Difference in Isokinetic Strength of the Muscles around Dominant and Nondominant Shoulders

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Background: *Muscle training usually plays an important role in the treatment of shoulder disorders. Clinicians traditionally predict the pre-injury strength of an injured shoulder by using the contralateral uninjured side as the baseline data.*
Objective: *The primary purpose of the present study was to determine the difference in isokinetic peak torque of dominant and nondominant shoulders.*
Material and Method: *Both shoulders of 39 healthy subjects (24 men, 15 women) were tested isokinetically by using the CON-TREX MJ dynamometer at two angular velocities (60 and 180 °/sec) during abduction, adduction, flexion, extension, internal rotation and external rotation.*
Result: *There were statistical differences of contralateral peak torque in almost all directions of shoulder muscle contractions except in shoulder flexion at both speeds. Peak torque of shoulder adduction, extension, and internal rotation were greater in the dominant side. Shoulder abduction and external rotation peak torque were greater in the nondominant side.*
Conclusion: *Therefore, clinicians should not directly use the isokinetic strength of the contralateral shoulder as normal baseline data for an injured side without consideration.*

Keywords: *Isokinetic, Muscle strength, Shoulder*

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Muscle strength training usually plays an important role in the treatment of shoulder disorders such as rotator cuff injury and shoulder instability. Evaluation of muscle strength is important for detecting muscle weakness caused by these disorders or disuse conditions, and for follow-up of patients after a rehabilitation program or surgery. Clinicians traditionally predict the pre-injury strength of an injured extremity by using the performance measurement of the uninjured extremity as the normal baseline data. Sapega[1] proposed useful guidelines to interpret side-to-side comparison of muscle performance: When normal individuals are evaluated, imbalances in strength of less than 10% can be considered normal, difference of 10-20% as possibly abnormal, and those greater than 20% probably abnormal. When one extremity is clearly expected to be weaker, on the basis of previous injury or disuse, differences of 10-20% can be considered probably abnormal and those of more than 20%, as almost certainly abnormal. The commonly used criterion of 80-90% of the measured capability in the uninvolved extremity can be used as a minimum standard for the involved extremity before the patient returns to sports or strenuous work after injury.

Isokinetic testing is an accurate quantitative measurement of muscle performance that tests at fixed angular velocity of joint motions. The most frequently used isokinetic variable is Peak Torque (PT, unit Nm). This correlates well with strength of the muscle. There were some isokinetic studies of the shoulder that compared the isokinetic variables of the dominant and non-dominant side. While some studies supported the bilateral correspondence[3-5], some did not[6-8]. There are a limited number of studies in Western countries.

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These may be different from those of the Eastern countries because of the differences in life style and recreational sports.

The purposes of the present study were to determine the difference in isokinetic peak torque of dominant and nondominant shoulders, and to determine correlation of bilateral differences in shoulder circumference, Mid-Upper-Arm Circumference (MUAC), Mid-Upperarm Muscle Circumference (MUMC), and grip strength with these bilateral isokinetic differences.

Material and Method

Thirty-nine subjects, 24 men and 15 women, between the age of 25 and 50 years (mean = 34 years) were tested. Average BMI of the subjects was 22.9 (18.4-30.6, SD = 2.6). Corresponding to the side used for doing labor work, 36 of the subjects were right upper extremity dominant and 3 were left upper extremity dominant. Exclusion criteria were 1) past history of shoulder disorders or surgery 2) abnormal physical findings in any side of the shoulders 3) pregnancy and 4) frequently playing asymmetrical sports (such as racket sports, throwing sports). The present study was approved by the Institutional Ethical Committee.

Isokinetic variables of both shoulders were measured by using the CON-TREX MJ dynamometer (CMV AG, Zurich, Switzerland). Isokinetic values were gravity-corrected by using the software provided with a dynamometer. The test consisted of 2 speeds (60 /sec and 180 /sec) and 3 couples of motions (abduction/adduction, flexion/extension and internal/external rotation)[9].

Both shoulders were tested with the same positions and range of motions. Shoulder abduction/adduction was tested first and followed by flexion/extension, and internal/external rotations. In every couple of motions, the dominant side was tested before the nondominant one.

After stretching exercise, the subject had a warm-up session by doing 5 times of submaximal repetitions of shoulder motions at slow speed (60 /sec), followed by a 2-minute rest periods before testing. The slow speed test included 5 maximal repetitions then a 2-minute rest. High speed (180 /sec) warm-up by doing 5 cycles of submaximal repetitions were done followed by a 2-minute rest prior to 5 maximal repetitions of high speed test. A two- minute rest period was allowed prior to the testing for the next joint movement.

Bilateral differences of shoulder circumference, MUAC, MUMC, and grip strength were measured to determine the correlation with isokinetic difference. Shoulder circumference was measured in neutral position at the uppermost level of the axilla. MUAC was measured at midway between the acromion and olecranon process. Tricep skinfold was measured by Lange skinfold caliper at both sides to calculate MUMC (MUMC = MUAC-3.14 Tricep skinfold). A handheld dynamometer was used to measure grip strength of both hands.

For statistical analysis, student's paired t test was used to test the isokinetic peak torque for bilateral difference with a level of significance at p value less than 0.05. Pearson correlation coefficient was used to determine the linear relationship between the bilateral differences of shoulder circumference, MUAC, MUMC and grip strength with those bilateral isokinetic differences.

Results

Peak torque of shoulder extension was greatest followed by adduction, flexion, abduction, internal rotation and external rotation in both tested angular velocities (60 and 180 /sec). There were statistical differences of contralateral peak torque in almost all directions of shoulder muscle contractions (abduction, adduction, extension, internal rotation and external rotation) except in shoulder flexion at both speeds (Table 1, 2). Peak torque of shoulder adduction, extension, and internal rotation were greater in the dominant side ($p < 0.05$). Shoulder abduction and external rotation peak torque were greater in the nondominant side ($p < 0.05$).

Table 3 demonstrates shoulder circumference, MUAC, MUMC and grip strength of both upper extremities. There was a low linear relationship between bilateral difference of those measurement values and bilateral difference of peak torque in all shoulder motions ($p > 0.05$) (Table 4,5).

Discussion

The strength of the muscles around the shoulder joint is important for joint motions and stability. Isokinetic testing provides quantitative data of muscle performance that had benefits in several clinical situations such as detection of muscle weakness, follow-up of the patient after treatment and planning for a return to sport activity. To evaluate muscle strength, clinicians traditionally use side to side comparison with an assumption of bilateral equivalence.

From previous isokinetic studies, there were different results. Ivey et al reported no statistical sig-

Table 1. Isokinetic measurement of both shoulders at 60 degree/sec speed

Shoulder motions	Peak torque (Nm)		p	95% confidence interval of the difference		Significant
	Dominant x (SD)	Nondominant x (SD)		minimum	maximum	
Abduction	35.5 (11.6)	43.3 (17.0)	0.004	-13.2	-2.7	S
Adduction	73.3 (27.3)	60.8 (20.6)	<0.001	7.02	17.9	S
Flexion	41.0 (12.8)	45.3 (17.1)	0.108	-9.6	0.99	NS
Extension	76.4 (27.7)	65.5 (19.8)	0.001	4.9	16.8	S
Internal rotation	42.8 (19.3)	34.3 (12.1)	0.003	3.0	14.0	S
External rotation	21.7 (8.9)	28.5 (11.4)	0.009	-11.7	-1.8	S

S = significant ($p < 0.05$), NS = not significant ($p > 0.05$)

Table 2. Isokinetic measurement of both shoulders at 180 degree/sec speed

Shoulder motions	Peak torque (Nm)		p	95% confidence interval of the difference		Significant
	Dominant x (SD)	Nondominant x (SD)		minimum	maximum	
Abduction	46.4 (16.1)	55.6 (18.6)	0.003	-15.1	-3.2	S
Adduction	87.1 (28.0)	73.4 (21.8)	<0.001	7.4	19.8	S
Flexion	57.8 (14.6)	58.9 (20.0)	0.707	-7.1	4.9	NS
Extension	89.5 (24.0)	77.8 (17.6)	<0.001	6.6	17.1	S
Internal rotation	46.1 (19.1)	38.0 (12.8)	0.005	2.5	13.6	S
External rotation	25.5 (10.4)	32.5 (13.8)	0.013	-12.6	-1.6	S

S = significant ($p < 0.05$), NS = not significant ($p > 0.05$)

Table 3. Shoulder circumference, midupperarm circumference, midupperarm muscle circumference, and grip strength of dominant and nondominant shoulders

Measurement data	Dominant x (SD)	Nondominant x (SD)
Shoulder circumference(cm)	30.9 (2.8)	30.4 (2.8)
MUAC(cm)	28.4 (3.0)	27.9 (3.0)
MUMC(cm)	23.6 (2.9)	23.0 (2.9)
Grip strength(Nm)	38.9 (9.2)	36.9 (9.3)

MUAC = midupperarm circumference, MUMC = midupperarm muscle circumference

nificant difference between dominant and nondominant isokinetic peak torque at both slow (60 /sec) and fast (180 /sec) speeds, even though there was a consistent pattern of greater strength in the dominant shoulder[3]. Maddux et al also found no significant difference existed between the dominant and nondominant shoulders in the isokinetic peak torque[4]. On the other hand, Cahalan et al measured shoulder strength of 50 subjects with the Cybex II dynamometer and found that the dominant side peak torque was significantly greater for male subjects in flexion at 180 and 300 per second and internal rotation at 0, 180 and 300 per second[7]. Perrin et al studied isokinetic variables in right hand dominant pitchers, swimmers, and non-athletes. Peak torque values were greater for the right than the left side in shoulder extension of all three

Table 4. Pearson correlation coefficient (r values) of bilateral difference in measurement data(shoulder circumference, MUAC, MUMC and grip strength) and bilateral difference of peak torque at 60 degree/sec speed

Bilateral difference of	Bilateral difference of peak torque					
	Abduction	Adduction	Flexion	Extension	Internal rotation	External rotation
Shoulder circumference	0.057	-0.041	-0.014	0.005	-0.030	0.037
MUAC	-0.013	0.059	0.007	0.062	0.090	0.047
MUMC	0.030	0.063	0.044	0.051	0.095	0.047
Grip strength	0.177	-0.009	0.134	-0.145	0.003	0.217

MUAC = midupperarm circumference, MUMC = midupperarm muscle circumference

Table 5. Pearson correlation coefficient (r values) of bilateral difference in measurement data(shoulder circumference, MUAC, MUMC and grip strength) and bilateral difference of peak torque at 180 degree/sec speed

Bilateral difference of	Bilateral difference of peak torque					
	Abduction	Adduction	Flexion	Extension	Internal rotation	External rotation
Shoulder circumference	0.059	-0.075	0.207	-0.081	-0.052	0.047
MUAC	0.010	0.043	0.155	-0.007	-0.021	0.035
MUMC	0.040	0.118	0.253	-0.050	-0.024	0.037
Grip strength	0.252	-0.116	0.065	-0.140	-0.007	0.113

MUAC = midupperarm circumference, MUMC = midupperarm muscle circumference

groups. Right side internal rotation (180 /sec) Total Acceleration Energy (TAE), Average Power (AP) and Total Work (TW) values were greater than the left for the pitchers but not for the swimmers and nonathletes. Chi-hung So et al measured isokinetic values during shoulder flexion and extension and found that there were significant bilateral correlations of contralateral isokinetic values and results also suggested significant bilateral difference(8).

Isokinetic strength of the shoulder may be affected by the types of sport activity and life style. This current study measured isokinetic peak torque of Thai subjects who did not play asymmetrical sports such as racquet or throwing sports. Shoulder muscles combine many actions in each direction of motions. Because there was no consensus about testing positions, the authors used the testing position that was easily reproduced for both shoulders. The results demonstrated significant bilateral differences of the isokinetic peak torque in almost all shoulder motion except flexion. The dominant shoulder did not always have a higher peak torque than the nondominant side. As an example, the shoulder abduction and external rotation peak torque were significantly higher in the nondiminant side. Sapega's guideline suggested that the muscle strength of both sides normally would not be more than 10% to 20% different. In the present study, there were differences in peak torque between the dominant and the nondominant shoulders of more than 20% in all directions of shoulder motions. Due to this, the authors questioned the use of Sapega's guideline to evaluate the abnormality of shoulder muscle strength.

Simple measurement data (shoulder circumference, MUAC, MUMC, and grip strength) were collected to determine their correlations with the bilateral isokinetic difference. The authors hypothesized that the side-to-side differences of these measurement data were supposed to be affected by the amount of upper extremities usage and that these parameters may be used to predict the bilateral difference of peak torque. But the results rejected this hypothesis as the bilateral differences of shoulder circumference, MUAC, MUMC and grip strength had low linear relationships with the contralateral difference of isokinetic peak torque.

In conclusion, clinicians should not directly use the isokinetic strength of the contralateral shoulder as normal baseline data for the injured side. The bilateral differences of shoulder circumference, MUAC, MUMC, and grip strength could not be used to predict the contralateral difference of the isokinetic peak torque.

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การศึกษาความแตกต่างด้านความแข็งแรงทางไอโซไคเนติคของกล้ามเนื้อไหล่ทั้งสองข้าง

พิสิฏฐ์ เลิศวานิช, ชนินทร์ ล่ำซำ, ธีรวัฒน์ กุลทนันทน์

การฝึกกล้ามเนื้อมีบทบาทสำคัญในการรักษาความผิดปกติของข้อไหล่ โดยทั่วไปมักประเมินกำลังกล้ามเนื้อไหล่ข้างที่บาดเจ็บโดยอาศัยกำลังของกล้ามเนื้อในข้างตรงข้ามซึ่งไม่ได้รับบาดเจ็บเป็นบรรทัดฐาน การศึกษานี้มีวัตถุประสงค์เพื่อประเมินความแตกต่างของค่า peak torque ของกล้ามเนื้อไหล่ระหว่างข้างถนัดและข้างไม่ถนัด โดยทำการวัดสมรรถภาพของกล้ามเนื้อไหล่ทั้งสองข้างในอาสาสมัคร 39 คน (ชาย 24 คน และ หญิง 15 คน) โดยเครื่อง CON-TREX MJ dynamometer ที่ความเร็วเชิงมุม 60 และ 180 องศาต่อวินาที ใน 6 ทิศทางการเคลื่อนไหว (abduction, adduction, flexion, extension, internal rotation และ external rotation)พบความแตกต่างอย่างมีนัยสำคัญทางสถิติของค่า peak torque ของกล้ามเนื้อไหล่ทั้งสองข้างในแทบทุกทิศทางการเคลื่อนไหว ยกเว้นflexion โดยค่า peak torque ของกล้ามเนื้อไหล่ข้างถนัด มีค่ามากกว่าในท่า adduction, extension และ internal rotation ส่วนในท่า abduction และexternal rotationนั้น กลับพบว่าค่า peak torque ของข้างไม่ถนัดมีค่ามากกว่าข้างถนัด ดังนั้นในทางปฏิบัติควรใช้ดุลยพินิจในการใช้กล้ามเนื้อในด้านตรงข้ามเพื่อประเมินกำลังกล้ามเนื้อไหล่ด้านที่ได้รับบาดเจ็บ