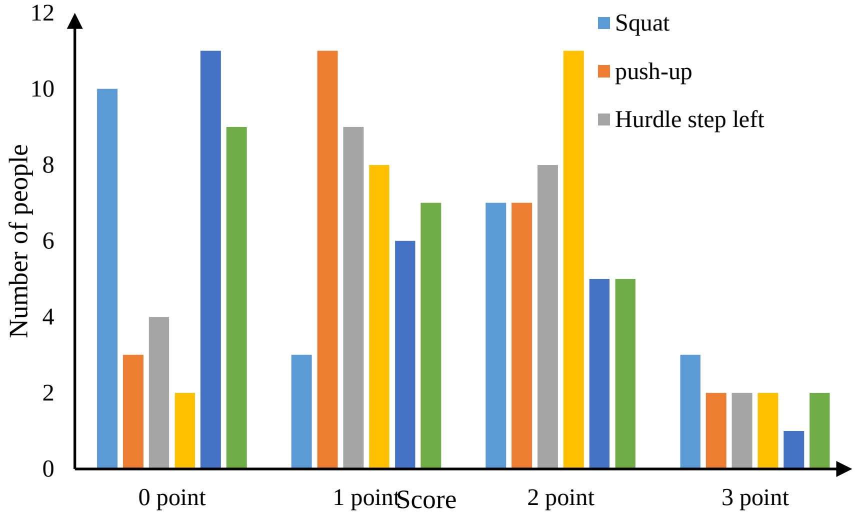
It can be seen from Figure 5 (a) that the minimum expected frequency is 2.74, the chi square value is 0.038, df=1, P=0.554, and from Figure 5 (b) that the upper and lower limits of the 95% confidence interval are 4.895 and 0.272 respectively. It can be seen from Figure 5 that P is significantly greater than 0.05, so it can be considered that there is no significant difference in the incidence of damage between the two groups.

To sum up: FMS score has no relationship with previous injury history. In the absence of pain, whether there is an injury history has no significant impact on FMS score, but body asymmetry has a significant correlation with FMS score. The cut-off point for predicting the injury probability of

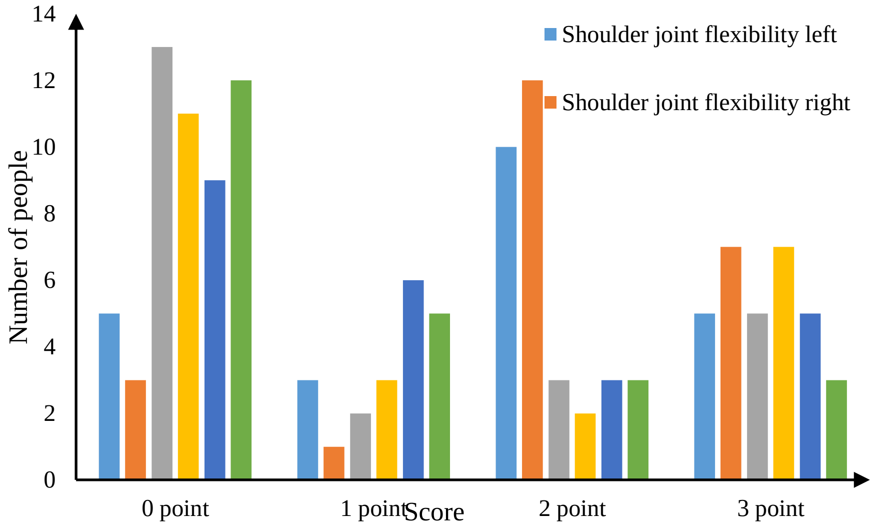
FMS and basketball players is 14 points. The injury rate during the observation period was related to the FMS score. When the FMS ≥ 14 points, the injury rate of athletes was higher, and when the FMS ≤ 14 points, the injury rate of athletes was lower. However, asymmetry cannot be regarded as an independent influencing factor of injury. The cut-off point of FMS score should be determined first, and asymmetry should be regarded as an additional risk factor.

4.2. Comparison of Test Results before and after Rehabilitation Physical Training

In November 2020, a comprehensive test before winter training was conducted for basketball in a sports university. After more than four months of high-intensity winter training, in March 2021, the experiment conducted a second round of testing on 23 major players, including FMS. After the comprehensive and systematic training in winter, the physical fitness and competitive level of athletes have changed greatly, as shown in Figures 6 and 7:



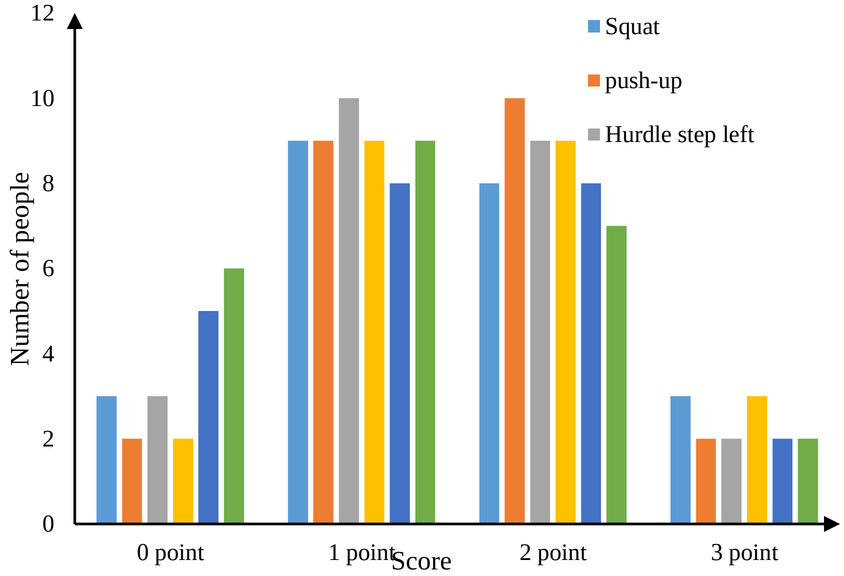
(a) Statistics of scores of squat, push up, hurdle stance and split leg squat before winter training



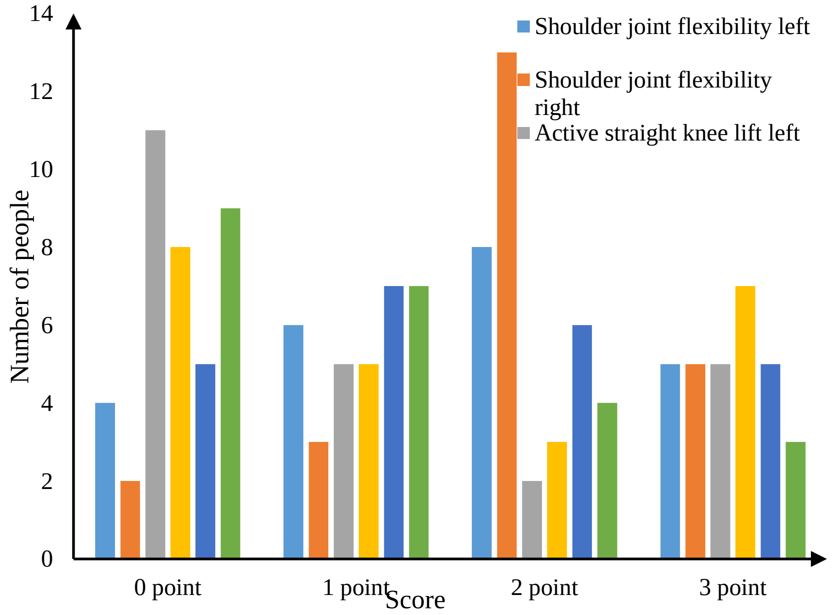
(b) Statistics on the number of scores of shoulder flexibility, active straight knee lifting and rotational stability before winter training

Figure 6. Statistics of scores of FMS test items before winter training

It can be seen from Figure 6 that the score of 0 is mainly concentrated in deep squatting, front and back leg squatting, active straight leg knee lifting, rotation stability and other items. The pain of athletes is mainly concentrated in the waist and knee. In addition, it can be seen from the data in the figure that the right side of the athlete has a better advantage than the left side in the symmetrical test. In the first and second test items, this asymmetry is particularly prominent. The results showed that the overall FMS score of basketball players was low, and exercise pain had a significant impact on performance. Similarly, athletes generally lack pillar strength and core stability, which may be due to their waist injuries.



(a) Statistics of scores of deep squat, push up, hurdle stance and front and back leg squat after winter training



(b) Statistics on the number of scores of shoulder flexibility, active straight knee lifting and rotational stability after winter training

Figure 7. Statistics of scores of FMS test items after winter training

It can be seen from Figure 7 that the score of 0 points dropped significantly, indicating that the physical fitness of the athletes has improved. There are 7 FMS motor function action screening questions, and the correlation between each item is very high. The item score is also the grading score, because the sample size is only 23. Therefore, it is impossible to compare the test results before and after winter training with conventional hypothesis tests, so only Wilcoxon test can be used. The test results show that under the same FMS test results before and after winter training, P=0.002 is less than 0.05, the results showed that the average FMS level before and after winter training was statistically different from that before and after winter training, and the average FMS score after winter training was higher than that before winter training. The results show that rehabilitation physical training has a great impact on the total score of FMS test, and the athletes' performance ability in rehabilitation physical training has been significantly improved, as shown in Table 4 and Table 5:

Table 4 Differences of athletes' total FMS scores before and after winter training

	Average of FMS total score
Before winter training	9.46±2.90
After winter training	12.63±2.55
Difference	0.002

It can be seen from Table 8 that there is a significant difference in the average growth rate of total FMS scores before and after rehabilitation training.

Table 5 Comparison of the difference in the growth rate of the total FMS scores of waist injured athletes before and after rehabilitation training

	Percentage
Average growth rate of FMS total score before rehabilitation training (%)	31.30±21.40
Average growth rate of FMS total score after rehabilitation training (%)	64.26±38.13
Difference	0.042

The results showed that after rehabilitation training, the total FMS score of athletes was significantly improved, and there was a significant difference compared with the growth rate of the total FMS score before and after the exercise. Through rehabilitation physical training for male basketball players, it can effectively improve their waist injuries and restore their sports functions.

5. Conclusion

The occurrence of spinal cord injury is one of the most common and serious sports injuries for athletes. The study found that the early rehabilitation of patients with upper limb movement disorder can effectively reduce the sports injury caused by upper limb movement disorder. The research shows that the use of neural injury prediction model is a safe, effective, economical and reliable strategy without adverse side effects for the rehabilitation of patients with upper limb motor disorders. According to the process of sports injury, this paper divides it into three stages: acute stage (9-12 weeks), stable stage (13-15 weeks), and recovery stage (16-20 weeks). The study found that the use of neural injury prediction model can more accurately predict the risk of motor injury in the rehabilitation treatment of patients with upper limb motor disorders. The study found that the use of neural injury prediction model to predict the risk of basketball sports injury can better predict the rehabilitation effect of upper limb movement disorder patients. It can avoid sports injury caused by bad living habits and limb dysfunction due to motor nerve damage, and avoid serious consequences caused by sports injury. Therefore, in the future, the neural injury prediction model can be used to predict the risk of basketball sports injury and provide a treatment plan, so as to realize the risk prediction of sports injury and rehabilitation treatment.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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