

Research Paper: Relationship Between Selected Performance Tests and Non-contact Sports Injuries in Male Wushu Players



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Purpose: Several tests have been proposed as injury predictor inventories in various sports; however, it is important to recognize which test is more appropriate to predict the injuries of a particular sport. Therefore, the present study aimed to investigate the relationship between selected functional tests and lower limb injuries in elite male wushu athletes.

Methods: In total, 40 wushu player were recruited from the national league (Mean±SD age: 25.1±4.9 y, weight: 67.3±7.7 kg, height: 175.3±4.7 cm). Functional Movement Screening (FMS), Tuck jump, single and double leg squats, Star Excursion Balance Test (SEBT), and Stork balance tests were performed in this research. All of the study variables were measured before the national competition, and after the competition, the rate of the injuries were assessed. The correlation between them was evaluated, subsequently. Descriptive data were used to describe the collected results. Besides, multivariate linear regression analysis was used to explore the relationship between the study variables.

Results: Multivariate linear regression analysis data suggested that LESS, stroke balance test, single-leg squat, and SEBT failed to predict lower extremities injuries; however, Tuck jump, FMS, and double leg squat could predict lower extremities injuries.

Conclusion: Based on the collected results, among the studied tests, trainers and researchers are suggested to employ the Tuck jump, FMS, and double leg squat tests to predict injuries in wushu male players; this test can also be used to prevent injuries in players.

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Highlights

- The performance tests such as Tuck jump, Functional Movement Screening (FMS), and double leg squat tests to predict injuries in wushu male players.
- These performance tests can prevent injuries in players.

Plain Language Summary

Wushu is among the most popular martial arts disciplines, originating in China. Most of the other martial arts are derived from this discipline. Wushu is a martial art that includes a combination of explosive, strength, and speed movements with combat techniques. The prevalence of wushu injuries at the 2009 Asian Championships was higher among women than men. Additionally, the highest prevalence of injury has been recorded in Mutai and Taekwondo. The prevalence of injuries in this discipline, according to studies, is 22807 incidents per 1000 athletes. Wushu competitions are held in the two styles of Sanda and Taolu. The Sanda section is performed as a fighting style, and the Taolu is conducted as a routine practice. Sanda style is more susceptible to injury due to its fighting mode. Performing hard and complicated movements, consistency in performing movements, and stability in performing techniques are the main factors in performing Taolu form in wushu competitions. The instability and vibration of the limbs cause points to be deducted from the athletes. In performing these movements, athletes who lack the necessary skills, strength, and ability present unstable movements. Our results showed that a significant relationship between motion screening tests, two leg squat and tuck jump tests, with athletes injuries. Based on the collected results, trainers and researchers are suggested to employ the Tuck jump, FMS, and double leg squat tests to predict injuries in wushu male players; this test can also be used to prevent injuries in players.

1. Introduction

There exist various disciplines in the world of martial arts, each consisting of different characteristics and rules. These disciplines include Karate, Taekwondo, and Wushu, i.e., recognized as the most common martial arts [1]; they also enjoy a desirable position in Iran. The essential benefits of these sports can be the ability to self-defense, increase physical fitness factors as well as flexibility, and enhance the self-confidence of athletes [2]. However, accidents and injuries in martial arts, like other high-impact sports, are inevitable. Besides, athletes in these disciplines are always exposed to numerous potential risks [2].

With the rise in the number of participants in martial arts and according to the unique rules and techniques used in these sports, the number of injuries is expected to increase. According to studies, the number of lower limb injuries in martial arts has been reported as 59% in Taekwondo and 30% in Karate [1].

Wushu is among the most popular martial arts disciplines, originating in China. Most of the other martial arts are derived from this discipline. Wushu is a martial art that includes a combination of explosive, strength, and

speed movements with combat techniques [3]. According to Pichet et al. (2014), the prevalence of wushu injuries at the 2009 Asian Championships was higher among women than men. Additionally, the highest prevalence of injury has been recorded in Mutai and Taekwondo [4]. The prevalence of injuries in this discipline, according to studies, is 22807 incidents per 1000 athletes. According to reports, there occurs 16176 injuries per 1000 male athletes and 32609 injuries per 1000 female athletes. The lower limb has the highest rate of injury (10294 injuries per 1000 athletes) [4].

Wushu competitions are held in the two styles of Sanda and Taolu. The Sanda section is performed as a fighting style, and the Taolu is conducted as a routine practice [5]. Sanda style is more susceptible to injury due to its fighting mode [6]. Performing hard and complicated movements, consistency in performing movements, and stability in performing techniques are the main factors in performing Taolu form in wushu competitions. The athlete holds the body in balance for a few seconds (about 3-5 seconds) while performing the technique at specific angles. A complexity of performing these movements is maintaining the body balanced by changing the movement of different parts of the body. The instability and vibration of the limbs cause points to be deducted from the athletes. In performing these movements, athletes who

lack the necessary skills, strength, and ability present unstable movements [7]. However, for Sanda, keeping balance is essential, due to its fight style, to prevent injury in contacts, in hitting, and receiving the blow. Movements and blows are not foreseen in martial arts battles. Therefore, maintaining balance in unforeseen circumstances is more difficult and complicated [8, 9].

The ability to successfully predict injury is a crucial goal in pre-season tests. Determining the ability of individuals to participate in sports events requires a careful assessment of the needs of that sport and requires specialized screening [10]. Motion assessment allows health and fitness professionals to recognize muscle imbalances as well as the strategy and order of using muscles by observing motor defects [11]. Predicting lower limb injuries, if they can be measured with a simple, cost-effective, and valid test, is a major step to prevent lower limb complications [12]; subsequently, individuals with a high percentage of the injury risk can minimize this possibility by various strength and balance exercises.

Several tests have been proposed to predict injury. For example, Letafatkar et al. (2014) stated that FMS scores could predict harm in the active students [10]. O'Connor et al. (2011) also prospectively evaluated the LESS test as a tool for the risk of knee ligament injury [13]. Based on their findings, the LESS score is an inappropriate tool for predicting knee ligament injuries. Plisky et al. (2006) stated that the star test is reliable for predicting lower limb injury [12].

Mirkarimpour et al. (2016) conducted a study using screening tests to predict injury in sports [14]. In their study, researchers examined FMS, SEBT, as well as the Y-balance test, LESS, and tuck jump. They concluded that factors, such as gender, history of injury, and participation in sports are essential and influential in the accuracy of these tests. They believed that their study results were inconsistent with those of the studies that introduced FMS as a predictor of injury. Researchers described the FMS test as incapable of predicting injury. However, SEBT and Y-balance tests could be predictors of injury. They also announced the LESS test as a tool for predicting injury after data analysis. Finally, the tuck jump test is useful in predicting injury. However, they argued that more studies are required in this regard [14]. In short, tests that are recognized as the predictors of injury generally include the Functional Movement Screening (FMS) tests. Tuck jumps, Single-leg Squat (SLS), Double-leg Squat (DLS), Stork Balance Test (SBT), Star Excursion Balance Test (SEBT), and Landing Error Scoring System (LESS).

The FMS is among the tests that numerous researchers agree on its ability to predict injuries in various sports [15]. However, contradictory study results are observed in the predictive power of this scale and some other performance inventories [16]. Given the nature of the wushu discipline, balance, and flexibility factors, along with other fitness characteristics, are of more importance. Implementing performance tests that challenge these factors will add to our knowledge concerning the effectiveness of these tests in predicting Wushu sports injuries. Thus, the present study aimed to investigate the relationship between these tests and sports injuries in the Wushu Sanda style.

2. Materials and Methods

This was a descriptive correlational study. The statistical population included male wushu players who participated in league competitions and national championship wushu competitions. Initially, 120 individuals were selected, and eventually, 100 wushu players were selected after reviewing the inclusion and exclusion criteria of the study. Wushu has two styles, Sanda and Taolu. Taolu style is dedicated to performing form and demonstrative movements; Sanda style is a confrontation and fighting one, which offers a complete set of martial arts. Given that Sanda (or Sanshu in Chinese) means free to struggle, the odds of injury to athletes is much higher in this style [3-5]. Therefore, Sanda style athletes were selected as the population and statistical sample in this study.

First, the information of all Sanda style Wushu athletes was prepared from the Wushu Federation for data collection. Next, 120 eligible athletes were considered to participate in the competitions. Then, the initial information form, including inclusion criteria, was completed by referring to the training place of athletes who lived in different cities. This step was conducted after receiving the consent form for participation in the research. Inclusion criteria included ≥ 3 years of Sanda-style professional experience, no history of lower limb injury in the past 6 months, and no history of lower limb surgery in the past year. Exclusion criteria also included the athlete's dissatisfaction to record the injury during the research, the reluctance of the athlete to cooperate in performing all pre-competition performance tests, and early elimination during the competition. According to the study exclusion criteria, approximately 20 subjects were excluded from the study. In the present study, the injury was considered as any harm that occurred during league matches, leading to visiting a doctor and receiving required medical intervention by the athlete. Non-contact injuries were considered among the injuries, due to the nature of this study.

Predicted performance tests were randomly performed for qualified athletes before training and competitions. Except for two tuck jump tests and the landing error scoring systems that required further camera and time, the research subjects were examined during training and competitions; in coordination with the team physician and the organizing committee, non-contact lower limbs injuries in athletes were also recorded using the injury registration form.

The functional tests of the present study included the tuck jump test, the One- and Two-Leg Squat, Stork Balance Test, FMS test, Star Balance test, and the LESS test. In the tuck jump test, the subject stands with his legs shoulder-width apart. This test is repeated for 10 seconds. When jumping, the subject raises two femurs to be parallel to the ground. Then, the subject lands on the previous position. The subject repeats this jump for 10 seconds. The subject is evaluated in the anterior and posterior directions using a camera. Ten defects in the subject's jumps are evaluated, including knee valgus when landing; thighs not reaching parallel to the ground; thighs failing to rise evenly; the position of the legs not being equal to the width of the shoulder; the legs not being parallel; the time of placing the feet on the ground is not equal; loud noise on landing; pause between jumps; jumping technique before 10 seconds, and the feet failing to land in their place [17]. Based on the previous studies, the reliability of this test has been reported to be 0.88 [18].

The one-leg squat test explores movement disorders of the motor chain, including pelvic obliquity, knee valgus, and the hyperpronation of the foot (subtalar joint). Accordingly, excellent, good, average, and low scores are assigned [19]. The reliability of this test is reported to be 0.87 [20]. The two-leg squat test has the features of a one-leg squat test. However, transferring body weight to the sides is also considered for evaluating the test, in addition to the parts mentioned in the one-leg squat test [21].

The stork balance stand test is used to assess the static balance. This test was designed as a standard tool for measuring static balance by Nelson and Johnson (1979). The test is performed in two cases with open and closed eyes, as follows: the subject stands on one leg with his hands on his waist. The sole of the other foot (free foot) rests on the inside of the knee. In this position, the subject stands on the supporting leg, and the examiner records his endurance time in this situation (seconds); the conditions that cause the whole test are as follows: the heel of the supporting leg is in contact with the ground, lifting the hands from the waist, and separating the free foot

from the knee of the support leg [22]. The reliability of this test is reported to range between 0.61 and 0.81 [23].

The FMS test consists of 7 movements, as follows: full squat, launch (left & right), rotational stability (left & right), shoulder mobility (left & right), trunk stability swimming, stepping over the obstacle (left & right), as well as actively and directly raising the foot (right & left). Each move is given three points starting from zero. If pain is experienced in the body during the movement, the athlete will be given a score of zero. If the subject is unable to move or is unstable during the movement, they are given a score of one. Score two is awarded if the person can perform the movement with a compensatory movement. A score of three is assigned to the individual when the movement is completed. Each test is repeated three times, and the total score equals 21 [24]. The reliability of this test is reported to range between 0.81 and 0.91 [25].

The Star Balance Stand Test is used to measure the dynamic balance. In this test, the athlete stands on one foot in the center of the circle with the heel in the center of the star and the toes on the line in the anterior direction. Then, the subject puts his hands on his hips and moves his other leg along the lines as much as he can; accordingly, the individual hits the ground with the maximum amount of approaching without bearing the weight to determine the extent of approaching. Then, the subject returns to the starting position (standing on both legs). The distance between the center of the star and the point of contact of the free foot is the extent of approaching. The foot length of the individual affects the distance he reaches. Therefore, the mean reaching distance is divided by the leg length of each test; subsequently, it is multiplied by 100 to calculate the dependent variable, and access distance is calculated as a percentage of foot length. This test is performed on both feet [26]. The reliability of this test is reported to range between 0.85 and 0.91 [27].

To evaluate the landing error test, initially, two cameras are installed in frontal and sagittal views at a distance of 4.8 and 4 meters, respectively. These two cameras record the jump performance from the mentioned views. This system is highly feasible and can clinically assess hazardous landing mechanics. To perform the test, the athletes jumped from a 31-cm platform in the pretest session; next, they landed in front of the platform at a distance of about 21% of their height. Then, they immediately conducted a maximum vertical jump. During the test training, it was emphasized that the person should jump as high as possible as soon as he descended from the platform. No feedback or training was provided to the individual during the test unless he performed the test

Table 1. The frequency of non-contact injuries in the studied subjects

Injury Type	No. (%)
Meniscus & cartilage	8 (24.2)
Sprain/ligament injuries	11 (33.3)
Luxation	2 (6.1)
Tendon injuries/rupture/tendonitis	1 (3)
Ecchymosis/bruises	5 (15.2)
Other injuries	6 (18.2)

PHYSICAL TREATMENTS

Table 2. A summary of the results of the multivariate regression model

	R	R ²	Balanced	Std. Error Estimation	F	df1	df2	P
Model	0.413	0.171	0.098	0.413	2.342	8	91	*0.025

* The level of significance: P<0.05.

PHYSICAL TREATMENTS

incorrectly. After the test training, individuals were allowed to practice two jumps to learn it.

The athletes, then, performed three correct jumps. If the subject failed to reach the specified horizontal distance or make the maximum vertical jump after landing, that turn was removed, and the jump-landing maneuver was repeated once more. The landing error scoring test has 47 items. A set of these questions concerns the condition of the lower limbs and trunk at the moment of the first impact with the ground (items 1-6). Another set evaluates foot position errors (items 7-11) and assesses the errors at the moment of the first impact with the ground (item 11); the moment when the whole sole is in contact with the ground (items 6-8), and during the time of the first impact and the maximum angle of flexion of the knee (item 9 & 10).

The third set evaluates the movements of the lower limbs and trunk during the times of the first impact with the ground and the maximum angle of flexion of the knee (items 12-14), and the time of maximum and knee valgus (item 15). The final score for each landing is calculated by the sum of the scores of all items (0-15) [17]. Studies have reported the reliability of this test to range between 0.72 and 0.81 [28].

Descriptive tests, such as mean and standard deviation were used to describe the data, and a multivariate linear regression test with input method was applied along with selected functional tests to investigate the relationship between the incidence of injury and other variables.

All statistical operations were performed by SPSS at a significance level of P<0.05.

Before conducting the research, a proposal was presented to the Ethics Committee of the Biomedical Research of the Institute of Sports Sciences for review with the permission of the Ministry of Health and Medical Education of Iran. After approving the proposal, the code IR.SSRC.REC.1398.031 was awarded to this research.

3. Results

The descriptive statistics data suggested that the mean age of the explored subjects was 25.47.9 years, their mean height was 175.4±4.6 cm, and their mean weight was 67.87.2 kg. The frequency and percentage of non-contact injuries in Wushu players are presented in Table 1, in which the highest rate of injury was related to ligament injuries (33.33%). Meniscus and cartilage injuries were also in second place (24.2%). Besides, the lowest rate of injury was related to tendon injuries and tears (3%) (Tables 1-3).

According to Table 4, there was no significant relationship between the one-leg squat test, the landing error scoring system, star balance, stork balance, and the recorded injury during matches. However, there was a significant relationship between motor screening tests, two-leg squat, and tuck jump, and the explored athletes' injuries (P<0.005).

Table 3. A summary of the results of the analysis of variance in multivariate regression test

Model	Sum of Squares	df	Mean Squares	F	P
Regression	3.201	8	0.400	2.342	*0.025
Remainder	15.549	91	0.171		
Total	18.750	99	---		

* The level of significance: P<0.05.

PHYSICAL TREATMENTS

Table 4. Correlation coefficients and presentation of variables in multivariate regression test

Test	B	Standard Error	t	P	
Tuck jump	-0.088	0.03	-0.314	-2.879	0.005*
Stork balance (left foot)	-0.007	0.007	-0.100	-0.982	0.329
Stork balance (right foot)	-0.008	0.008	-0.100	-0.984	0.302
One-leg squat	0.043	0.055	0.099	0.777	0.439
Two-leg squat	-0.066	0.030	-0.304	-2.173	0.032 *
Star Balance	-0.002	0.006	-0.032	-0.281	0.816
The landing Error scoring System	0.005	0.022	0.029	0.234	0.006
FMS	0.057	0.026	0.269	2,224	0.029 *

* The level of significance: P<0.05.

PHYSICAL TREATMENTS

4. Discussion

The study investigated the relationship between selected performance tests and non-contact sports lower limb injuries in Sanda male Wushu players. The findings indicated a significant relationship between motion screening tests, two leg squat and tuck jump tests, and athletes' injuries. Studies have revealed that the tuck jump test is useful for examining landing defects during plyometric exercises [29]. In the last decade, numerous researchers have evaluated the relationship between hip and knee mechanics during landing and cutting movements, using two- and three-Dimensional (3D) motion analysis systems. However, these methods cannot be used frequently due to complex analysis and high cost [30].

Lisman et al. (2008) evaluated the results of the tuck jump test and the reduced risk of injury [31]. The researchers stated that the tuck jump test could be used to diagnose neuromuscular imbalances that ultimately lead to knee injuries [31]. Tuck jumps are also employed to assess improvements in lower limb biomechanics. If the athletes can improve their neuromuscular control in the frequent tuck jumps, they are subsequently gaining control over the neuromuscular function of the knee joint; thus, they can improve the acquired skills and reduce

the odds of injury. Performing a weaker leg tuck jump requires more effort to present balance performance between the two legs. However, neuromuscular adaptation occurs more frequently in weaker legs [29].

Chorba et al. (2016) evaluated the reliability of the screening assessments of the risk of tuck jump injury in young elite male soccer players [32]. They stated that the overall tuck jump score is reliable for assessing elite young soccer players; however, due to the within-subject variation, caution should be observed in the individual interpretation of the score combination [18]. Despite the better balance of women, compared to men, female athletes are more prone to be injured than men. This is because the women's landing pattern is associated with more valgus [32]. Therefore, by evaluating the tuck jump, successive tuck jumps with high valgus can indicate the susceptibility of injury to the lower limb. The reason for the inconsistency of the results of the present study with the study of Reed et al. (2016) could be the gender of the subjects, and the type of injury studied. This is because, in their study, the knee valgus was directly related to the type of ligament injury. However, the present study evaluated males, and a more comprehensive range of injuries was investigated. Garrison et al. (2011) stated that the tuck jump test could be a suitable

predictor of injury to individuals and athletes during the match season [33]. The reason for the consistency of the results of the present study with those obtained by Garrison et al. (2011) can also be the study duration [33].

The FMS test is known as one of the most valid functional inventories for predicting the incidence of injury in athletes in various sports. Furthermore, the prediction ability of this test set has been repeatedly supported by previous studies. The present research findings demonstrated that the adequacy of each performance test could be affected by the type of sport and different athletes. This is because the nature of each sport requires different capabilities for athletes in that sport. Additionally, the individuals with a total score of <14 in the FMS test are 5.6 times more likely to be injured than those with higher and better overall scores [10].

Kiesel et al. (2007) examined the relationship between the FMS of English Premier League soccer players and the odds of severe injury [34]. They concluded that the FMS test could predict severe injuries in soccer. They argued that athletes with a lower rate of FMS are more prone to injury; and a score of <14 was considered as a positive predictor of severe injuries with 91% specificity and 54% sensitivity, as well as 11.7 times higher probability of injury [34].

In this regard, Lisman et al. (2012) investigated the FMS test and the prediction of aerobic exercise injury. In this study, 447 subjects were examined. They concluded that running time is shorter with lower scores. This test can also predict injury in these athletes [31]. Chorba et al. (2010) used the FMS test to determine the risk of injury in female athletes [32]. They concluded that a score <14 on the test increased the probability of injury by 4 times [31-39]. The primary purpose of the FMS test is to assess the body's motor chain system [32]. The incidence of most upper limb injuries in martial arts is further, i.e., due to collisions, because the upper limbs fail to carry much weight. However, in the lower limbs, a change in the motor chain can easily cause injury due to the weight-bearing.

Most relevant studies have supported that the FMS test involves most of the lower limbs in soccer players or runners; thus, it is tangible that an FMS test can better predict injury in these disciplines, compared to the others [39-41]. Chimera et al. (2016) conducted a study using screening tests to predict injury in sports [42]. They examined the FMS test, star balance test, Y-balance test, the LESS, and tuck jump test. They accordingly documented the FMS test failed to predict injury. Nevertheless, the

star balance test, the Y-balance test, and the LESS test could predict injury and introduced the tuck jump test as a useful scale in predicting effective injury. Finally, they stated that characteristics, such as gender, history of injury, and participation in sports are critical and influence the accuracy of these tests. Further studies are required in this area [14].

Hoover et al. (2008), as well as Sorensen et al. (2009), believed that the FMS could not predict the odds of injury due to a sensitivity of <50% [28, 29]. They have a sensitivity of 8.3% and a specificity of 94.5% for marathon runners. Moreover, Sorensen suggested a sensitivity of 53.8% and 52.3% specificity for it.

One study that was very cautious about the ability of FMS to predict injury was conducted by O'Connor et al. (2011) [13]. In their study, they examined 874 subjects. The results of their study revealed that FMS had 45% sensitivity and 71% specificity for non-fatal and severe injuries; and 12% sensitivity and 94% specificity for severe injuries. Therefore, according to these results, the FMS lacks a high ability to predict injury [13].

Butler et al. (2013) also examined dynamic balance performance and lower limb injuries in 59 college soccer players [35]. They found that players who scored <89.6% on the Y-balance test were 3.5 times more likely to be injured than the other players. They stated that the dynamic balance test during the pre-season phase was merely successful in identifying players prone to injury during the season [35].

In this study, the Y-balance test was applied to assess balance. The collected results indicated that low scores of the Y-balance test failed to predict injury-prone runners; it was also impossible for marathon runners to determine the risk of injury through the cut-off point of the Y-balance test. Scholars stated that the insignificance of the findings might be due to the broad age range of the subjects (age: 25-60 years), subjects' experience, the recording of minor injuries, and errors in surveys [43].

In contrast, Williams (2015), in a study on male and female marathon runners, observed no predictive association between injury incidence and dynamic balance performance [44]. Low scores on balance tests indicate the presence of neuromuscular control deficits as an essential risk factor for the occurrence of injuries [44].

Flippa (2010) believed that muscle coordination and proprioception significantly impact the performance of the star balance test and poor neuromuscular coordina-

tion. It can negatively affect the dynamic stability of the lower limbs [45].

Khayambashi et al. (2017) conducted a study titled «predicting ankle and knee injuries by static balance test.» [46]. They found a significant relationship between athletes' balance and lower limb injuries. The related results indicated that the one-leg balance test could be used as a predictive scale in lower limb injuries [46]. McGuine et al. (2000) reported that postural oscillation can be a predictor of ankle injuries [47]. However, some studies did not consider having better balance as a determining factor in reducing the rate of injury in athletes. These studies include the one conducted by DiStefano et al. (2009). They concluded that although balance exercises reduce ligament damage, it, surprisingly, increases the risk of knee injury in women, and overuse in men [48].

Complicated steps must be performed to evaluate imaging, especially 3D imaging. The researchers employed video recording while moving to solve the limitations of such measurements; most of them have used the frontal surface view in two dimensions. One-leg and two-leg squat tests are very common, useful, and valid clinical screening tools to assess the condition of the trunk (central stability) and the entire lower limb [49].

Additionally, healthy female athletes, compared to male athletes, presented dorsiflexion and ankle pronation; internal rotation and hip adduction; external tibial rotation; reduced lateral flexion of the torso; anterior pelvic rotation; less hip flexion, and larger lower limb valgus in these tests [50]. Besides, there was a significant relationship between individuals performance in this test and the control of knee movement in the frontal plane and strength of thigh muscles [51]. It has also been suggested that the evaluation of angle and torque of the knee valgus predicts non-contact the Anterior Cruciate Ligament (ACL) injury with 78% sensitivity and 73% accuracy [52]. Various 2D lower limb assessment methods have been reported. All measurements employed motion assessment on the frontal plane using standard video cameras and standard software for motion analysis.

In ligament dysfunction, the muscles fail to fully absorb the ground reaction force, and joints and ligaments must absorb a large amount of force, shortly. The absorption of excessive force in a brief time can lead to ligament injuries. The reaction force of the ground controls the movements of the lower limbs and puts the knee in the valgus position [52, 53]. Although in several studies, the landing error scoring system tests were not introduced as predictors of injury, the validity of this test equals

0.84 [53]. In an extensive review study by Dallinga et al. (2012), they concluded that the landing error test is valid for predicting lower limb injury [54]. According to studies, a five-degree increase in knee valgus enhances the pressure on the knee by up to 6 times [55]. The researchers also found that athletes with ACL injury encountered more abduction angles and torque, compared to healthy athletes during landing [55]. Instead of using the leading lower limb movers, the individual uses anatomical structures and static stabilizers to absorb the ground reaction force [56].

The results of these studies are inconsistent with those of the present study. In the current study, the landing error test could not explain the relationship between lower limb injuries. The reasons for the inconsistency of these results are the type of discipline studied, gender, time, and the type of evaluation of variables.

5. Conclusion

Based on the collected results, among the studied tests, trainers and researchers are suggested to employ the Tuck jump, FMS, and double leg squat tests to predict injuries in wushu male players; this test can also be used to prevent injuries in players.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles were considered in this article. The participants were informed about the purpose of the research and its implementation stages; they were also assured about the confidentiality of their information; moreover, they were allowed to leave the study whenever they wish, and if desired, the results of the research would be available to them. After describing the test protocol to all subjects before participating in the study, they all signed an informed consent form.

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Authors' contributions

Conceptualization, Methodology: Abbas Ghafouri, Fariba Mohammadi, and Behnaz Ganji; Supervision, Data collection, Writing – original draft, and Data analysis: Abbas Ghafouri, Fariba Mohammadi; Investigation: Fariba Mohammadi.

Conflict of interest

The authors declared no conflict of interest.

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