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Research Article

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Analysis on biomechanics characteristics and countermeasures for knee pain when practicing Taijiquan

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ABSTRACT

In the process of practicing Taijiquan, the symptom of knee pain will happen from time to time, the pain symptom is closely connected to such factors as the movement postures, technical movements, contraction force of lower limb muscles and ligament traction. This research is designed to analyze and compare the sports biomechanics between the trainees with the symptom of knee pain and Taijiquan coaches with skilled technology through the experimental method; the results show that the result of knee pain symptom has something to do with the unscientific training and failing to master the correct technical essentials.

Keywords: Taijiquan, Knee Joint, Pain, Biomechanics Characteristics

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INTRODUCTION

Taijiquan is a treasure of Chinese martial arts and health maintenance, its unique philosophic thoughts, combat charm and health maintenance effect are deeply loved by the people at various social classes at home and abroad; as a kind of method to preserve health and build up body which has abundant connotation and is suitable for the young and the old, it has walked from China to the world. In July 2002, the USA Time magazine compared the ancient Chinese Taijiquan sport to a perfect sport, which has a good regulating effect for human cardiovascular system, endocrine system, nervous system and musculoskeletal system.

"Taijiquan" is a kind of sport to seek quietness out of movement. It is a kind of fistic technique integrating health maintenance and self-defense which is developed on the basis of health preservation method; and it is the wisdom crystallization of the sages through the ages[1]. The boxing frame hides the four skills (kick, hit, throw and grasp) in unarmed combat of martial arts in the circular motion incessantly according to the physiological structure and mechanics principle, making the functions of various human organs develop perfectly. For centuries, the continuous practices have proved that Taijiquan is a kind of important means to build up body and prevent diseases and it has stepped on the stage of medical treatment means as a means of auxiliary treatment for various diseases[2]. However, the phenomenon of knee pain will often occur if the beginners fail to grasp the main points. Whether on earth is Taijiquan helpful to body building or not? There are also many experts and scholars at home and abroad questioning the problem[3]. Therefore, this article is designed to conduct relevant research on the biomechanics characteristics for the knee pain triggered by the improper practicing behaviors for Taijiquan, discuss the relationship between Taijiquan sport and knee pain; meanwhile, put forward corresponding preventive measures in the hope that the practicers will benefit from them.

EXPERIMENTAL SECTION

1. Research object and method

1.1 Research Object

Six Taijiquan coaches (4 males and 2 females) and 10 Taijiquan practicers (5 males and females respectively) with the symptom of knee pain are drawn randomly. Their average ages: 35.2 years old for male and 37.7 years old for female; average heights: 169.6cm for male and 160.6cm for female.

1.2Research design

1.2.1 Research instrument

The QUALISYS—MCU500 infrared long-range test system (six lenses) which is made in Sweden is adopted to conduct three-dimensional sports biomechanics shooting with the frequency of 50 frames/second for the tested objects when they complete Taijiquan movement technology.

QUALISYS system, i.e. infrared light spot test system, has six lenses aiming at the research object, it can conduct three-dimensional test to the whole process of the motion of the object[4]. The QUALISYS system is composed of MCU (Motion Capture Unit), reflection marker, computer and related software.

1.2.2 Testing process

1.2.2.1 Preparatory phase to calibrate the testing instrument

According to the site size needed for Taijiquan movement drill, to erect QUALISYS— MCU500 infrared long-range test system which is made in Sweden, and adjust the height, pitch angle and focal length of the six lenses to make the position of coordinate frame in each lens is just in the lower middle and make the light spot is appropriate in size. When calibrating, the experimenters will continuously shake calibration rod to calibrate the test space within the space which will be probably reached by the technical movement of athletes, the calibration time is 10 seconds, totally 500 pictures. The system can automatically calculate the calibration parameters of the six lenses and judge if they have passed the calibration.

1.2.2.2 Index selection

The main indicators selected in this research are the change values of three-dimensional space of the three rotary freedom degrees of knee joint in the process of movement, i.e. flexion degree of knee joint, inward and outward rotation as well as introversion and eversion rotation, acquiring the relevant data for the changes of joints with the movement time.

1.2.3 Data processing method

After the experiment, the professional teachers of sports biomechanics will define the various mark points pasted in the process of test process, the system can automatically calculate and give the three-dimensional coordinates of various mark points relative to space calibration coordinate system. According to the requirements of research purpose, to apply the relevant programs in Qualisys system and use SPSS16.0 software to calculate and sort out the kinematics indicators and dynamics indicators obtained.

2. Measurement result and analysis

2.1 The composition characteristics and movement mode of knee joint

Knee joint is composed of medial and lateral condyles of femur, medial and lateral condyles of tibia as well as patella. Its structural features are: articular capsule is strong and there are many ligaments. There are anterior and posterior cruciate ligaments (to prevent the tibia from shifting forward and backward) for the internal ligament of the capsule; for the external ligament of the capsule, there is a patellar ligament in the front, there is a tibial collateral ligament at the inner side and a fibular collateral ligament at the outer side, as well as an oblique popliteal ligament in the rear. There are two menisci in the articular cavity, of which, the lateral meniscus shows an “O” shape and the medial meniscus is relatively large, showing a “C” shape, its peripheral middle part is closely connected with the tibial collateral ligament. It also contains plicae alares and suprapatellar bursa. The main mode of motion is flexion, since the collateral ligament is slack when the knee is bended, rotary motion can be made.

2.2 Division of knee joint activity cycle in the main movements of Taijiquan

Table 1 Division of Knee Joint Activity Cycle in the Main Movements of Taijiquan

Phase name	Name of movement phase		
Support phase	Repulse Monkey Single-support phase	Wave Hands like Clouds Double-support phase	Fair Lady Works at the Shuttle Turning phase

According to the need of research purpose, the main tests are simplified to be the three main movements including Repulse Monkey, Wave Hands like Clouds, Left Fair Lady Works at the Shuttle; we shall observe the data of freedom of motion for the knee joint in single-support phase, double-support phase and turning phase.

2.3 Measuring result

The result reveals that there are obvious differences for the flexion and rotary angles of right knee in single-support phase, double-support phase and turning phase between the coaches and the trainees with pain symptom measured from the movements of Repulse Monkey, Wave Hands like Clouds and Fair Lady Works at the Shuttle in Taijiquan. (See Table 2 for reference). (0)

Table 2 The Comparative Result of Right Knee Freedom Degree Between Coaches and Trainees with Pain Symptom (X±S)

	Repulse Monkey Right knee flexion (0)	Wave Hands like Clouds Right knee flexion(0)	Fair Lady Works at the Shuttle Outward rotation of right knee (0)	n
Coaches	147.4±3.6	151.6±5.4	17.2±2.6	6
Trainees with pain symptom	141.1±9.3**	148.5±11.9**	22.2±6.1**	10

Notes: The comparative result of right knee freedom degree between coaches and trainees with pain symptom is P<0.05, there are obvious differences.

2.4 Analysis

2.4.1 Single-support phase—analysis on the comparative result of right knee freedom degrees between coaches and trainees with pain symptom in the movement of ″Repulse Monkey″

We can see from Table 2 that the flexion angle (average value is 141.1°) of right knee of the trainees with pain symptom is obviously smaller than the angle of the coaches (average value is 147.4°) when they complete the movement of ″Repulse Monkey″, and there is the significance. In the process of testing, it is observed that the movement strides of the trainees with pain symptom are oversize and the center of gravity is too unbalanced, all of these have increased the weight support of the knee joint. Because, as to the movement of raising left leg to step back in ″Repulse Monkey″, its gravity center is completely moved to the right support leg, the upper body keeps neutral, then slightly adjust waist and hip, raise left knee to step back with an arc shape to the left back, the crosswise spacing of two feet is 30 ~ 40cm, the right tiptoe falls to the ground (at this time, the proportion of gravity centers of left and right feet is 9:1), then the left sole steps steadily and open the hip and circle the crotch rapidly. At the moment, the gravity center has been transited from 9:1 to 7:3 or 6:4. But if the gravity center is not changed (still 9:1) after raising left leg to step back, then the weight on the right knee is too much, which exceeds the tolerance capacity of the knee and is apt to result in hurt, as well as not beneficial to the smooth movement of gravity center. If the hind leg knee joint is straightened and fails to complete the circular scotch, it will more increase the pressure of front knee. Therefore, when raising the left leg, if the flexion of right knee joint is oversize, a dead angle will form, which will certainly result in the occurrence of aching feeling.

2.4.2 Double-support phase— analysis on the comparative result of right knee freedom degrees between coaches and trainees with pain symptom in the movement of ″Wave Hands like Clouds″

We can see from Table 2 that the flexion angle (average value is 148.5°) of right knee of the trainees with pain symptom is obviously smaller than the angle of the coaches (average value is 151.6°) when they complete the movement of ″Wave Hands like Clouds″, and there is the significance. In the process of testing, it is observed that the trainees with pain symptom have too-low ″flexion″ angles when they complete ″Wave Hands like Clouds″, the knees have completely exceeded the

toes and the movement is lack of standardization. Because, when we practice ″Wave Hands like Clouds″ of Taijiquan, the body position is asked to be straight and centered, sinking the shoulders and dropping the elbows, bending the knees and loosening the hip, in this way, a part of weight which is originally borne by the hip is all borne by the quadriceps femoris (quadriceps femoris has the function of stretching the knee joint) in the muscle of thigh due to the looseness of hip, which has increased the burden of quadriceps femoris accordingly. Since the patellar ligament is the tendon extension of quadriceps femoris, it will stretch with the contraction of quadriceps femoris; the fiercer the quadriceps femoris contracts, the severer the patellar ligament stretches. According to the sliding filament mechanism in sports science, when the muscle is lengthened and contracted excessively, the muscle is in the most powerless status. When the knees exceed the toes, the knee will excessively bend to be less than 90°, quadriceps femoris (mainly rectus femoris) will become powerless due to the excessive elongation. At the moment, the patellar ligament connected with quadriceps femoris is also stretched excessively; since quadriceps femoris has been in a powerless status, most of the pressure from the weight of upper body is burdened by patellar ligament; when quadriceps femoris contracts vigorously, it will be easy to arouse the patellar ligament is avulsed and separated from the position of tibial tuberosity; therefore, it will make the patellar ligament injured most easily when the knees exceed the toes, even result in chondromalacia patellae (a kind of strain symptom) for a long time. In addition, excessive bending forward of the body will also increase the pressure of knee joint.

2.4.3 Turning phase-- analysis on the comparative result of right knee freedom degrees between coaches and trainees with pain symptom in the movement of ″Fair Lady Works at the Shuttle″

We can see from Table 2 that the outward rotation angle (average value is 22.2°) of right knee of the trainees with pain symptom is obviously smaller than the angle of the coaches (average value is 17.2°) when they complete the movement of ″Fair Lady Works at the Shuttle″, and there is the significance. The normal physiological movement of the knee joint is longitudinal flexion and extension movement. Relevant research has proved that the scanning of MRI sagittal plane shows the anterior cruciate ligament is in the best condition when the knee joint rotates outward to be 15-20°; so it is clear that the reason for the occurrence of pain symptom is that the oversize abducent angle of knee joint makes the knee joint burden improper force.

When the movement of ″Fair Lady Works at the Shuttle″ is completed, in forward lunge, foreleg tiptoes are outward excessively and the shank is in an abducent outward rotation position. The knee conducts a flexion and extension movement and a rotary movement at the same time, the meniscus needs to make shift changes according to the different requirements for these two movements, which makes the lateral meniscus is suddenly abraded and damaged between lateral femoral condyle and tibia platform. If abducent angle is too large, anterior cruciate ligament is not in good condition, either; meanwhile, the combined injuries will accompany with it including anterior cruciate ligament strain and medial ligament tearing and synovium injury, thus making the knee joint swell and pain.

2.5 Measures to prevent and avoid knee pain symptom

The purpose to prevent the knee pain symptom and injuries in the sport of Taijiquan is to improve sports technology and sports effect, as well as build up bodies and promote physical and metal health. Therefore, the prevention for sports injury shall be done well.

2.5.1 To master correct technical essentials of movements

To master correct basic movement posture and correct movement technical essentials and practice them in the proper way is the first thing to prevent sports injury[5]. Therefore, we should strengthen the practice of basic technology, lay solid basic skills, and make every gesture and motion up to the standard, especially the false and true interchange of footwork, we had better practice each kind of step form and footwork independently and constantly; after mastering the correct step form and footwork, and can convert briskly and smoothly, then we can enter complete routine movement learning. In the learning from simple to complex and from easy to difficult, we can understand and master the technical essentials of movements faster and correctly.

2.5.2 To warm up fully

The warm-up purpose is to overcome the inertia of various functional activities and shorten the time to enter the working state. The viscosity of muscles and ligaments is reduced after the muscles experience the warm-up of the organism and the elasticity of muscles is strengthened; meanwhile, it also promotes the articular capsule to secrete more synovial fluid to

reduce the friction of joints and increase the flexibility and movement range of the joints, thus preventing the injury of muscles, joints and ligaments. Therefore, before practicing Taijiquan, we must warm up fully; especially the knee joints which bear the biggest load in the whole body shall be fully exercised in the warm-up.

2.5.3 To strengthen the training on lower limb strength and knee joint ligament auxiliary devices

The insufficient leg strength and weak pulling force of the ligaments around the knee joint are also the important reasons for the injury of knee joint due to oversize load. Therefore, the training on lower limb strength shall be strengthened; especially the training on the endurance of muscle strength of quadriceps femoris and the training on the pulling force of patellar ligament shall be strengthened in order to improve the stability and sensitivity of the knee joints[6]. The methods of Taichi stance keeping, up-down stance exercise and lifting loaded leg can be adopted to improve the functions of quadriceps femoris and the patella.

2.5.4 To strength self-protection awareness

In the teaching and training, the teachers shall pay attention to cultivate the self-protection awareness of the trainees[7]. They shall ask the trainees to understand the characteristics and law for the injury of knee joint and shall make detailed explanations and demonstrations to the movement technologies which are apt to result in the injury of knee joint, making the trainees have correct concepts to the movement tips. In the practice, pay attention to the work of muscles and ligaments with alternate tension with relaxation, pay attention to the high relaxation of knee joint when the knee is lifted in the conversion of footwork, making the knee joint can have a rest as soon as possible after the tension, thus postponing joint fatigue; in the meantime, shall pay attention to the partial reaction of lower limb motion organs at any time, if such symptoms as muscle ache, stiffness and joint pain occur, the load of lower limbs shall be adjusted timely, the center of gravity shall be improved or the exercise shall be suspended.

2.5.5 To complete arrangement and relaxation work of knee joints

The arrangement and relaxation of knee joints after the practice is a kind of method to eliminate the fatigue of knee joints and prevent sports injury. We can shake the muscles of thighs relaxedly and massage the knee joints[8]. We can rub and knead the upper and lower positions of knee joints or their peripheries with our palm, heel of hand or finger pulp; rub and knead the positions of bilateral accessory ligaments with the pulp of thumb and thenar eminence for a long time; bend and stretch the shanks relaxedly, and make mild inward and outward rotation activities under the circumstance of bending the knees. We shall make the knee joints obtain sufficient rest through the massage on the knee joints.

CONCLUSION

Taijiquan emphasizes consciousness not brute force, it emphasizes to relax the muscles and joints of the whole body with consciousness so as to reduce the emotional stress and increase the circumfluence of qi and blood, increase the flexibility of the organism and extend the time of muscle endurance contraction, and make the internal force reach the metapodium smoothly. The real reason for the knee pain happening to the practicers is improper method, such as seeking low position excessively, low center of gravity, excessive outward rotation of knee joints, all of which have aggravated the burden of knee joints and made their own load exceed the tolerance capacity of the organism; after a long time, the injury of knee joints will occur.

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