Is there Relationship between Pectoralis Minor Muscle Length and Shoulder Rotator Muscles Strength?ⁱ

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Abstract Problem Statement: In joint movement, agonist and antagonist muscle strength, as well as the length and the shortness of these muscles is an important parameter. Muscle shortness is one of the factor that responsible of sports injuries. Shoulder is one of the most injured joint in Judo. In this joint, determination of the relationship between muscle shortness and agonist-antagonist muscles strength will be effective to increase muscle strength, sportive performance and prevent sports injuries. Purpose of Study: This study was conducted to determine the relationship between pectoralis minor (PM) muscle length and shoulder internal(IR)/external(ER) rotation isokinetic muscle strength in Judo athletes. Methods: The study included 80 (56 males, 24 female) professional Judo athletes aged between 14-25 (mean 17,31±2,51). Isokinetic muscle strength was assessed by ISOMED 2000® device. Pectoralis minor length was evaluated using a flexible tape measure in resting position. The assessments were made bilaterally. Findings and Results: There was a strong and statistically significant correlation between the PM length and the shoulder IR and ER peak torque values at both angular velocities and both sides ($p < 0,01$). Conclusions and Recommendations: It was determined that the relationship between the length of the PM muscle and the internal and external rotator muscle strength of Judo athletes. Therefore, we think that by increasing shoulder muscle strength to enhance sportive performance, stretching exercises for PM muscle shortening should be added to training programs.

Keywords Isokinetic Strength, Judo Players, Pectoralis Minor Length

while performing different techniques [1]. Judo athletes ought to be fast, strong and flexible to successfully defeat opponents' moves. Flexibility may be defined as the maximal passive physiological range of motion in the joint movement. Lack of flexibility will affect the athlete's ability to do certain Judo techniques. Athletes' more flexible muscles lead improved range of motion in related joint which reducing risk of injury during the game [2].

The shoulder (22%) is one of the most commonly injured joint in Judo. Many factors such as age, gender, lack of muscle flexibility, strength asymmetry and sport year affect the occurrence of these injuries [3]. Among these factors; lack of muscle flexibility, especially inadequate pectoralis minor muscle length is responsible for making shoulder vulnerable to injury [4].

The pectoralis minor (PM) muscle attaches to the coracoid process of the scapula and inserts on ribs three, four, and five near the costosternal junction [5,6]. It is the only scapulothoracic muscle with an anterior thoracic attachment. The fiber orientation of the PM muscle favors scapular internal rotation (IR), downward rotation, and anterior tilt (AT), and for this reason, it is considered an antagonist to the necessary scapular motions during arm elevation. Repetitive use of the upper extremity for activities that protract and downwardly rotate the scapula may also contribute to adaptive shortening. PM's adaptive shortening leads to changes in the resting position of the scapula and altered scapular kinematics and these changes can cause imbalance between agonist and antagonist muscle strength of shoulder joint [4].

While the relationship between muscle shortness and sports injuries has been determined in the literature [4,8], there is no sufficient evidence regarding these injuries' mechanisms

We hypothesized because of muscles that adaptively shortened due to repetitive movements being unable to contract in the optimal position, muscle strength would decrease and loss of strength would cause muscle strength imbalance

1. Introduction

Judo is a high-intensity competitive sport in which the athletes are constantly pulling and pushing each other

The purpose of this study was to determine the relationship between PM muscle length and shoulder IR/ER isokinetic muscle strength in Judo athletes. Assessment of shortness of these muscle groups and determination of the relationship between these shortness and muscular strength of related joints will explain shortening related injury mechanisms in Judo athletes.

2. Materials and Methods

2.1. Participants

The study was conducted with the aim of determining the effects of PM muscle lengths on shoulder strength in Judo athletes in the Ministry of Youth and Sports, Sports General Directorate, Department of Health Services Center of Athlete Training and Health Research in Ankara, Turkey. The study consisted of 80 (56 males and 24 female) Judo athletes, who complied with the criteria and voluntarily participated in the study. The means of ages, standing heights, body masses and Body Mass Index (BMI) were $17,18 \pm 2,47$ years, $1,70 \pm 0,08$ m, $69,92 \pm 8,19$ kg and $23,66 \pm 4,50$, respectively for participants. All the athletes and coaches who accepted to participate in the study were informed about the study purpose, the assessments included in the study and the benefits of the study and the study was based on volunteerism.

2.2. Isokinetic Muscle Strength Assessment

Isokinetic muscle strength was assessed by ISOMED 2000® device. Prior to the test, the athletes did general and special warming workouts for 10 minutes. Following the warming, the athletes were taken to the isokinetic device one by one for measurement and the device was adjusted according to their individual anthropometric structures. During the test, their weights were entered in the computer and the program was set. The suitability of the movement ranges of the joint to be tested to the angles that are to be tested was determined by making the athletes do a sample movement at a very low speed. The joint angles were adjusted in the assessment by considering the joint movement ranges of the persons and the measurement characteristics of the device. A concentric-concentric strength measurement was made for the shoulder IR/ER movement between the angles of 0° ER and 90° IR [Figure.1].

Figure 1. Assessment of isokinetic muscle strength: Shoulder IR / ER isokinetic muscle strength test position

The assessment protocol for shoulder joint; the athletes warmed by doing the IR/ER movement at $60^\circ/\text{sec}$ with three repetitions as submaximal and they were ensured to perceive the movement. Following the warming movement and a one-minute rest, they did maximal IR/ER movement at $60^\circ/\text{sec}$ speed with five repetitions and again following a one-minute rest, they warmed again by doing the IR/ER movement at $180^\circ/\text{sec}$ with three repetitions as submaximal and they were ensured to perceive the new movement speed and again following a one-minute rest, they did maximal IR/ER movement at $180^\circ/\text{sec}$ speed and with 15 repetitions and the test was completed. The assessments were made bilaterally for each joint and first the dominant side was assessed and three minutes later the non-dominant side was assessed.

2.3. Pectoralis Minor (PM) Length Assessment

PM length was measured in the resting position using a tape measure with 0.10-cm resolution before isokinetic muscle strength test. The caudal edge of the fourth rib at the sternum and the inferomedial aspect of the coracoid process were palpated and marked with a pencil [Figure 2A] [5,9,10]. The distance between these landmarks was measured. During the resting position measurements (Figure 2B), participants were asked to remain in a relaxed and neutral posture with the arms at the side, avoid postural correction and exhale just before the measurement.

Figure 2. Bony landmarks used to represent pectoralis minor length (A) and measurement of pectoralis minor length taken with a tape measure (B).

Table 1. The peak torque values of dominant- nondominant shoulder IR and ER movements of the athletes at 60°/sec and 180°/sec velocity, and PM muscle length measurement results

		Dominant Side	Non-Dominant Side
IR Peak Torque (Nm)	60°/sec.	56,59±19,31	52,84±17,62
	180°/sec.	51,01±16,65	48,51±16,03
ER Peak Torque (Nm)	60°/sec.	29,88±9,66	28,19±9,62
	180°/sec.	51,01±16,65	48,51±16,03
Flex Peak Torque (Nm)	60°/sec.	99,99±31,23	101,11±27,44
	180°/sec.	78,21±22,31	78,92±19,61
Ext Peak Torque (Nm)	60°/sec.	182,73±52,99	181,56±52,57
	180°/sec.	128,78±33,19	131,25±38,43
PML(cm)		17,35±3,21	17,38±2,99
PKET(degree)		161,22±8,31	159,62±8,49

IR: Internal Rotation; ER: External Rotation; Nm: Newton/meter; PML: Pectoralis Minor Length

Table 2. The relationship between shoulder IR and ER movements at 60°/sec and 180°/sec velocity of the athletes and PM muscles length

VARIABLES	DMIR PT 60°/sec	NDIR PT 60°/sec	DMER PT 60°/sec	NDMER PT 60°/sec	DMIR PT 180°/sec	NDIR PT 180°/sec	DMER PT 180°/sec	NDMER PT 180°/sec
PMLDM	,708(**)	,708(**)	,682(**)	,606(**)	,685(**)	,675(**)	,723(**)	,535(**)
PMLNDM	,685(**)	,686(**)	,657(**)	,593(**)	,677(**)	,662(**)	,713(**)	,531(**)

*p<0.05 **p<0.01 * Pearson Correlation DM: Dominant Side; NDM: Non-Dominant Side; IR: Internal Rotation; ER: External Rotation; PML: Pectoralis Minor Length

2.4. Statistical Analysis

All the data obtained from the measurements of athletes were analyzed with statistical software package "SPSS (Statistical Package for Social Sciences Inc., Chicago, IL, USA) For Windows Release 22.0". The Kolmogorov-Smirnov test was used to determine if the data was normally distributed or not. The relationship between pectoralis minor muscle lengths and shoulder isokinetic muscle strength was analyzed by Pearson correlation test. The statistical significance was set at $p < 0.05$ [12].

3. Findings

The peak torque values of dominant- nondominant shoulder IR and ER movements of the athletes at 60°/sec and 180°/sec velocity, and PM muscle length measurement results are shown in Table 1.

The relationship between shoulder IR and ER movements of the athletes at 60°/sec and 180°/sec velocity and PM muscle length are shown in Table.2

Table. 2 shows that there was a strong and statistically significant correlation between the PM length and the shoulder IR and ER peak torque values at both angular

velocities and both sides ($p < 0,01$).

4. Discussion

As result of our study that is aimed to determine the relationship between shoulder IR/ER isokinetic muscles and PM muscle length in Judo athletes, it was found a strong and statistically significant correlation between the PM length and the shoulder IR and ER peak torque values at both angular velocities and both sides.

The results of this study support our hypothesis that because of muscles which adaptively shortened due to repetitive movements being unable to contract in the optimal position, muscle strength would decrease and loss of strength would cause muscle strength imbalance. In our study, it was determined that PM muscle shortness negatively effect on internal and external rotators' muscle strength.

PM minor adaptive shortening that is altered scapular kinematics by increased scapular IR and decreased scapular posterior tilt (PT) during arm elevation is a risk factor for shoulder injuries in athletes [13]. It causes muscle strength difference between dominant and nondominant extremities by making strength imbalance between scapular agonist and antagonist muscle groups [4,5,14]. Moreover, agonist/antagonist muscle strength imbalance and dominant-nondominant side strength asymmetry make the shoulder joint prone to injuries in athletes. This result is consisted with the findings of studies in the literature.

Our study shows that routine PM stretching exercises should be added to the training programs to prevent the possible PM muscle shortening which is result of the nature of the Judo sport and to prevent sports injuries in the shoulder region. Because our study shows us that PM muscle shortness is not only related to shoulder IR muscles' strength which is short and unable to contact in optimal position but also with ER muscle's strength trying to produce force in lengthening position and being unable to contact in optimal position secondary to shortness in agonist muscle.

To the best of our knowledge this is the first study to scrutinize the relationship between PM muscle length and shoulder muscle strength of Judo athletes. Future studies are needed to investigate this relationship in different sports branches with high shoulder injury frequency rates. In addition, future research should focus on examining how muscular strength is affected and how the shoulder injury frequency rate changes after the training programs involving PM muscle effective stretching in Judo sport.

There was no evidence about the relationship between PM muscle length and shoulder injury.

In addition to that, we couldn't find any research about neither the normal length of PM muscle in demographically similar, healthy sedentary, nor the

difference of PM length in people with or without shoulder injuries. In our study, it is found that the average length of the PM muscle was 17 cm. Since there is no study about whether this is a shortness or not, it is very difficult to explain that the relation between PM muscle length and shoulder IR/ER isokinetic muscle strength is related to shortness.

5. Conclusions

It was determined that the length of the PM muscle and the internal and external rotator muscle strength of Judo athletes is positively correlated. Therefore, in Judo athletes when planning training program to prevent especially shoulder joint injuries and enhance muscle strength and sportive performance, PM muscle length should be taken into consideration and we recommend that proper stretching and flexibility exercise for shortening muscle group should be added to routine training programs.

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ⁱThis study is Selected Paper of and presented in 4nd World Conference on Health Sciences (H-SCI 2017) 28 April-30 April 2017 Grandpark Lara Hotels & Convention Center –Antalya, Lara, Turkey