

Research Paper

Relationship Between Shoulder and Knee Muscles Isokinetic Strength and Musculoskeletal Injuries in Iranian National Judo Teams: A Prospective Cohort Study

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Citation Mian Darbandi Sh, Zarei M. Relationship Between Shoulder and Knee Muscles Isokinetic Strength and Musculoskeletal Injuries in Iranian National Judo Teams: A Prospective Cohort Study. *Physical Treatments*. 2023; 13(4):225-234. <http://dx.doi.org/10.32598/ptj.13.4.403.4>

<http://dx.doi.org/10.32598/ptj.13.4.403.4>

**Article info:**

Received: 26 Apr 2023

Accepted: 23 Jul 2023

Available Online: 01 Oct 2023

Keywords:

Muscle strength, Athletic injuries, Martial arts, Risk assessment

ABSTRACT

Purpose: Judo stands as one of the world's oldest sports. However, the frequency of injuries in judo is also high. Crucially, identifying risk factors is necessary to prevent injuries. Despite the functional importance of strength in judo, the relationship between isokinetic strength and sports injuries has been little studied. The objective of this study was to prospectively examine the correlation between isokinetic muscle strength in elite judokas and the frequency of injuries.

Methods: The population of this cohort and prospective study included judokas of different age groups from the Iranian national teams in 2020. Fifty-three of these judokas voluntarily participated in the study. Before the camps, the isokinetic strength of the knee flexors and extensors as well as the internal and external rotators muscles of the shoulders were measured at speeds of 60 and 300°/s, and the injuries to these judokas were also recorded for nine months using a logistic regression test.

Results: The findings indicated a significant association between the ratio of the maximum isokinetic strength of the hamstring to quadriceps muscle and judoka injuries at a speed of 60°/s. A significant relationship was also found between the ratio of the maximum isokinetic strength of the shoulder flexors and shoulder extensors in judoka injuries at a speed of 300°/s. However, no significant relationship was found between the strength ratio of the external and internal rotators of the shoulder in injuries of judokas at 60 and 300°/s ($P > 0.05$).

Conclusion: The ratio of isokinetic strength between the muscles in the lower and upper limbs can serve as a predictive indicator for injuries among judokas. Consequently, it is recommended to employ these tests to evaluate injury risk.

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Highlights

- The hamstrings-to-quadriceps (H:Q) isokinetic strength ratio at an angular velocity of 60°/s is a risk factor for lower extremity injury of Iranian national judokas.
- The flexor-to-extensor (FL:EX) shoulder muscle isokinetic strength ratio at an angular velocity of 300°/s is a risk factor for upper extremity injury of Iranian national judokas.
- There is no statistically significant correlation between the torque ratio of the shoulder's external rotator muscles and its internal rotator muscles and the injury of the upper extremity of Iranian national judokas.

Plain Language Summary

Identifying the risk factors of sports injuries helps to prevent these injuries. Strength is one of the most important indicators of success in sports, but few studies have examined the role of this factor in the occurrence of sports injuries. Therefore, the aim of the present study was to investigate the relationship between the isokinetic strength of the muscles of elite judokas and the incidence of injuries in a prospective method. All the judokas of the national teams participated in this study. We measured the isokinetic strength of different muscles of these judokas and then recorded their injuries for nine months. The hamstrings-to-quadriceps (H:Q) isokinetic strength ratio at an angular velocity of 60°/s is a risk factor for lower extremity injury of Iranian national judokas. Also, the flexor-to-extensor (FL:EX) shoulder muscle isokinetic strength ratio at an angular velocity of 300°/s is a risk factor for upper extremity injury of Iranian national judokas. However, there is no significant correlation between the ratios of the torque of the external rotator muscles to the internal rotator of the shoulder with the injury of the upper extremity of Iranian national judokas.

1. Introduction

Judo is one of the most popular martial arts in the world, and the first discipline of martial arts that joined the Olympics in 1964 [1]. According to statistics, 200 countries are members of the world federation of this sport and 20 million athletes are active in this sport in five continents. Judo players try to disrupt the opponent's center of gravity, perform suitable techniques, and score points; however, some of these movements can lead to long-term injury and disability of the athletes [2]. Pocecco et al. examined the injuries of men and women in the 1997 Asian Games and stated that women (28.41 injuries per 1000 athletes) and men (18.25 injuries per 1000 athletes) got injured [3]. They also compared the injuries in football, volleyball, judo, karate, ice hockey, and basketball using the data recorded in the insurance. They stated that the incidence of karate and judo injuries was higher than other sports. They have reported that the prevalence of injuries that occurred during the 2008 and 2012 Olympic Games was about 11-12%, which shows the high level of injury in this sport. Lariosa et al. [4] reported that the Philippine student judo team from 2011 to 2016 had a total of 180 injuries with a rate of 9.4 per 1000 athletes exposed. Kim et al. [5] also reported that South Korean Olympic judokas had at least four injuries

per year. In general, studies have reported the prevalence of injury in judo between 12 and 30% [1]. In Iran, Rahnama et al. [6] compared the injuries of 66 professional male judokas and 66 non-professional male judokas during one year. They reported that 20.98 professional judokas and 40.67 non-professional judokas were injured per 1000 athletes. These injuries mostly involve the knee and shoulder areas. Therefore, in order to safeguard the safety and well-being of judokas and prevent unnecessary financial expenditures, injury prevention in this sport is imperative.

Recognizing risk factors is crucial for the prevention of injuries. Researchers have introduced various risk factors for judo injuries, such as age, gender, weight [7], balance [8], skill level [9], equipment used [5], the lack of sufficient supervision of the coach on training and the experience of judokas [10]. Numerous researchers have regarded muscular strength and endurance as the most critical factors contributing to the success of elite judokas [9]. Judo practitioners rely on maximum dynamic strength for executing both defensive and offensive techniques. Techniques that involve lifting and throwing opponents require considerable strength. Also, isokinetic strength is essential for a judoka to control the opponent [9]. Many researchers have studied the role of different types of strength in the occurrence or non-occurrence

of sports injuries in other sports, such as football, volleyball, and wrestling. For example, Hoseini et al. [11] showed a significant relationship between the isokinetic strength of the lower limb muscles of wrestlers and their injuries. For this reason, the assessment of various types of strength has become one of the main tests to prevent injury in this sport, and many world's leading teams in various sports perform isometric and isokinetic strength tests in pre-season evaluations. Nevertheless, despite the functional significance of strength in judo, a few studies have been done on the relationship between strength and injuries in this sport. Hence, the objective of this study was to prospectively explore the relationship between the isokinetic strength of knee flexor and extensor muscles, as well as the isokinetic strength of flexor and extensor muscles and shoulder rotators in elite judo athletes, and their injury prevalence.

2. Materials and Methods

The current research was a cohort and prospective study. Predictive variables of this research included isokinetic strength of knee flexor and extensor muscles, isokinetic strength of flexor and extensor muscles, and shoulder rotators. The predicted variable was the occurrence or non-occurrence of injury. A total of 53 male judokas from the national team willingly took part in the pre-participation screening tests, following the necessary coordination and approval from the National Judo Federation and the national team coaches. All participants were chosen as potential members of the judo national team and engaged in full-time training within a high-level competitive setting, with a minimum of five training sessions per week. No formal sample size calculation was conducted, as the study included all the members of the national teams in Iran ($n=53$). This approach was chosen to avoid including lower-level players who did not meet the criteria for the intended target population.

All subjects agreed to participate in the research by signing the consent form. After the subjects entered the laboratory, their height, weight, and fat percentage were measured by the Inbody 770 device. Then, the judokas warmed up for 10 minutes on the bike with the desired intensity and speed. Then, the isokinetic strength of the knee flexor and extensor muscles, shoulder flexor and extensor muscles, as well as the internal and external rotators of the shoulder were measured at different speeds using an isokinetic dynamometer (Biodex 4 Pro System; Switzerland).

To assess the isokinetic strength of the knee flexor and extensor muscles, the participant was instructed to sit on the device's chair, ensuring their body was in a comfortable and standardized position. To ensure the test was conducted optimally and in a standardized manner, straps were used to secure the person's trunk, hip, and thigh to the device.

The participants were requested to complete three sets with three repetitions with maximum effort at the speeds of 60 and 300°/s of flexor and extensor of the knee in the range of motion (ROM) of 7 to 115° with 30 seconds of rest between each set [12]. To quantify the maximum torque of the dominant shoulder flexor and extensor muscles, the participants moved their arms in the sagittal plane and carried out three repetitions with maximum effort within the range of 0 to 180°/s with a low speed of 60°/s and a high speed of 300°/s in a concentric/concentric contraction (Figure 1). There was a 30-second rest between each attempt and a 5-minute rest between each test [13].

To measure the maximum torque of the internal and external rotator muscles of the dominant shoulder, the subject was placed in a sitting position on a chair. The subject's shoulder was in the plane of the scapula (90 degrees of abduction and 30 degrees of forward flexion), his elbow was in 90 degrees of flexion and the wrist was in a neutral position, and three repetitions were performed with maximum effort at a low speed of 60°/s and at a high speed of 300°/s in a concentric/concentric manner [14]. The ROM of the rotators was 150°, which was measured from -60 to +90° for internal rotators and external rotators, and there was no movement in the horizontal plane [15]. Rest time was 30 seconds between each set and 5 minutes rest between each test. During the execution of each test, verbal encouragement was also used (Figure 2). Finally, the maximum torque recorded in each of these efforts was divided by body weight.

In this study, an injury was documented under the following criteria: 1) It occurred during training or competition, 2) Required medical assistance, and 3) Made the injured judoka unable to participate in the next day's training session or competition [16]. Following data collection, the demographic characteristics of the participants, along with the research variables, were subjected to analysis using SPSS software, version 26. To explore the potential predictive relationship between isokinetic muscle strength indices and athletes' injuries, a logistic regression test was employed at a significance level of 95%, where α was set at ≤ 0.5 .

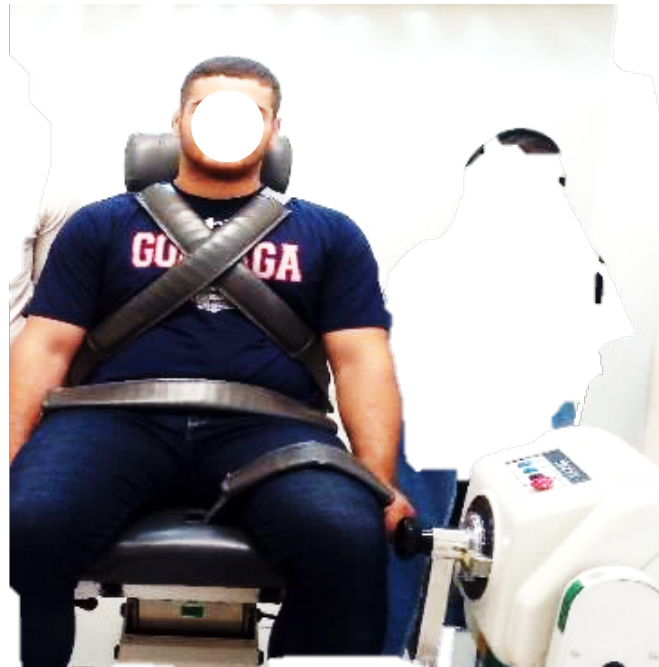


Figure 1. How to measure hamstring and quadriceps strength

PHYSICAL TREATMENTS

3. Results

To explore the correlation between specific internal risk factors and musculoskeletal injuries among judokas, a cohort study involved 53 judo participants. [Table 1](#) provides an overview of demographic and anthropometric data, including age, height, weight, body mass index, and body fat percentage, recorded at the study's outset for the judo athletes.

Top of form

During the nine months of the study, 62 injuries were recorded. Also, 70% of injuries were acute and 30% were chronic. The findings of the logistic regression test revealed a significant correlation between the ratio of the maximum strength of the concentric torque in the hamstring muscles and the quadriceps (H/Q) at a speed of 60°/s and the injury of Iranian national team judokas ($P=0.02$; odds ratio [OR]=0.90). However, no significant relationship was observed at the speed of 300°/s ($P<0.05$) ([Table 2](#)).



Figure 2. Measuring the muscle strength of shoulder flexors and extensors

PHYSICAL TREATMENTS

Table 1. Anthropometric characteristics of judokas participating in the study

Characteristics	Mean±SD		P
	Uninjured Judokas (n=38)	Injured Judokas (n=15)	
Age (y)	18.66±3.16	18.73±2.96	0.93
Height (cm)	174.45±6.85	177.40±8.01	0.18
Weight (kg)	74.95±10.84	76.33±13.77	0.70
Body Mass Index (kg/m ²)	23.31±3.45	22.54±4.21	0.49

PHYSICAL TREATMENTS

Also, the results of the logistic regression test showed that there is no significant relationship between the ratio of the peak torque of the flexor muscles to the shoulder extensor with the injury of judo athletes at a speed of 60°/s, but there is a significant relationship between the ratio of the maximum torque of the flexor muscles to the shoulder extensor with the injury of judo athletes at a speed of 300°/s (OR=0.93; P=0.04) (Table 3).

The finding of the logistic regression analysis indicated no significant correlation between the ratio of the torque of the external rotator muscles to the internal rotator of the shoulder with the injury of the upper extremity of Iranian national judokas at speeds of 60 and 300°/s (Table 4).

4. Discussion

The results of the current research demonstrated a significant correlation between the ratio of the maximum isokinetic strength of the flexor muscles to the knee extensor muscles and injuries of the national team judokas at a speed of 60°/s. However, the same variable was not significant at the speed of 300°/s. Also, no significant

correlation was observed between the ratio of concentric strength of flexor to shoulder extensor muscles and the musculoskeletal injuries of national judokas at a speed of 60°/s, but at a speed of 300°/s, there was a significant correlation between the ratio of flexor to extensor muscles of the shoulder and injuries of judo players. The results of this research showed no significant relationship between the ratio of the concentric torque of the external rotator muscles to the internal rotator of the shoulder with the injury of national team judokas at speeds of 60 and 300°/s.

There is a limited number of studies on the relationship between the isokinetic strength of knee flexor muscles and injuries in judo athletes, as well as individual sports in general. The majority of similar research has been conducted in team and ball sports. For instance, it has been revealed that the isokinetic strength of the quadriceps muscles at a speed of 60°/s is not a predictive factor for hamstring injuries [17]. Also, in the context of English Premier League soccer players, it has been established that the isokinetic strength of the knee extensor muscles at an angular velocity of 180°/s is not a reliable predictor

Table 2. The results of logistic regression analysis to compare the isokinetic strength of knee flexors and extensor of injured and uninjured judokas

Variables	Mean±SD		OR	P
	Injured Players (n=15)	Uninjured Players (n=38)		
The ratio of knee flexor to extensor strength at a speed of 60°/s	46±10.7	52±7	0.90	0.02*
PT of the extensor muscles at a speed of 60°/s (Nm)	274.4±41.6	265.4±49.2	1.00	0.52
PT of flexor muscles at a speed of 60 degrees per second to the weight	130.4±30.7	136.5±26.4	0.99	0.46
The ratio of knee flexor to extensor strength at a speed of 300°/s	53.8±9.2	59.00±10.8	0.94	0.11
PT of the extensor muscles at a speed of 300°/s (Nm)	154.5±37.6	139.3±32.9	1.01	0.15
PT of flexor muscles at a speed of 300°/s	81.00±23.7	81.70±23.4	0.99	0.91

PT: Peak torque; OR: Odds ratio.

*Significant differences.

PHYSICAL TREATMENTS

Table 3. The results of logistic regression analysis to compare the isokinetic strength of shoulder flexors and extensors of injured and uninjured judokas

Variables	Mean±SD		OR	P
	Injured Judokas (n=15)	Uninjured Judokas (n=38)		
The ratio of shoulder flexor to extensor strength at a speed of 60°/s	81.5±13.6	84.3±15.10	0.98	0.48
Peak torque of the extensor muscles at a speed of 60°/s (Nm)	115.2±26.5	111.80±24.1	1.01	0.63
Peak torque of flexor muscles at a speed of 60°/s to the weight	91.1±17.1	93.1±21.2	0.99	0.75
The ratio of shoulder flexor to extensor strength at a speed of 300°/s	82.3±12.5	91.9±11.9	0.92	0.04*
Peak torque of the extensor muscles at a speed of 300°/s (Nm)	96.3±24.3	88.8±20.8	1.01	0.34
Peak torque of flexor muscles at a speed of 300°/s	78.9±19.8	81.1±19.9	0.99	0.75

OR: Odds ratio.

*Significant differences.

of hamstring injuries [18]. Similar results were reported by Bakken et al. [19], who conducted research on players from 14 Qatar Premier League teams and found that the maximum torque of quadriceps muscles at a speed of 60°/s was not significantly associated with the occurrence of injuries. Furthermore, the isokinetic strength of quadriceps muscles in both male and female basketball and floorball players was not indicative of the likelihood of knee injuries [20].

For over six decades, the ratio of hamstring muscle strength to quadriceps strength has been employed as a method to detect muscle imbalances, and knee joint stability, and describe the characteristics of muscle strength around the knee. However, there is a difference of opinion in using this index as a predictive factor of injury. The findings of this study indicated that the ratio of isokinetic strength between the hamstrings and quadriceps at a speed of 300°/s was not a reliable predictor of injuries

in judo players. Bakken et al. also reported similar results, stating that the ratio of isokinetic strength between the hamstrings and quadriceps at speeds of 300°/s could not forecast injuries in soccer players [19]. Furthermore, Hietamo et al. also found that the ratio of isokinetic strength between hamstring muscles and quadriceps had no significant correlation with knee injuries [20].

On the other hand, the ratio of the isokinetic strength of flexor to extensor muscles can predict injuries. Yeung et al. studied 44 Hong Kong sprinters and measured the isokinetic strength of hamstring muscles and quadriceps at different angular velocities and stated that the ratio of hamstrings to quadriceps at 60°/s can predict hamstring injuries. They also stated that reducing the ratio of hamstrings to quadriceps to less than 60% at 60°/s can increase the risk of hamstring injuries by 17 times [21].

Table 4. Comparison of the isokinetic strength of shoulder external and internal rotator muscle of injured and uninjured judokas

Variables	Mean±SD		OR	P
	Injured Judokas (n=15)	Uninjured Judokas (n=38)		
The ratio of shoulder external to internal rotator muscle strength at a speed of 60°/s	72.7±11.7	75.3±14.5	0.98	0.53
Peak torque of the internal rotator muscle at a speed of 60°/s (Nm)	65.40±19.90	65.60±17.20	1.00	0.98
Peak torque of external rotator muscle at a speed of 60°/s (Nm)	46.2±10.7	47.8±10.8	0.98	0.61
The ratio of shoulder external to internal rotator muscle strength at a speed of 300°/s	80.5±17.2	79±11.3	1.01	0.70
Peak torque of the internal rotator muscle at a speed of 300°/s (Nm)	54.1±15.6	52.8±13.60	1.01	0.75
Peak torque of external rotator muscle at a speed of 300°/s	42.4±11.7	40.7±8.30	1.01	0.56

OR: Odds ratio.

Ruas et al. put forth the argument that solely evaluating the ratio of maximum torque between hamstring and quadriceps muscles may not comprehensively address the neuromuscular factors influencing injury occurrence. They proposed that for more effective injury prediction, the consideration of the ratio between antagonistic and agonistic muscles at various angles and angular velocities should be taken into account. Additionally, these researchers suggested that factors, such as torque development rate, muscle size, and muscle activation could be incorporated to enhance the accuracy of injury prediction [22].

Similar to the findings in the current study, McDonough et al. carried out a study involving 22 rugby players and concluded that the isokinetic strength of the shoulder muscles in the vicinity was not effective in predicting shoulder joint injuries [23]. In a study conducted by Forthomme et al., the isokinetic strength of shoulder rotator muscles was assessed in 108 handball players at angular velocities of 60 and 240°/s for concentric contractions and 60°/s for eccentric contractions. The researchers found that the maximum isokinetic torque at any of the tested speeds and contraction types was not effective in predicting shoulder joint injuries. Additionally, the isokinetic power ratios between flexor and extensor muscles and internal and external rotators did not prove to be predictive of injuries either [24]. In a study conducted by Vogelpohl and Kollock, the isokinetic strength of shoulder muscles in 15 baseball players was assessed. Their findings indicated that isokinetic strength at angular velocities of 60 and 180°/s did not serve as a predictor for injuries. One potential explanation for the lack of a significant relationship between isokinetic strength and injury occurrence may be the one-sided nature of this investigation. Sports injuries can have numerous and diverse causes; thus, it is important to consider the multifactorial nature of risk factors when studying injury factors [25]. Different risk factors interact and the role of each factor cannot be investigated in isolation. For this reason, in the new approaches to investigate the risk factors of sports injuries, machine learning approaches are used to investigate the interactions of risk factors with each other.

The majority of the tests conducted in this study were carried out in a seated position without weight bearing, and in an open-chain fashion. However, the actions and movements of judo players during training and competition significantly differ from these conditions. These tests may not be directly applicable to the typical actions and movements encountered in judo. It appears that measurements conducted under weight-bearing condi-

tions and in settings closely resembling the demands of judo could provide more relevant performance insights. Another limitation of this study is the age and weight of the subjects. As previous studies have shown, age and weight can be considered risk factors for the occurrence of injuries. Judo is a sport with different weights and different age groups, and this problem can affect the injury of judo players. Therefore, due to the limitation in the number of the community, the researchers were not able to control the effect of weight and age group of the athletes as a risk factor, and this issue should be considered in the generalization of the results.

5. Conclusion

The results of the present research showed that there is a significant relationship between the ratio of the maximum isokinetic strength of the hamstring muscle to the quadriceps and the injury of national judo players at a speed of 60°/s, but the same variable was not significant at a speed of 300°/s. Also, a significant relationship was observed between the ratio of the maximum isokinetic strength of flexors and shoulder extensors at a speed of 300°/s, but this ratio was not significant at a speed of 60°/s. The results of the test regarding external to internal rotators of the shoulder at two speeds of 60 and 300°/s were not significant. According to the results obtained from the present research and the ability to predict the damage, it is suggested that the Judo Federation, the Judo Board of the provinces, the national team coaches, the officials of the professional league, and the clubs of the country by conducting the test capable of predicting injuries, identify the weakness and functional imbalance of athletes before the injury occurs.

Ethical Considerations

Compliance with ethical guidelines

This article adhered to all ethical principles in line with the Helsinki Convention. The participants were provided with information regarding the study's objectives, and their information was guaranteed to be kept confidential. A written consent form was signed by the subjects.

Funding

The paper was extracted from the master's thesis of Shirzad Mian Darbandi, approved by Department of Corrective Exercises and Sports Injuries, Faculty of Sport Sciences and Health, [Shahid Beheshti University of Medical Sciences](#).

Authors' contributions

Both authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

Acknowledgments

The authors sincerely appreciate the participating judo athletes and coaches.

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