

REHABILITATION PRINCIPLE AND PROGRESSIVE FUNCTIONAL TRAINING METHOD OF KNEE JOINT

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Abstract:

As the most complex joint in human body, the stability of knee joint is the basis of the whole knee joint movement. Common knee injuries are collateral ligament injury, anterior and posterior cruciate ligament injury, meniscus injury, patellar strain, etc.. Prehabilitation is more important than treatment. The rehabilitation principle of knee joint includes two parts: treatment and training. On the basis of using all kinds of physical therapy to solve the pain problem, we should pay more attention to the function training of knee joint. This training method is usually from simple movement to complex, from low-level to high-level. It is a progressive training method, so it can enhance the knee function, and speed up the rehabilitation process effectively. The knee joint training exercise includes balance, lower limb knee joint proprioception and strength training to lower limb power chain, the stability training of the knee joint is also an important content of preventive exercise.

Key words: Rehabilitation; functional training; prehabilitation; stability; balance...

THE STRUCTURE OF THE KNEE JOINT

The knee joint is one of the most complex human body. The structures of the knee joint include the femur, tibia, fibula, patella. The main function of the knee joint is flexion and extension movement, in semi flexion or flexion 90 degrees rotate slightly. The muscles and tendons around the knee joint, medial and lateral collateral ligament, anterior and posterior cruciate ligament and meniscus of inner and outer structure, to maintain the stability of knee joint. Injury in any component of the knee joint will affect the overall function of the knee joint[1]. There are four ligaments in the knee joint, the medial collateral ligament (MCL), the lateral collateral ligament (LCL), the anterior cruciate ligament (ACL), and the posterior cruciate ligament (PCL). The lateral collateral ligament is used to strengthen the knee joint from the coronal plane, and the cruciate ligament (anterior cruciate ligament and posterior cruciate ligament) is used to strengthen the knee joint from the sagittal plane. The two fiber bundles of the medial collateral ligament, one longitudinal and one oblique. The medial

joint capsule composite structure can prevent excessive knee valgus. In valgus stress, the superficial medial collateral ligament were the most vulnerable to injury. The fiber in the knee extension tension, relax in flexion. When the internal rotation of the tibia is performed, the fiber is in a vertical relaxation position, and the fiber is inclined and tense when doing external rotation. The anterior cruciate ligament comes from the femur and ends in the tibia, and the posterior cruciate ligament comes from the femur and ends at the tibia. The anterior cruciate ligament attaches to the lateral femoral condyle, and inclined forward end at the tibial intercondylar eminence. In the whole range of motion of knee joint, anterior cruciate ligament tension is changing. When the knee ACL tension, and knee extension exists after external beam tension. The average ligament is 4 cm long, 1 cm thick averagely. The main function of the anterior cruciate ligament is to minimize the anterior displacement of the tibia and prevent the internal rotation of the tibia, which is also the mechanism of the ligament injury[2][3].

There are several potential damage factors in

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the structure of the knee joint, such as a long force lever line in the knee joint, lacks of the surrounding muscles, ligaments on both sides of the buckling relaxation, joint stability decreased; in the process of sports training and competitions, there are a lot of technical support for the lower limb movements, running jump, bending and twisting, will increase more burden to the knee joint definitely. Therefore, the knee joint is more prone to sports injury of the joint.

BIOMECHANICAL ANALYSIS OF THE KNEE JOINT

Joint biomechanics is usually focus on affiliated movement in connection of joint surface. The biomechanical characteristics of knee joints in gait analysis are influenced by muscle strength, joint stability and direction of motion. Some scholars have found that such as normal gait performance should be with good stability in the support phase, and in support of the knee joint can absorb shock energy accumulation, during the swing phase knee can drive the movement of the lower leg and foot, to complete this action at about 60 degrees of knee flexion. At the same time, the normal gait should be bilateral symmetry, although it will be affected by left and right, but if the asymmetry is more than 8%-10%, it can be considered that there is an abnormal phenomenon. In addition to the changes in flexion angle, there are also scholars to study the knee in a certain angle and different internal and external rotation abduction and adduction condition, the pressure change between the tibiofemoral joint. The test results show when joint angle changes occurred 1 degrees, can affect the biomechanical properties of the tibiofemoral joint; and in rotation and adduction or abduction and abnormal, more likely to cause meniscus stress concentration, resulting in injury.

On the other hand, knee injury and knee osteoarthritis patients compared to normal people has its specific biomechanical properties of knee joint. Farrokhi S [13] was compared with gait analysis of 12 normal subjects and 14 patients with knee osteoarthritis. It was found that the knee flexion of the patients with first touchdown was much less than that of the

normal subjects. The abnormality of knee joint inversion in gait analysis can cause the abrasion of medial and lateral tibial cartilage and aggravate the symptom [14]. Some scholars [15] have found the correlation between knee injury and knee biomechanical characteristics in gait analysis. So the analysis of the key link of abnormal gait is helpful to discover the risk factors of knee joint injury, and has important guiding significance for the Prehabilitation and rehabilitation of the disease.

Affiliated movements include two types of rolling and sliding. Two kinds of motion usually occur together or continuously, and the effect usually is that when one surface rolls, the other face slides in the opposite direction. A comprehensive understanding of the joint support structure and the forces exerted on the patellofemoral joint, knee joint and ankle joint can provide a reference for the rehabilitation course and safe return to the exercise field [4]. If the knee ligament is a static stability system, then the muscle around the knee is a dynamic stability system. The displacement of the anterior cruciate ligament is mainly in front of the femoral tibial limit. Suffer from excessive valgus stress, the medial collateral ligament of knee joint will help maintain stability. The lateral collateral ligament and anterior cruciate ligament joint to maintain its rotational stability.

There may be patellofemoral pain in an running athlete. The cause of pain may be the insufficiency of the gluteal muscle strength, the tension of the iliotibial band, the increase of the angle during the motion of the femur, and the pronation of the subtalar joint. Reducing the frequency can reduce the number of steps, then decrease the total pressure of the patellofemoral joint. The movement and lateral knee flexion required offset will lead to continuous stress acting on the patellofemoral joint. Running with tibial internal rotation, anterior cruciate ligament injury will increase. Lateral swing movement will give more pressure in patellofemoral joint.

At high speed, the patellofemoral pain syndrome is actually the result of insufficient muscle strength around the knee joint. In addition, insufficient muscle strength of the

gluteus medius, gluteus maximus, and psoas muscles may also increase the pain of the patella at high speed movement. In running movement, hamstrings, Poor flexibility of quadriceps, soleus, gastrocnemius flexibility will increase the pain in the patellofemoral syndrome.

2. Elementary, intermediate and advanced Prehabilitation

Prehabilitation can be divided into three levels ,elementary, intermediate, and advanced Prehabilitation. Elementary Prehabilitation involves the avoidance of injury. An example is ankle braces being worn as a protection device, even those with no history of previous ankle injuries. If elementary Prehabilitation activities were effective, there would be a lesser chance of injuries occurring in the first place. Intermediate Prehabilitation involves an early diagnosis and treatment should be acquired once an injury has occurred. The goal of obtaining early diagnosis is to ensure that the injury is receiving proper care and recovering correctly, therefore concerns about other unrelated medical issues have been reduced. Lastly, advanced Prehabilitation is solely focused on the rehabilitation to reduce and correct an existing disability resulting from the traumatic event. An example in the case of an athlete who has obtained an ankle injury the rehabilitation would consist of balance exercises to acquire the strength and mobility back ,wearing an ankle brace, while gradually returning to the sport.

COMMON INJURY OF KNEE JOINT

(1) injury of medial collateral ligament

The medial collateral ligament from the femoral epicondyle to the medial tibial condyle. Attached to the medial collateral ligament and joint capsule, meniscus structure. Knee flexion (about 130-150 degrees), with the sudden abduction of the crus, or foot and leg fixed, sudden adduction and internal rotation of the thigh, can make the medial collateral ligament injury. The injury also occurred in others event: the jump when the landing is not correct, no legs together, unilateral leg to abduction movement and body weight loss of balance, or joint lateral violence and impact damage. The torsion force

is closely related to the degree of injury. The serious torsion force can make the ligament rupture completely, and tear the medial meniscus and the anterior cruciate ligament injury at the same time.

(2) injury of the lateral collateral ligament

The lateral collateral ligament attaches from Lateral condyle of femur to the fibular head. Flexion of the knee, with sudden adduction and internal rotation of the crus, or sudden abduction and external rotation of the thigh, can occur lateral collateral ligament injury. The lateral collateral ligament is a round beam, stronger than the medial collateral ligament, and with the reinforcement from biceps femurs tendon and iliotibial band tendon, it has the less chance of ligament damage.

(3) cruciate ligament injury

The cruciate ligament locate in the knee joint capsule, a total of two for anterior cruciate ligament and posterior cruciate ligament. The cruciate ligament locate in front of the tibial intercondylar eminence, to the medial and lateral of the femoral fossa. The main function is to limit the excessive forward and backward movement of tibia. The knee joint is in the semi flexion position, and the sudden rotation, adduction and abduction are the important mechanisms of the cruciate ligament injury. Single anterior cruciate ligament injury is not rare, and usually occur with medial collateral ligament or meniscus injury.

(4) meniscus injury

The meniscus is located within the knee meniscus cartilage, hence the name. The structures are thick at the edge and thin in the middle. They are filled in the tibia, the lateral condyle and the femoral and intercondylar space respectively. Meniscus deepened the tibial plateau articular fossa, increase the stability of knee joint. Knee flexion with half crus abduction and adduction and internal rotation of the knee joint at the same time, suddenly Straighten the knee joint, there will be contradiction movement of the meniscus. With the crus leg in abduction and internal rotation, or adduction and external rotation, meniscus will be sliding with rotation of the femur, then

meniscus must be returned to the original position when the knee joint straightens. If the knee is in flexion, abduction or adduction and internal rotation while suddenly straightens the knee, the meniscus cannot return to the original position timely, it makes the meniscus stocking between the femoral condyle and tibial plateau, with the sharp grinding, twisting, so it can directly cause meniscus tear.

THE IDEA OF FUNCTIONAL EXERCISE AFTER KNEE INJURY

The focus of the clinical rehabilitation after injury is the joint ROM, flexibility and strength recovery exercises. The athletes in the rehabilitation function training must also be more advanced in order to securely engage in sports activities. The training of rehabilitation function must proceed from easy to difficult, from simple to complex, from the sagittal plane to the coronal plane, and gradually complete the mission [5].

The anatomical structure of the knee that maintains the dynamic stability of the knee joint is located in the anterior, posterior, medial and lateral positions of the knee joint. It is easy to be divided into quadrants. Contraction of these muscle structures results in movement of the joints and provides dynamic protection for the supporting structures of the femoral and tibial joints (including ligaments and menisci). Therefore, the reconstruction of joint stability should not only include the reconstruction of joint biomechanics, but also the reconstruction of a sound neuromuscular feedback mechanism [6-7]. The principle of rehabilitation training is to maintain the stability of structure. Not only for functional training after injury, also gradually used to enhance athletic performance. Some of the lower limb function training is widely used to prehabilitation. Sports injury and some degenerative joint diseases often lead to the loss of joint proprioception, which results in the reduction of joint neuromuscular control, and that may be one of the important causes of functional joint instability. Dynamic balance interface training is used to enhance the stability of lower limbs, and prevent sports injuries, it has been widely applied to rehabilitation

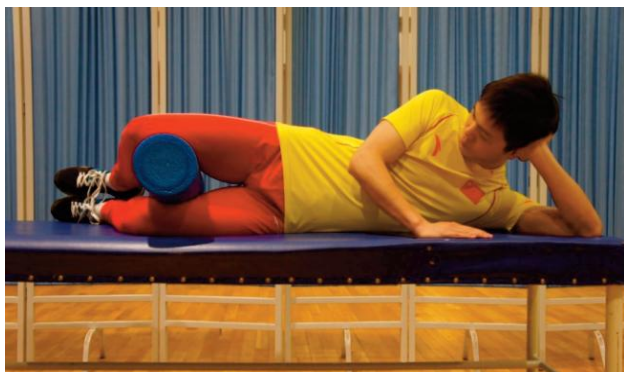
practice [8]. Neuromuscular control and proprioception training, muscle strength and coordination training can enhance the musculoskeletal system, produce appropriate feedback to the central nervous system, and improve joint stability and function [9-12].

For patella strain, the functional training schedule is generally believed that the "closed chain" resistance exercise is the main practice, while do less "open chain" resistance exercise. The so-called closed chain resistance exercises, refers to the practice with the both ends of the joint is fixed during the exercises, such as supine knee extensor resistance exercise; the "open chain" resistance exercise refers to the exercises with proximal end fixation and distal end extension, such as weight-bearing exercises with knee extension. The advantages of closed chain resistance exercises are: 1) per unit area of the knee joint cartilage pressure is small, it can reduce the symptoms and pain during exercise, and also can reduce the damage caused by itself on knee joint exercises; 2) in the closed chain resistance exercise, when the knee extension to a certain angle (more than 150 degrees), not only the quadriceps femoris is involved in the knee extension work, hamstring muscle (semitendinosus) is also involved in it.

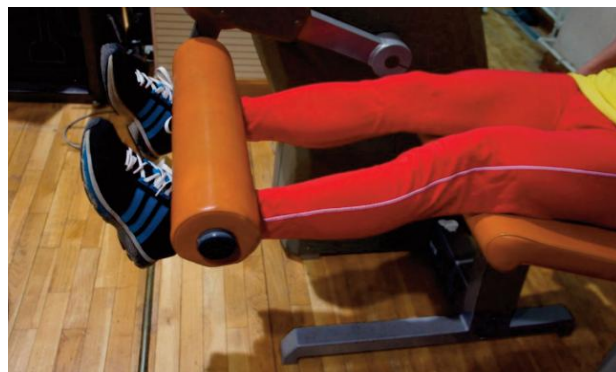
Thus, the closed chain resistance exercise can not only develop the quadriceps femoris muscle strength, but also contribute to the development of the hamstring muscle strength, then it will be more conducive to the balance of muscles strength around knee, and improve the stability of knee joint.

In addition, the lower limb "three joint stretch" (triple extension) is the most important source of strength of lower limbs, it plays a decisive role in the sport ability of the human body. Once the injury recovered to a certain level, with no joint movement disorder, without the pain, "three joint extension" (triple extension) the strength exercises should be started as soon as possible.

- (1) Open chain functional exercises.
- (2) Closed chain exercises
- (3) Practice of combining strength with



1.1. Exercise of middle gluteal muscle in lateral position



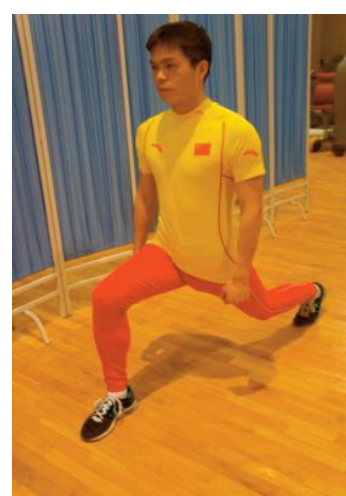
1.2. Straight leg raising of the four leg of the femoral head



1.3. Leg stretching exercises



2.1. Squatting of the four muscles of the femoral head



2.2. Bow step



2.3. Step down exercise



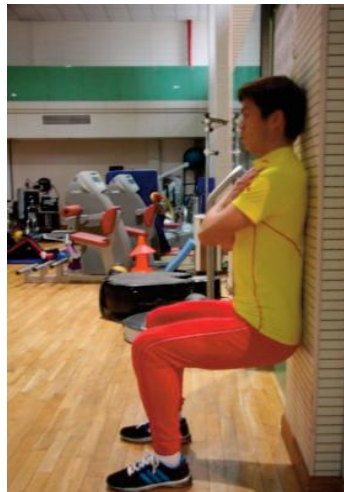
2.4. Dumbbell lunge down the steps



2.5. Stretch lunge



2.6. Shoulder barbell lunge



2.7. Squat



2.8. Lateral bow step



2.9. One leg squat



2.10. Barbell step up



2.11. The upper extension of a single leg step



2.12. Squat up and down with one leg



2.13. Knee prone position



3.1. The elastic band body feeling



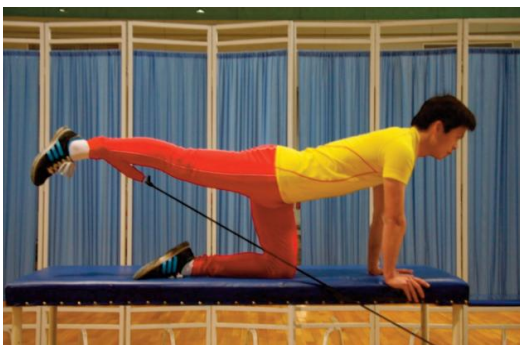
3.2. One leg balancing squat



3.3. Ball picking with one leg balance pad



3.4. Single leg balance pad to throw the ball



3.5. Hip extension



4.1.Acute muscle strain - Intermediate frequency interference



4.7. Chronic patellar tendinitis, plantar fasciitis - Shock wave

proprioception.

(4) Physiotherapeutic Instruments (Physical therapy for adjuvant treatment)

4.2. Fatigue periostitis -Ultrasound

4.3. Intra-articular injury - Ultrashort wave

4.4. Ligament and muscle injury after injury recovery - Microwave + focused ultrasound

4.5. Tendonitis, synovitis, etc - Focused ultrasound treatment

4.6. Acute injury and chronic injury of acute attacks - Combination of cold treatment and heat treatment.

The prehabilitation exercise of knee joint injury requires comprehensive consideration, and according to their own features, combined

with the characteristics of special injury, formulate personalized projects meet the characteristics of preventive exercise program. The athletes will get comprehensive development to the knee joint proprioception, muscle balance development and balance of the lower limb, then reduce the risk of knee injury.

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