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External to internal glenohumeral strength ratio in non-traumatic rotator cuff pathologies

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Background and study aims: **A correct agonist -antagonist strength relationship for shoulder external and internal rotation is necessary for functional stability of the shoulder. This strength relationship is described by the ratio of external to internal strength (ER/IR).The aim of this stydy is to produce comparative data as regards the ER/IR ratio in subjects with different non-traumatic rotator cuff diseases.** ***Design and setting:*** **A cross-sectional study in an outpatient clinic in a tertiary care university hospital.** ***Methods:*** **In 55 subjects with rotator cuff disease (confirmed by physical examination and assessed by ultrasound and magnetic resonance arthrography), the ER/IR ratio of the shoulder was isometrically measured with a hand-held dynamometer and compared with values pertaining to the unaffected shoulder of the same individuals.** ***Results:*** **The mean ER/IR values in the overall group were 0.89 (SD 0.18) and 0.94 (SD 0.22) for the affected and unaffected shoulders, respectively. The ratio was 0.87 (SD 0.23) in patients with subdeltoid bursitis, 0.88 (SD 0.16) in rotator cuff tendinopathy and 0.87 (SD 0.22) in patients with rotator cuff tears.** ***Conclusions:*** **The ER/IR ratio appears to be similar between the affected and unaffected shoulders of subjects with nontraumatic cuff pathologies.**

Key words: Shoulder, rotator cuff, isometric strength, dynamometry, ultrasound.

INTRODUCTION

The glenohumeral joint maintains the largest range of motion among all the body joints and this requires efficiency of every shoulder muscle. An appropriate balance of agonist and antagonist muscle strength is necessary to provide sufficient active stability to maintain normal shoulder kinematics. Likewise, any disorder in the balance of these muscles will negatively influence the shoulder biomechanics and increase the possibility of shoulder disease.

Rotator cuff (RC) disorders are the underlying cause in 65% to 70% of people with shoulder pain[1,2]. Several studies have demonstrated that an imbalance between the strength of the external rotator (ER) and internal rotator (IR) muscles is present in subjects with RC disorders[3,4,5,6,7,8,9,10]. However, in many of those studies either the sample size was small or lacks data from the contralateral side. Besides many of these studies lack the necessary imaging such as ultrasound and MRI puts limitations to the results of these studies. This study tried to avoid these pitfalls using a greater sample size, different gender and age groups and strong additional imaging such as ultrasound and MRI of the affected shoulder and ultrasound of the control shoulder.

Accordingly, the aim of this study was to comparatively measure the ER/IR values in patients with various RC disorders.

MATERIALS AND METHODS

Subjects with shoulder pain for more than 12 weeks were recruited if physical examination findings such as a painful arc, a positive Hawkins-Kennedy and Jobe test were encountered. Patients were excluded if they had previous shoulder trauma, frozen shoulder, inflammatory arthritis and radiographic evidence of osteoarthritis. All included subjects underwent bilateral shoulder ultrasound (US) examination and unilateral magnetic resonance arthrography (MRA) for the symptomatic shoulders.

Depending of the US and MRA findings, patients were divided into three groups according to the presence of bursitis, RC tendinopathy or RC partial/ full-thickness tears. Patients were excluded when two or more findings were simultaneously present. As the US examination was performed on both shoulders, data from subjects who had abnormal findings in their asymptomatic shoulders were not used in the study. 55 patients with nontraumatic unilateral RC disease were included in the study. This study was approved by the institutional medical ethics review board. All participants signed an informed consent form before participation.

The US was performed using a Toshiba Aplio 300 using a 7-9 MHZ transducer following the EURO-MUSCULUS/USPRM protocols[11]. MRA of the symptomatic shoulder was performed on a Ingenia Elition 3.0T with a large shoulder coil. The US and MRA were performed in the same university radiology service on the same day and evaluated by two MD's specialized in musculoskeletal radiology and holding a PhD degree and each with more than 15 years of experience.

Isokinetic and isometric testing are valid methods for measurement of muscle strength providing an unbiased estimation of muscle strength using a linear scale enabling accuracy and sensitivity. Isometric strength testing with a hand held dynamometer (HHD) is a relatively inexpensive and efficient way to assess strength[12,13,14]. In many studies HHD has proven to have good-to-excellent intra- and interrater reliability and also good validity[15,16,17,18,19,20,21,22,23,24]. A HHD (Mecmesin myometer, Broadridge Heath, England) with a measurement range of 0 to 300 Newton (N) and a precision of 0.1 was used. The HHD was factory calibrated and recalibrated before each use. In measuring isometric strength, the "make" method rather than the "break" method was used given the higher reliability coefficients[22,26]. After the examiner explained the test and showed the direction of movement, subjects were asked to build up their force gradually to a maximum voluntary effort over a two second period and to apply maximum force for about three seconds. Each task was repeated twice with 15 seconds between measurements. The peak isometric strength was the average of the two trials and was used for analysis.

During the testing, subjects were in standing position with their arms besides the body. The testing order was standardized and consisted of abduction of the shoulder, flexion of the elbow and external and internal rotation of the shoulder. For testing the abduction, the shoulder was at neutral and the elbow in extended position. The dynamometer was placed proximal to the styloid process. For elbow flexion, the shoulder was at neutral, the elbow at 90° flexion and the forearm in supination. The dynamometer was placed proximal to the styloid process. For internal rotation, shoulder was at neutral and the elbow at 90° flexed position. The dynamometer was placed just proximal to the styloid process. For external rotation, the shoulder was at 0° abduction and 45° internal rotation[27].

To minimalize bias, all tests were performed by the same rehabilitation physician with long experience in muscle testing. The strength of the examiner was strong enough to hold against the isometric contraction of the subjects being tested.

All statistical analysis was performed using SPSS Statistics 22 Data are presented as median (range) and mean (standard deviation) values. Normality of the data was tested by Shapiro-Wilk test and visual inspection of the QQ-plots. As most of the ER/IR ratios were not normally distributed, non-parametric tests were used. ER/IR ratios were compared using Wilcoxon signed rank and Kruskal-Wallis tests for affected vs. unaffected shoulders and for shoulders among three groups, respectively. A p-value of 0.05 or lower was considered significant.

RESULTS

Demographic data of the participants are summarized in Table I. Depending of the US and MRA findings, the patients were categorized into three groups (based on causality) as bursitis (n=10), cuff tendinopathy (n=27) and cuff tears (n=18). ER/IR ratios of the individuals are given in Table II. The ER/IR ratios of the affected (0.89±0.18, range 0.43-1.24) and unaffected (0.94±0.22, range 0.22-1.86) shoulders were similar (p=0.11). The subjects with bursitis showed an ER/IR ratio of 0.87±0.23 in the affected and 0.98±0.18 in the unaffected shoulder. The subjects with tendinopathy showed an ER/IR ratio of 0.88±0.16 in the affected and,

Table I. — Demographic data of the subjects based on gender and age category.

	n	%	Average age	20-40y	40-60y	60+y
Male	37	(67.3%)	47.2 (21-69)	n=11 (20.0%)	n=17 (30.9%)	n=9 (16.4%)
Female	18	(32.7%)	50.6 (26-65)	n=3 (5.5%)	n=13 (23.6%)	n=2 (3.6%)

Table II. — ER/IR ratio in 55 subjects.

Subject	Gender	Ratio ER/IR Sympt	Ratio ER/IR Asympt	Subject	Gender	Ratio ER/IR Sympt	Ratio ER/IR Asympt
1	M	0.86	0.99	29	M	0.94	0.88
2	F	0.89	1.13	30	F	0.83	0.90
3	F	1.14	1.04	31	M	1.22	1.03
4	M	0.52	1.11	32	F	1.14	0.88
5	M	0.87	1.17	33	M	1.03	0.82
6	M	0.89	0.89	34	M	0.97	1.34
7	M	1.21	1.00	35	F	0.92	0.79
8	F	0.91	0.87	36	M	1.02	0.77
9	F	0.43	1.39	37	M	1.07	1.19
10	F	0.55	0.91	38	M	0.64	0.83
11	M	1.08	0.93	39	F	0.74	0.63
12	M	0.91	0.75	40	M	0.82	0.93
13	M	0.84	1.20	41	M	0.61	0.22
14	F	0.88	0.77	42	M	0.81	0.90
15	F	0.92	1.08	43	M	1.23	0.90
16	M	0.90	0.94	44	M	0.76	1.02
17	F	0.81	0.96	45	M	0.70	1.01
18	F	0.81	1.03	46	M	1.09	1.86
19	F	1.00	0.58	47	F	0.75	0.78
20	M	1.24	0.98	48	M	0.75	0.85
21	M	0.90	1.00	49	F	0.76	0.82
22	M	0.98	0.97	50	M	0.76	0.99
23	M	1.04	0.95	51	M	0.73	0.87
24	M	0.94	1.02	52	M	0.94	1.10
25	M	0.95	0.75	53	F	0.79	0.80
26	M	1.08	1.03	54	M	0.79	0.73
27	M	0.84	0.82	55	M	0.66	0.66
28	F	0.85	1.01				

Table III. — Average, standard deviation and p-value for Bursitis, Cuff tendinosis and Cuff Tear.

	Sympto		Asympto		
	average	stand. Dev.	average	stand. Dev.	p
Bursitis	0,87	0,23	0,98	0,18	0,33
Cuff tendinosis	0,88	0,16	0,93	0,27	0,29
Cuff tear	0,93	0,16	0,86	0,08	0,17

0.93±0.27 in the unaffected shoulder. The subjects with a cuff tear showed an ER/IR ratio of 0.87±0.22 in the affected and, 0.95±0.19 in the unaffected shoulder (see Table III). The difference between the affected vs. the unaffected shoulder in the 3 causalities was statistically insignificant, with all $p > 0.05$

DISCUSSION

A lot of research has already been done on measuring muscle strength of the shoulder in overhead athletes and healthy people. Less research has been done on the strength in cohorts with non-traumatic RC disease. We systematically searched electronic databases with the following search term: muscle strength of the glenohumeral muscles in a non athletic population with non-traumatic RC disease. Reports on shoulders with instability or SLAP lesions where omitted. As in the case with any literature review some evidence may have been unintentionally overlooked. Many studies have a full data set of strength measurements but do not discuss the ER/IR ratio[28,29,30,31,32,33,34,35,36]. Only one study comments on the ER/IR ratio whereby 51 cases with subacromial shoulder impingement and 51 asymptomatic controls matched for age, gender and hand dominance were evaluated using isokinetic testing[37]. The authors report that either using eccentric or concentric testing the ER/IR were similar between the affected and nonaffected shoulder. We observed that the ER/IR ratios are similar between affected and nonaffected shoulders so our results confirm the findings of the above mentioned study In the overall group the ER/IR ratio is 0.89 (SD 0.18) for the affected shoulder and 0.94 (SD 0.22) for the unaffected shoulder. This difference is not significant as $p>0.05$.

When sub analyzing the group for the 3 different pathologies the results are: In the bursitis group for the affected shoulder 0.87 (SD 0.23) and the nonaffected shoulder 0.98 (SD 0.18), in the tendinopathy group for the affected shoulder 0.88 (SD 0.16) and the nonaffected shoulder 0.93 (SD 0.27) and in the cuff tear group the affected shoulder 0.93 (SD 0.16) and the nonaffected shoulder 0.86 (SD 0.08). These differences are non-significant with $p=0.33$ in the bursitis group, $p=0.29$ in the cuff tendinopathy group and $p=0.17$ in the cuff tear group.

The strengths of the study are the following. First we measured the ER/ IR ratio in the affected and the unaffected shoulder in the same person. This leads to results with more sustainability. Second by examining each affected shoulder with ultrasound and MRA we were completely sure about the underlying pathology and excluding any posttraumatic pathology. Third by examining all nonaffected shoulders with ultrasound we excluded any underlying pathology in this shoulder.

There are some limitations worth noting for the study. First, the data generated by muscle testing must be cautiously handled – also taking in account the possible impact of discomfort or pain during the testing. We tried to accommodate the subjects in the most appropriate position in this regard. Second, although upper limb dominance is negligible in normal subjects in contrast to overhead athletes, the lack of pertinent analysis might be another limitation in the study[38,39]. Third the sample size or our study was sometimes small with regards to subgroup analysis.

CONCLUSION

This study concludes that the ER/IR ratio is not different in the with a RC disease affected shoulder and the contralateral not affected shoulder. In planning the rehabilitation of shoulder disfunction, this ratio seems to be of no great importance. There is need for future studies on assessing other shoulder strength ratios such as abduction/external(ABD/ER) or abduction/ internal (ABD/IR).

Conflict of interest: the authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.
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