Shoulder rotator strength in patients with stage I-II subacromial impingement: Relationship to pain, disability, and quality of life

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The purpose of this study was two-fold: to determine the shoulder rotator strength in patients with stage I and II subacromial impingement syndrome and to explore its relationship with pain, disability, and quality of life. Thirteen patients with at least 2 positive tests (Neer, Hawkins, painful arc) on the dominant side and 25 unaffected control subjects were included. All individuals had an intact rotator cuff bilaterally, as evaluated by sonography. Isokinetic testing of the shoulder internal and external rotators was performed using Biodex System 3 during concentric/concentric shoulder rotations at a velocity of 60°/s in the scapular plane. The Shoulder Pain and Disability Index, Simple Shoulder Test, and Nottingham Health Profile were self-reported by all subjects. Peak torque values of patients were found to be indifferent from those of controls'. External and internal rotation strength were negatively correlated with pain (r = .63, r = .66, P < .05). In spite of shoulder pain and disability, general health in stage I and II impingement patients did not show any deterioration. (J Shoulder Elbow Surg 2008;17:893-897.)

Subacromial impingement syndrome (SIS) is an encroachment of subacromial tissues, rotator cuff, subacromial bursa, and the long head of the biceps tendon, as a result of narrowing of the subacromial space.[17,19] It is one of the major causes of shoulder pain and may lead to functional disability and reduction in quality of life.[4,6,14,20,26]

Some intrinsic and extrinsic mechanisms are thought to play a role in the development of SIS.[8,17] Inflammation of the tendons and bursae and degeneration of the rotator cuff are intrinsic causes. Extrinsic mechanisms are the factors that cause a decrease in the subacromial outlet, ie, acromial morphology and spurs, os acromiale, degeneration of the acromioclavicular joint, stiffness and thickening of the coracoacromial ligament, morphology of the coracoid process, and alterations in shoulder kinematics. Alterations of shoulder kinematics include weakness of rotator cuff musculature, changes in scapulothoracic rhythm, glenohumeral instability, capsular tightness, and poor posture.[17]

The effect of rotator cuff weakness on SIS has received much attention, and some of the studies are based on biomechanical simulations on human cadavers.[1,18,24] They all suggest that during shoulder abduction, the rotator cuff muscles are important to counteract the superior pulling effect of the deltoid muscle on the humeral head, as well as for stability in the antero-posterior plane.[1,18,24] Another study demonstrated that the excursion of the humeral head during shoulder abduction increased after fatigue of the rotator cuff muscles.[5] There are only a few studies that measure the rotator muscle strength isokinetically and compare it with those of healthy controls, but their results are conflicting.[2,12,14,25,27]

The purpose of this study was two-fold. First, we aimed to determine comparatively the shoulder rotator muscle strength in patients with stage I and II subacromial impingement syndrome. Second, we tried to explore its relationship with pain, disability, and quality of life.

MATERIALS AND METHODS

A total of 38 subjects volunteered to participate in the study, which was approved by the local Ethical Committee. All individuals were informed of the study and gave informed consent. Ten female and 3 male SIS patients (mean age, 37.8 years; range, 26-52 years) were enrolled from patients who applied to the Physical Medicine and Rehabilitation Department due to shoulder pain for more than 4 weeks. Twenty females and 5 males (mean age, 37.1 years; range, 24-53 years) without shoulder problems, as determined by self-reporting and clinical evaluation, were enrolled as the control group from the clinical staff and patient escorts. The controls were matched to the SIS subjects for age, sex, height, and body weight.

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Patients were eligible if their medical history excluded all of the following: any trauma to the shoulder or neck; recent conservative or surgical treatment (including injection) to the shoulder within the last 6 months; any inflammatory, infectious, neurological, chronic metabolic or malignant disease, and participation in upper extremity-related sports professionally. Those with bilateral or nondominant side involvement were also excluded.

All subjects underwent detailed neurologic and musculoskeletal evaluations in addition to a thorough physical examination. Neer, Hawkins, painful arc, Jobe, lift off, Patte, Speed, Yergason, drop arm, horizontal adduction, and apprehension tests were performed after checking for periarticular tenderness, manual muscle strength, and shoulder range of motion.[21] The patient was diagnosed as having SIS and was included in the study if the physical examination revealed at least 2 positive impingement maneuvers (Neer, Hawkins and painful arc) and no other shoulder or neck pathology, restriction, or weakness existed. Radiographs of the chest, neck, and shoulder were taken to exclude chest related pathology, significant cervical or shoulder joint degeneration, and morphologic anomalies. Sonography was performed, using Diasus 5-10 MHz lineer probe (Diasus Dynamic Imaging Ltd, Scotland, UK), by a physiatrist experienced in sonography, who was also blind to the clinical findings of the subjects. Shoulders were examined with anterior, posterior, and lateral views, in longitudinal and transverse planes bilaterally. The presence of a partial or full-thickness rotator cuff tear was confirmed based on the criteria of Van Holsbeeck.[22] Subjects having no sonographical evidence of a rotator cuff tear were directed to the following questionnaires and isokinetic testing.

Pain, disability, and quality of life were assessed with the Shoulder Pain and Disability Index (SPADI), Simple Shoulder Test (SST), and Nottingham Health Profile (NHP). Scores were computed as described by the authors.[3,7,10-11,13,15,28] All subjects completed the questionnaires before strength testing.

Isokinetic testing of the shoulder rotator muscles was performed using a Biodex System 3 (Biodex Medical System, Shirley, NY) dynamometer. Subjects were seated and their trunks were fastened with seatbelts. The drum of the dynamometer was tilted 50° from the vertical axis and rotated 20° as required by the scapular plane, which is the shoulder position in 45° abduction and 30° forward flexion.[9] The protocol of bilateral concentric/concentric shoulder internal and external rotations at a velocity of 60°/s (5 repetitions) was used. After giving explanations, the subjects were familiarized with the procedure by performing 1 set of submaximal contractions. Then, 1 maximal practice repetition was done before data were collected for the analysis. Measurements were made through a total range of 90° (45° of internal rotation and 45° of external rotation), and standardized verbal instructions were given to all subjects during the testing procedure. External and internal rotation peak torque values (ERPT, IRPT) were noted, and peak torque deficit was calculated as:

(Uninvolved - involved side) / Uninvolved side × 100.

For calculations of the percent deficit in the control group, dominant side replaced the involved side (as the dominant side was involved in all of the patients).

Table I Demographics of the groups

	SIS (n = 13) Mean ± SD	Control (n = 25) Mean ± SD	*P*
Age, years	37.8 ± 9.4	37.1 ± 9.0	.840
Height, cm	164.7 ± 7.2	164.4 ± 7.4	.900
Body weight, kg	62.3 ± 10.2	63.1 ± 9.8	.830
Sex	10 F, 3 M	20 F, 5M	

SD, standard deviation; sex is reported as number of females (F) and males (M).

Table II Median pain and disability scores (with 25th and 75th percentiles)

	SIS (n = 13)		Control (n = 25)		
	Median	**(25-75)**	**Median**	**(25-75)**	***P***
SPADI					
Pain	56.0	(37.0-79.0)	0	(0-3.0)	.00
Disability	32.5	(24.2-54.4)	0	(0-5.7)	.00
Total	46.9	(30.8-61.9)	0	(0-4.6)	.00
SST	58.3	(33.3-78.4)	100	(82.6-100)	.00
NHP pain	25.0	(6.3-32.5)	0	(0-18.8)	.02

SPADI, Shoulder Pain and Disability Index; SST, Simple Shoulder Test; NHP, Nottingham Health Profile.

Data analysis

Statistical analysis was done with Statistical Package for Social Sciences 11.5 (SPSS, Chicago, IL). All variables were tested for normality (Shapiro-Wilks test). For comparison between groups, either Student *t* test or Mann-Whitney U test was used depending on the distribution of data. Paired sample *t* test and Wilcoxon signed rank test were used for comparison between the dominant and nondominant sides within each group. Spearman rank correlation coefficients were used to assess the relationship between strength, pain, and disability. The level of significance was set at $P < .05$.

RESULTS

Demographics of the groups were similar (Table I). All of the patients were right-handed and had unilateral shoulder pain on the dominant side for 1-36 months, with a median of 6 months. Patients' scores on SPADI, SST, and pain domain of NHP were significantly different from those of the control group (Table II). The remaining domains of NHP (energy level, emotional reaction, physical mobility, sleep, social isolation, and distress scores) were similar between groups.

Median ERPT or IRPT values and ERPT/IRPT ratio of SIS patients were found to be similar to those of controls' (Table III). IRPT deficit was significant only in the patient group. Regarding the comparisons within groups, no difference was found between dominant

Table III Comparison of the isokinetic test results, median values (with 25th and 75th percentiles)

	SIS (n = 13)		Control (n = 25)		
	Median	(25-75)	Median	(25-75)	*P*
ERPT Dom (Nm)	17.9	(13.2-25.6)	18.6	(15.7-27.8)	.56
IRPT Dom (Nm)	30.6	(22.6-39.1)	32.5	(28.1-37.8)	.31
ERPT NDom (Nm)	15.7	(13.6-25.7)	18.0	(15.0-24.9)	.84
IRPT NDom (Nm)	30.8	(24.6-48.1)	30.4	(26.7-35.3)	.32
ERPT/IRPT Dom	55.2	(44.3-78.4)	60.5	(53.5-70.7)	.39
ERPT deficit	−8.2	(−20.7 – 28.2)	−9.2	(-27.4 - 4.4)	.38
IRPT deficit	3.5	(−1.3 – 18.3)	−3.4	(−14.9 – 6.2)	.04*

ERPT Dom, external rotation peak torque of the dominant side; IRPT Dom, internal rotation peak torque of the dominant side; ERPT NDom, ERPT of the nondominant side; IRPT NDom, IRPT of the nondominant side; ERPT/IRPT, external rotation peak torque – internal rotation peak torque ratio.
*Statistically significant difference $P < .05$.

and nondominant sides in the SIS group, whereas the median ERPT value of the dominant side was significantly higher than that of the nondominant side in the control group ($P = .04$).

The rotator muscle strength was moderately and negatively correlated with the pain scores of SPADI and NHP. No significant correlations were found between muscle strength values and the disability scores of SPADI and SST scores (Table IV).

Table IV Correlations between pain and disability scores and isokinetic measurements

	ERPT *R*	IRPT *R*
SPADI pain	−0.63*	−0.66*
SPADI disability	0.01	−0.15
SST	0.41	0.33
NPH pain	−0.49	−0.59*

R, Spearman rank correlation coefficient.
*Statistically significant correlation, $P < .05$.

DISCUSSION

The main findings of this study were that peak torque values did not seem to differ between either the groups or the patients' symptomatic and asymptomatic sides. Additionally, although shoulder pain and disability scores were significantly higher in the patient group, other NHP section scores were similar among groups, and a moderate and negative correlation was found between the rotator muscle strength and pain scores.

Although rotator cuff weakness is considered as one of the causes leading to SIS, there are only a few studies that have measured rotator muscle strength in these patients.[2,12,14,16,23,25,27] Studies using isokinetic tests for measuring rotator muscle strength and comparing SIS patients with healthy controls are even fewer.[2,12,14,23,25,27] In most of those studies, rotator muscle strength has usually been measured in the scapular plane, which is the optimum plane for such isokinetic measurements in SIS.[2,12,14,25,27] Two other points concerning the isokinetic measurements in these studies are that the total range was restricted to the pain-free arc and that either only one speed was used or similar results were attained during testing at different speeds.[2,12,14,25,27] Warner et al [27] found no consistent peak torque deficit in SIS patients. In their study, IRPT values of the dominant side were higher than the nondominant side in the control group. Furthermore, the ERPT/IRPT ratio was lower in the patient group, suggesting a relative ER weakness in SIS. Leroux et al[12] reported that ERPT/IRPT ratio was significantly greater in both operative and nonoperative SIS patients, and that IR strength was weaker than the control subjects. The sample sizes were small in both studies, and patient compared to control groups did not seem to be matched appropriately for age and sex. Tyler et al[25] measured the shoulder rotator strength isokinetically at 60°/s and 180°/s, as well as manually with a handheld dynamometer in the scapular plane and in 90° shoulder abduction. Comparing dominant-nondominant side deficits of the control subjects with the symptomatic-asymptomatic side deficits of the SIS patients, they found no significant difference between the isokinetic testings. However, the handheld dynamometer quantified an ER deficit in the patient group, at 90° shoulder abduction position, and an IR deficit in the control group, at both the scapular plane and 90° shoulder abduction. Failure of the isokinetic tests to detect the strength deficit was explained by their measuring the peak torque value at the middle range of the motion. However, the handheld dynamometer measured the strength at the end-range, where the deficit might be more significant. The lack of proper matching between the groups for age and gender and not having considered the dominancy of the symptomatic side were the major limitations of their study. In our study, comparisons within groups revealed only higher ER strength on the dominant side in the control group. Although IR deficits of the SIS group were statistically significant, they were too small to be considered as clinically important. The ERPT/IRPT ratios were similar. These results might suggest that SIS patients with intact rotator cuff would have a minor decrease in both IR and ER strength compared to controls. We suggest that the similarity of peak torque values between, respectively, the groups and the patients' symptomatic and asymptomatic sides might be related to either the selection of SIS patients with intact rotator cuffs or to strict matching and small group sizes.

Although shoulder pain and disability scores were significantly higher in the patient group; the rest of the NHP section scores were similar. Accompanying health problems of the control group, the absence of a rotator cuff tear in the patients, and the fact that NHP is not specific for shoulder problems might have played role in this finding.

Our results of moderate and negative correlations between rotator muscle strength and pain scores are, at least, partially in accordance with MacDermid et al.[14] They reported a higher relationship between pain/disability and the isometric tests compared to isokinetic test results. Additionally, they demonstrated significantly lower rotator muscle strengths (ER and IR) in SIS patients that were more apparent in the ER. These findings seem to be in contrast to those of our study, and we attribute this discrepancy to control matching better, imaging of an intact rotator cuff, and consideration of the extremity dominance in our study. Moreover, the lack of correlation between rotator muscle strength and disability in our study could be due to the fact that our patients were in relatively early stages of impingement; therefore, they could have completed the isokinetic testing without much discomfort. Testing in the scapular plane at a slower speed (60°/s) and using a total range that was restricted to the pain-free arc also might have contributed to this result.

In light of our study, we imply that the shoulder rotator muscle strength has a moderate and negative relationship with shoulder pain. In spite of pain and disability, there seems to be no significant, isokinetically measured, rotator muscle weakness or deterioration in the quality of life in stage I and II SIS patients. Future studies with larger sample sizes, which compare the strength of SIS patients in different stages, are needed.

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