

## BIOMECHANICAL ANALYSIS OF KNEE JOINT INJURIES CAUSED BY TORNADO KICK TURN 720° TO HORSE STEP LANDING

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### ABSTRACT

**Objective:** Injury caused by tornado kick turn 720° to horse step landing in Wushu jump is studied with detailed analysis of the biomechanical principles of the injuries.

**Methods:** The author selected 3450 cases of athlete injured in Wushu routine movements between January 2014 and January 2016. Documentary analysis, logical analysis and expert interviews were used to analyze the biomechanical principles of the knee joint injury in athletes. Then based on the results, future rehabilitation measures are proposed.

**Results:** Wushu athletes' landing in tornado kick turn 720° to horse step can cause serious damage to the knee, as huge impact will be created by the moment during landing. At the same time, the weight of Wushu athletes as well as height of the arch will exert huge impact on athletes' knee joint.

**Conclusion:** During tornado kick turn 720° to horse step landing, Wushu athletes should pay more attention to the serious force generated by the movement and try to slow down landing time in order to reduce the impact. This will effectively protect the athletes' knee joint and keep the athletes healthy, which is important in the Wushu athletes' career.

**Keywords:** Tornado, Horse Step, Landing, Knee Joint Injury, Sports, Biomechanics.

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### Introduction

Recent years witnessed remarkable development of competitive Wushu, in which high difficulty movements became a common goal for Wushu athletes and coaches. At the same time, in Wushu movements, poorly executed movements can cause injuries to athletes, which cause lifelong impact on the athletes' career.

Hence, it is necessary for Wushu athletes and coaches to do scientific experiments to understand scientific basis of Wushu movements and try to avoid serious injuries. Knee joint injury is relatively common in training or competition of Chinese Wushu athletes, the main reason being that movements with higher difficulty coefficient are attempted, mainly tornado kick turn 720° to horse step landing.

This movement can cause knee joint injuries during landing which negatively impact athletes' career. As a result, coach and related personnel need to analyze the biomechanical principles of sports' injuries and formulate scientifically backed training regimes, which can limit the chances of serious injuries during athletes' development. Figure 1 shows a tornado movement in Wushu art.

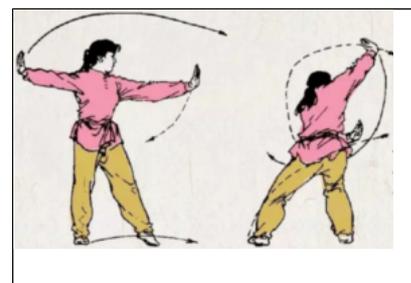


Figure 1: Picture of tornado.

## Methods

### General Information

The 3450 cases of athletes who have knee joint injury sustained due to tornado kick turn 720° to horse step landing are analyzed. All the study's subjects are professional Wushu athletes, with 2250 male and 1200 females. The average age of the athletes was  $23.4 \pm 1.8$ , with the oldest athlete being 28 years old, while the youngest was 15 years old.

### Expert Interviews Research Method

The author conducted in-depth interviews with Wushu's team leaders and professors from a number of institutes that teach physical education. The experts and scholars elaborated on the normalization of tornado kick turn 720° to horse step, observed athletes' knee joint injury and tried to understand key technology of this action.

### Questionnaire Survey

Questionnaire survey was conducted among athletes and coaches, while the analysis was done by Wushu and biomechanics experts. The final research results were obtained and analyzed. The recovery rate of the questionnaire was 100%.

### Three Dimensional Imaging Measurement Method

Three dimensional imaging measurement of some elite athletes of a sports team was done, captured at 50 frames per second and data processing was done with APAS-2000. Figure 2 shows three dimensional imaging measurement:



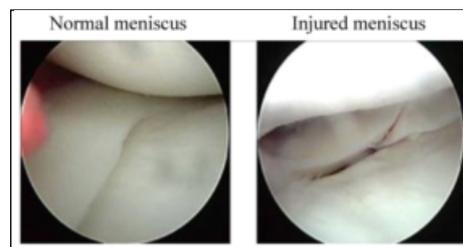
**Figure 2:** Tornado kick turn 720° to horse step completed by a Wushu athlete.

## Results

### Types of Knee Joint Injury Caused by Tornado Kick Turn 720° to Horse Step landing

Questionnaire survey of coaches and athletes revealed that after the jump in tornado kick turn 720° to horse step, athletes are most susceptible to injury at the right knee. The injury types are divided

into chronic injury and acute injury, of which chronic injury occur more often<sup>(1)</sup>. The injured sites are usually the of meniscus and the collateral ligament of the knee joint. The main cause of this phenomenon is that after the athletes complete the tornado kick turn 720° to horse step, the knee joint will ascend, which will create a serious grinding and squeezing of the hip joint and femoral torsion. This impact might be beyond athletes' endurance capacity, leading to serious meniscus injury<sup>(2)</sup>. Figure 3 shows images of normal and injured menisci. The X-ray image of a patient with knee joint injury (female, 22 years old) is shown in Figure 4.



**Figure 3:** Image of a normal meniscus and an injured meniscus.



**Figure 4:** X-ray image of a patient with knee joint injury (female, 22 years old).

With three-dimensional imaging measurement techniques, characteristic data of each phase of the tornado kick turn 720° to horse step's process can be analyzed. The main phases of tornado kick turn 720° to horse step includes hop buffer, off-ground, soar<sup>(3)</sup>. In this process, athletes' soar mainly means that athletes' foot is lift off the ground with center of gravity reaching maximum height, while the landing stage refers to the stage from maximum height of athletes' center of gravity to time of contact with the ground. While the highest center of gravity refers to the height when athletes' speed becomes zero during the jump<sup>(4)</sup>.

Taking a certain athlete's data as the example, when center of gravity was at the height of 50 cm, the buffer time was 0.3 seconds, so there is a positive correlation between athletes' highest center of

gravity and the height of arch. This buffering time helps athletes to complete the aerial part of the jump more effectively, finish the buffer actions, and thus smoothly complete the tornado kick turn 720° to horse step. Once athletes' commencing height and rotation height are not sufficient during take-off, longer buffer before landing is needed to complete movements with such level of difficulty<sup>(5-7)</sup>.

In addition, after Wushu athletes complete the tornado kick turn 720° to horse step, velocity of center of gravity and the force one the legs will change significantly at landing. Athletes' knee joint injury mainly occurs during landing due to the falling process after the soar when downward velocity of the body is increasing gradually. In the whole process, when athletes' speed reaches the minimum, or close to zero, that is where the maximum buffer time takes place<sup>(8,9)</sup>.

Therefore, it can be concluded that there is very close relationship between force applied on athletes, movement speed and movement completion time. Therefore, in order to avoid great damage brought by strong impact during landing; athletes should try to prolong their buffer time for landing, in order to reduce the impact of ground on their bodies. Prior to athletes' landing on the ground, slower speed of soar can prolong buffer before landing, thus increasing stability during landing.

During Wushu athletes' tornado kick turn 720° to horse step, the landing buffer time will be strongly affected by the jump. Once athletes' jump preparation is inadequate, difficulty coefficient for inner side of the knee joint to complete corresponding difficulty movement will be significantly increased, which goes far beyond the tolerance level of the athlete's body, resulting in serious injury to the meniscus and lateral collateral ligament<sup>(10,11)</sup>.

### ***Changes of Knee Joint Angle during the Landing Period after Wushu Athletes' Action Is Completed***

After Wushu's athletes complete the tornado kick turn 720° to horse step and land, the knee joint angle will change drastically, forming an angle between the knee joint, hip joint and ankle joint. In the process of landing, the left knee joint angle of athletes will be less than that of right knee<sup>(9, 10)</sup>. Athletes' prolonged buffer time can be achieved through adjustments to their body's movement so that the jump can be successfully completed<sup>(12,13)</sup>.

However, athletes' weight is a relative variable. When athletes' weight and height of arch are

maintained within a certain range, athletes need to adjust their own body movements before landing on the ground. The adjustments required includes the angle of left and right knee, thus delaying landing time which reduces the impact force<sup>(14)</sup>.

### **Discussion**

In short, athletes and coaches should pay more attention in future trainings, especially to the process of landing in tornado kick turn 720° to horse step. Athletes should preliminarily tighten the muscles of the lower limbs, thus improving the bearing capacity of their body and avoiding injuries. In terms of enhancing physical capabilities of athletes, strength of the lower limb muscles need to be enhanced to increase muscle elasticity and flexibility. Coaches should also train athletes and eliminate weak links in their bodies, hence improve athletes' lower limb and enhance their capacity to withstand impact. Technically, athletes need to improve stability and virtuosity of the tornado kick turn 720° to the horse step in order to avoid injuries during Wushu competitions.

Detailed analysis of the biomechanical principles can help in normalizing the athletes' movement and avoiding injuries. Meanwhile, athletes' self-protection awareness shall be improved, so that they can ensure safe execution of Wushu's movements in future trainings and competitions.

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