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Does strength deficit correlate with shoulder function in patients with rotator cuff tears? Characteristics of massive tears

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Background: The correlation between shoulder strength deficits and function in rotator cuff tears remains uncertain. This study aimed to determine the correlation between shoulder strength deficits and shoulder function evaluated by various clinical scoring systems.
Methods: A total of 262 patients (mean age, 59.67 years [standard deviation, 8.06 years]) who underwent full-thickness rotator cuff repair were included. Patients in group I (n = 188) had small to large rotator cuff tears, whereas those in group II (n = 74) had massive rotator cuff tears. Demographic factors, isokinetic test results, and shoulder function evaluated using various scoring systems were obtained. Correlation differences according to severity of the rotator cuff tear were evaluated.
Results: We found weak correlations between shoulder strength deficits (peak torque and total work) and clinical outcomes in patients with rotator cuff tears ($r = -0.288$). For patients in group I (nonmassive tears), we found a weaker correlation ($r = -0.242$) according to the tear pattern. However, shoulder strength deficits in group II patients (massive tears) were strongly correlated with American Shoulder and Elbow Surgeons ($r = -0.598$), Constant ($r = -0.582$), and Short Form 36 ($r = -0.511$) scores, especially regarding internal rotator strength deficits.
Conclusions: Shoulder strength deficits measured via isokinetic testing and shoulder function were weakly correlated in patients with rotator cuff tears. However, shoulder strength deficits in patients with massive tears considerably worsened shoulder function and systemic disability, but not regional disability. In particular, internal rotator strength deficits were strongly correlated with poor shoulder function.
Level of evidence: Basic Science Study; Validation of Outcome Instruments

Keywords: Rotator cuff; tear; strength deficit; isokinetic test; clinical symptoms; shoulder

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A shoulder strength deficit that results from a rotator cuff tear causes disability and clinical symptoms and is an important factor in the diagnosis, evaluation, and prognosis of rotator cuff disease. Isokinetic muscle performance testing, which evaluates strength deficits in the shoulder musculature complex, has a high degree of accuracy and test-retest reliability.[3,23] Previous studies reported that shoulder strength measured by isokinetic testing correlated with important parameters such as tear size, fatty degeneration, postoperative retear, and clinical test findings.[26,32]

Controversy exists as to whether a strength deficit is representative of the actual shoulder function measured by clinical scoring systems.[10,21] A high percentage of patients with painless rotator cuff tears are asymptomatic but may have significant strength deficits[24]; there are also patients who have symptomatic shoulder strength deficits despite successful pain control. As a result, there is no consensus that shoulder function measured by clinical scoring systems directly reflects the shoulder strength deficit.[21]

Ascertaining the degree to which a strength deficit contributes to a patient's clinical symptoms is important to understand the rotator cuff pathology and determine a treatment strategy. To our knowledge, no study has provided an integrated correlation between shoulder strength deficits and function according to tear severity. Therefore, this study sought to (1) identify the correlation between shoulder strength deficits and function measured by various clinical scoring systems (Simple Shoulder Test [SST] score, American Shoulder and Elbow Surgeons [ASES] score, Constant score, and Short Form 36 [SF-36] score) and (2) determine whether the extent of the correlation changes according to tear severity. We hypothesized that (1) there would be distinct correlations between shoulder strength deficits and function and (2) the degree of correlation would differ by tear severity.

Materials and methods

Demographic data

Patients with full-thickness rotator cuff tears who underwent surgery at our hospital from November 2010 to October 2016 were identified. Those who had been evaluated by preoperative isokinetic testing and clinical scoring systems (SST, ASES, Constant, and SF-36 scores) were selected for this study.

The indication for surgery was persistent pain that did not respond to conservative treatment, such as anti-inflammatory medication, physical therapy, steroid injection, and activity modification, for at least 6 months. Magnetic resonance imaging (MRI) was performed to confirm the rotator cuff tears.

We excluded patients whose range of motion was restricted below a certain level during isokinetic testing because of stiffness (n = 151). Shoulder stiffness was defined as forward flexion lower than 120° passively, external rotation with the arm at the side lower than 30° passively, and internal rotation at the back lower than L3 passively, as described in our previous study.[32] We also excluded patients with symptomatic lesions in the contralateral shoulder (n = 58), cuff tear arthropathy (n = 14), or a history of shoulder surgery (n = 9). As a result, a final total of 262 patients (104 men and 158 women; mean age, 59.67 years [standard deviation, 8.06 years]) were enrolled.

Among all enrolled patients, 41 had small tears, 123 had medium tears, 24 had large tears, and 74 had massive tears. A massive rotator cuff tear was defined as complete disruption of 2 or more rotator cuff tendons. On the basis of previous reports,[6,13] we divided the patients into 2 groups: Group I patients (non-massive tear group, n = 188) had small to large tears, and group II patients (massive tear group, n = 74) had massive rotator cuff tears. According to previous reports, patients with massive tears show a more significant tendency toward fatal defects in the coupling force mechanism than those with smaller tears (Tables I and II).[1]

Clinical and structural variables

The following data were recorded: age, sex, arm dominance, symptom duration and aggravation, hypertension, heart disease, smoking, diabetes mellitus, steroid injection history in the ipsilateral shoulder joint, traumatic event, level of sports activity, shoulder stiffness, extent of shoulder activity, and bone mineral density. We prospectively collected the entire data set for all patients undergoing surgery for rotator cuff tears.

Fatty degeneration of the rotator cuff muscles and tear size in the anteroposterior dimension, as well as the amount of retraction, were evaluated via MRI by a musculoskeletal radiologist. The degree of fatty degeneration in each rotator cuff muscle (supraspinatus, infraspinatus, and subscapularis) was graded using criteria established by Goutallier et al.[14] Although this grading system was originally established using computed tomography, we applied it to the scapular Y view of T1-weighted MRI sequences, as described by Fuchs et al.[12] The patients' bone mineral density values were measured just before surgery by dual-energy x-ray absorptiometry (Lunar Prodigy with enCORE, version 8.8; GE Medical Systems, Milwaukee, WI, USA), and the lowest T score of the proximal femur and lumbar spine was recorded, except the value for the Ward area of the proximal femur.

Isokinetic testing and shoulder function

The Biodex System 3 PRO (Biodex, Shirley, NY, USA) was used for the isokinetic muscle performance test. All isokinetic procedures were performed as previously described.[26,32] The test was performed with the patient in a sitting position with 2 bands on his or her chest to fix the upper trunk. Abduction was tested with the patient's trunk supported in a reclined position 40° from vertical in the scapular plane between 0° and 110°. Abduction, external rotation, and internal rotation were tested with the patient's shoulder in a neutral position and the elbow flexed to 90°. We measured isokinetic strength deficits (peak torque [PT] and total work [TW]) in abduction, external rotation, and internal rotation at a load of 60°/second. The contralateral side was considered normal for each patient, and values were calculated as a percentage of the normal contralateral side. For PT (in newton meters), we used the highest torque value during 5 repetitive isokinetic efforts. TW (in joules) indicated the work performed by the patients in the repetition that produced the greatest value during 5 repetitive isokinetic efforts.[26] Shoulder function was measured using regional and systemic scoring systems; regional disability was measured using SST, ASES, and Constant scores and systemic disability was measured using SF-36 scores (Physical Component Summary [PCS] and Mental Component Summary [MCS]) by an independent researcher. The SST score was converted from a 12-point scale to a 100-point scale (multiplied by 100 and divided by 12) to aid in the comparison of our data with data from a previous study.[30] The ASES score involves score summation with a 100-point system (50 points for daily function and 50 points for pain). All assessments were conducted at the time of preoperative admission.

Statistical analysis

Differences between groups I and II were determined using the independent *t* test or Mann-Whitney *U* test for continuous variables and the χ^2 test or Fisher exact test for categorical variables. Comparative and correlation analyses were performed to evaluate the correlations between isokinetic strength deficits and the clinical variables. The Pearson correlation coefficients were interpreted as follows: greater than 0.5 indicated a strong association; 0.3 to 0.5, a moderate association; and 0.1 to 0.3, a weak association.[11] Statistical analyses were conducted using SPSS software for Windows (version 15.0; IBM, Armonk, NY, USA). All statistical tests were 2-tailed, and $P < .05$ was considered statistically significant.

Results

Intergroup comparisons

The demographic factors differed between the patients in the massive tear group (group II, n = 74) and those in the nonmassive tear group (group I, n = 188). Although the 2 groups were similar in terms of sex (P = .132) and dominant side (P = .517) (Tables I and II), group II included older patients (P = .001) and patients with severe osteoporosis ($P \leq .001$). In group II, the mean tear size in the anteroposterior dimension and the amount of retraction were more severe ($P \leq .001$ for both) and fatty degeneration was more prominent ($P \leq .001$ for all) than in group I. Patients in group II had significantly inferior shoulder function according to the ASES score (P = .002), Constant score (P = .009), and SF-36 PCS score ($P \leq .001$) compared with those in group I.

Correlation between shoulder strength deficits and function

Shoulder strength and function were weakly correlated in all patients (Tables III and IV). The strongest correlation was between internal rotation TW and the ASES score (r = –0.333). Abduction TW was strongly correlated with the SF-36 PCS score (r = –0.348), and external rotation TW was strongly correlated with the SST score (r = –0.318).

Different correlation patterns were observed between groups I and II. In group I, a weak correlation to no correlation was found between shoulder strength and function compared with all patients, and no greater than a moderate correlation was found for any of the categories (all correlation coefficients < 0.3) (Tables V and VI).

In group II, abduction PT was moderately correlated with the ASES score (r = –0.304) and SF-36 PCS score (r = –0.348) and abduction TW was moderately correlated with the Constant score (r = –0.388) and ASES score

Table I Demographic data

Variable	Total	Group I	Group II	*P* value
No. of Patients	262	188	74	
Age, yr	59.67 (8.06)	58.29 (7.31)	63.19 (8.81)	.001*
Sex: M/F	104/158	80/108	24/50	.132
Dominant side: yes/no	213/49	151/37	62/12	.517
Symptom onset, d	34.97 (58.94)	30.59 (48.65)	45.86 (78.27)	.06
Smoking: yes/no	221/41	155/33	66/8	.176
Trauma Hx: yes/no	212/50	150/38	62/12	.459
DM: yes/no	229/33	169/19	60/14	.053
HTN: yes/no	191/71	140/48	51/23	.363
BMD	−1.10 (1.23)	−0.81 (1.10)	−1.69 (1.28)	<.001*
Hypercholesterolemia	235/27	169/19	66/8	.866
Preoperative steroid injection: yes/no	225/37	164/24	61/13	.315
Level of sports activity†: high/medium/low	56/114/92	42/84/62	14/30/30	.505
Overhead sports: yes/no	182/80	128/60	54/20	.439
Shoulder activity while working†: high/medium/low	65/136/61	47/98/43	18/38/18	.968

M, male; *F*, female; *Hx*, history; *DM*, diabetes mellitus; *HTN*, hypertension; *BMD*, bone mineral density.
Data are presented as number of patients or mean (standard deviation).
* Statistically significant.
† We defined a high level of sports activity as dynamic or contact sports (eg, boxing, basketball, rugby, and tennis); a medium level as static sports (eg, golf, yoga, and running); and a low level as mild or no sports activities. We defined a high work level as heavy manual labor, a medium level as manual labor with less physical activity, and a low level as sedentary work.

Table II Clinical data

Variable	Total	Group I	Group II	P value
No. of patients	262	188	74	
Tear size, mm*	22 (13)	15 (6)	41 (6)	<.001†
Amount of retraction, mm*	23 (2)	18 (7)	38 (7)	<.001†
Combined pathology				
SLAP lesion	84	64	20	.273
AC arthritis	41	32	9	.33
Biceps tear	61	40	21	.406
GFDI	1.46 (0.81)	1.26 (0.62)	2.05 (0.99)	<.001†
Fatty infiltration grade: 0/1/2/3/4/5‡				
Supraspinatus	3/49/118/44/48	3/41/93/23/19	0/8/24/14/28	<.001†
Infraspinatus	42/147/44/9/20	35/120/28/3/2	7/27/16/6/18	<.001†
Subscapularis	71/146/31/7/7	64/107/16/1/0	7/30/15/6/7	<.001†
VAS pain score	4.73 (1.65)	4.63 (1.59)	5.00 (1.77)	.122
ASES score	57.55 (16.40)	59.52 (15.42)	52.55 (17.82)	.002†
SST score	36.41 (19.00)	37.03 (19.43)	34.52 (17.65)	.391
Constant score	50.20 (9.49)	51.15 (8.86)	47.78 (10.60)	.009†
SF-36 PCS score	40.59 (7.19)	41.67 (5.95)	37.84 (9.14)	<.001†
SF-36 MCS score	44.85 (10.11)	45.31 (10.06)	43.78 (10.18)	.245

SLAP, superior labrum anterior-posterior; *AC*, acromioclavicular; *GFDI*, global fatty degeneration index; *VAS*, visual analog scale; *ASES*, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test; *SF-36*, Short Form 36; *PCS*, Physical Component Summary; *MCS*, Mental Component Summary.
Data are presented as number of patients or mean (standard deviation).
* Tear size was measured intraoperatively using a calibrated probe after débridement of degenerated tendon edges. The anteroposterior dimension was measured at the lateral edge of the footprint, and the amount of retraction was estimated by the distance from the apex of the tear to the lateral footprint.
† Statistically significant.
‡ Fatty infiltration of each rotator cuff muscle (supraspinatus, infraspinatus, and subscapularis) was evaluated according to the criteria established by Goutallier et al[14] and Fuchs et al.[12]

(r = –0.362) and strongly correlated with the SF-36 PCS score (r = –0.511) (Tables VII and VIII). External rotation PT was weakly correlated with the ASES score, SF-36 PCS score, and SF-36 MCS score, and external rotation TW was moderately correlated with the SST score (r = –0.429), Constant score (r = –0.387), and ASES score (r = –0.345) (Table VII). Internal rotation PT was moderately correlated with the visual analog scale score (r = 0.385), SST score (r = –0.368), Constant score (r = –0.463), ASES score (r = –0.468), and SF-36 PCS score (r = –0.404), and internal rotation TW was moderately correlated with the visual analog scale score (r = 0.475), SST score (r = –0.369), and SF-36 PCS score (r = –0.378) and strongly correlated with the Constant score (r = –0.582) and ASES score (r = –0.598) (Table VIII). Strong correlations were found between abduction TW and the systemic scoring system (SF-36 PCS score, r = –0.511), as well as between internal rotation TW and the regional scoring systems (Constant score, r = –0.582; ASES score, r = –0.598).

Table III Correlation between shoulder strength deficits in peak torque and shoulder function in both groups (N = 262)

	VAS score	SST score	Constant score	ASES score	SF-36 PCS score	SF-36 MCS score
Abduction						
CC	0.233*	–0.210*	–0.214*	–0.268*	–0.283*	–0.107*
P value	<.001	.001	<.001	<.001	<.001	.083
External rotation						
CC	0.079	–0.223*	–0.133*	–0.065	–0.053	0.015
P value	.228	.001	.031	.293	.395	.814
Internal rotation						
CC	0.153	–0.208*	–0.201*	–0.212*	–0.169*	–0.129*
P value	.019	.002	.001	.001	.006	.037

VAS, visual analog scale; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *SF-36*, Short Form 36; *PCS*, Physical Component Summary; *MCS*, Mental Component Summary; *CC*, correlation coefficient.
* Weak correlation: Pearson correlation coefficients of 0.1 to 0.3.

Table IV Correlation between shoulder strength deficits in total work and shoulder function in both groups (N = 262)

	VAS score	SST score	Constant score	ASES score	SF-36 PCS score	SF-36 MCS score
Abduction						
CC	0.109*	−0.166*	−0.179*	−0.179*	−0.316†	−0.052*
P value	.096	.013	.004	.004	<.001	.398
External rotation						
CC	0.181*	−0.318†	−0.254*	−0.230*	−0.206*	−0.028
P value	.005	<.001	<.001	<.001	.001	.654
Internal rotation						
CC	0.242*	−0.181*	−0.257*	−0.333†	−0.278*	−0.144*
P value	<.001	.006	<.001	<.001	<.001	.020

VAS, visual analog scale; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *SF-36*, Short Form 36; *PCS*, Physical Component Summary; *MCS*, Mental Component Summary; *CC*, correlation coefficient.
* Weak correlation: Pearson correlation coefficients of 0.1 to 0.3.
† Moderate correlation: Pearson correlation coefficients of 0.3 to 0.5.

Discussion

The principal findings of our study are that (1) a weak correlation exists between shoulder strength deficits and clinical symptoms in rotator cuff tears and (2) the degree of correlation differs between nonmassive and massive rotator cuff tears. The rotator cuff plays a role in both the rotation of the humeral head and the compression of the humeral head within the glenoid cavity.[2,27] The muscles that comprise this stabilizing mechanism are the subscapularis, infraspinatus, and teres minor, which constitute the transverse force couple, and the deltoid, supraspinatus, teres major, latissimus dorsi, and pectoralis major, which constitute the frontal force couple. If this mechanism fails even once, strength deficits and progressive loss of shoulder function may occur.[4,5,15,20,27,31] McCabe et al[22] reported that larger and more involved rotator cuff tears led to greater impairments of shoulder abduction strength, whereas another study reported that both abduction strength and forward flexion correlated with tear size.[19]

Despite the obvious connection, the extent to which a strength deficit induces loss of shoulder function has not been elucidated. MacDermid et al[21] studied 84 patients with chronic impingement syndrome by use of a dynamometer and found a strongly negative correlation between strength, especially external rotation, and both Shoulder Pain and Disability Index and SF-36 scores. By contrast, Itoi et al[18] reported that an isolated supraspinatus tear did not significantly decrease shoulder activity.

Our study's findings demonstrate the connection between shoulder strength deficits and function in greater detail and with a relatively large population. Shoulder strength deficits may play a limited role in shoulder function, but tear size appears to be a key factor in the degree of correlation.

According to our findings, a weak correlation between shoulder strength and function existed in our patients (Tables III and IV). Shoulder function measured by clinical scoring systems appropriately hinges on the levels of both strength deficits and pain. Therefore, shoulder strength deficits do not always directly correlate with a severe loss of shoulder function measured by clinical scoring systems. In the group I patients, this tendency toward a lack of direct correlation was more prominent (Tables V and VI). The deltoid and parascapular muscles can compensate for less severe rotator cuff dysfunction by appropriately engaging

Table V Correlation between shoulder strength deficits in peak torque and shoulder function in group I (nonmassive tear group)

	VAS score	SST score	Constant score	ASES score	SF-36 PCS score	SF-36 MCS score
Abduction						
CC	0.222*	−0.202*	−0.129*	−0.177*	−0.145*	−0.024
P value	.004	.008	.077	.015	.047	.744
External rotation						
CC	0.040	−0.215*	−0.104*	−0.005	0.048	0.064
P value	.606	.005	.158	.948	.516	.388
Internal rotation						
CC	0.049	−0.166*	−0.056	−0.075	−0.005	−0.072
P value	.528	.030	.442	.307	.948	.326

VAS, visual analog scale; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *SF-36*, Short Form 36; *PCS*, Physical Component Summary; *MCS*, Mental Component Summary; *CC*, correlation coefficient.
* Weak correlation: Pearson correlation coefficients of 0.1 to 0.3.

Table VI Correlation between shoulder strength deficits in total work and shoulder function in group I (nonmassive tear group)

	VAS score	SST score	Constant score	ASES score	SF-36 PCS score	SF-36 MCS score
Abduction						
CC	0.073	−0.155*	−0.064*	−0.075	−0.188*	0.004
P value	.345	.043	.386	.310	.010	.954
External rotation						
CC	0.095	−0.276*	−0.127*	−0.100*	−0.106	0.054
P value	.217	<.001	.083	.171	.149	.462
Internal rotation						
CC	0.112*	−0.114*	−0.027*	−0.140*	−0.132	−0.073
P value	.146	.138	.709	.057	.071	.322

VAS, visual analog scale; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *SF-36*, Short Form 36; *PCS*, Physical Component Summary; *MCS*, Mental Component Summary; *CC*, correlation coefficient.
* Weak correlation: Pearson correlation coefficients of 0.1 to 0.3.

the coupling force. Shoulder function mainly depends on pain rather than weakness; in cases of pathology with little pain, such as synovitis, bursitis, or tendinitis, the patient may be less symptomatic despite the presence of a distinct strength deficit. Therefore, only a minimal correlation between shoulder strength (abduction) and functional disability was observed in our group I patients.

However, shoulder disability in our group II patients was mainly associated with weakness rather than pain. In these patients, the deltoid and parascapular muscles could not compensate for the huge rotator cuff deficit; therefore, shoulder weakness was correlated with function according to the clinical scoring systems. Furthermore, muscle weakness created both regional disability and systemic deterioration (SF-36 PCS and MCS). In particular, internal rotation PT was moderately correlated and internal rotation TW was strongly correlated with SST, ASES, Constant, and SF-36 PCS scores, whereas internal rotation weakness was mostly correlated with severe regional disability (Tables VII and VIII).

Our findings have 2 clinical implications: First, the partial repair of irreparable massive tears was significant because group II patients could be converted to group I. Several studies have reported that partial repair of an irreparable tear resulted in clinical improvement.[5,7,9,16,17,25,27,31] On the basis of our data, even partial recovery of the transverse force couple mechanism can significantly change the correlation between shoulder strength and function. Second, there was a strong correlation between internal rotator strength and disability in the group II patients. In particular, internal rotator strength was most strongly correlated with functional disability. According to a previous report, intactness of the subscapularis, especially the lower portion, plays a role in maintaining the transverse coupling force mechanism.[8] Therefore, subscapularis repair may be pivotal in patients with massive tears. We also found that the TW deficit was strongly correlated with shoulder function. The TW deficit represents the sum of torque during repetitive exercise. Therefore, this could reduce the disturbance during measurements, which may yield objective and reliable outcome data compared with PT.

There are several limitations in our study. First, our study was retrospective, and no interobserver or intraobserver reliability was established for the isokinetic

Table VII Correlation between shoulder strength deficits in peak torque and shoulder function in group II (massive tear group)

	VAS score	SST score	Constant score	ASES score	SF-36 PCS score	SF-36 MCS score
Abduction						
CC	0.190*	−0.205*	−0.255*	−0.304†	−0.348†	−0.256*
P value	.132	.130	.028	.009	.002	.028
External rotation						
CC	0.165	−0.253	−0.178	−0.167*	−0.184*	−0.086*
P value	.193	.060	.129	.155	.116	.467
Internal rotation						
CC	0.385†	−0.368†	−0.463†	−0.468†	−0.404†	−0.248*
P value	.002	.005	<.001	<.001	<.001	.033

VAS, visual analog scale; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *SF-36*, Short Form 36; *PCS*, Physical Component Summary; *MCS*, Mental Component Summary; *CC*, correlation coefficient.
* Weak correlation: Pearson correlation coefficients of 0.1 to 0.3.
† Moderate correlation: Pearson correlation coefficients of 0.3 to 0.5.

Table VIII Correlation between shoulder strength deficits in total work and shoulder function in group II (massive tear group)

	VAS score	SST score	Constant score	ASES score	SF-36 PCS score	SF-36 MCS score
Abduction						
CC	0.173*	−0.192*	−0.388†	−0.362†	−0.511‡	−0.172*
P value	.171	.157	.001	.002	<.001	.144
External rotation						
CC	0.299*	−0.429†	−0.387†	−0.345†	−0.209*	−0.136*
P value	.017	.001	.001	.003	.074	.247
Internal rotation						
CC	0.475†	−0.369†	−0.582‡	−0.598‡	−0.378†	−0.255*
P value	<.001	.005	<.001	<.001	.001	.028

VAS, visual analog scale; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons; *SF-36*, Short Form 36; *PCS*, Physical Component Summary; *MCS*, Mental Component Summary; *CC*, correlation coefficient.
* Weak correlation: Pearson correlation coefficients of 0.1 to 0.3.
† Moderate correlation: Pearson correlation coefficients of 0.3 to 0.5.
‡ Large correlation: Pearson correlation coefficients greater than 0.5.

test; however, the isokinetic test is a proven objective and reliable method[19,26,28,29] that accurately reflects rotator cuff status. Second, although we excluded patients who were unable to initiate and endure the isokinetic test owing to pain- and stiffness-related errors, there were potential confounding factors during the measurement process. Third, this study contains only preoperative correlations between strength and clinical scores. A postoperative comparison between the improved patient group (from group II to group I) and the unimproved patient group may be informative. However, obtaining sufficient follow-up isokinetic postoperative data from this study population was difficult.

Conclusion

Shoulder strength deficits measured by the isokinetic test were weakly correlated with shoulder function. Shoulder strength deficits, especially internal rotator strength deficits, significantly worsened regional shoulder function and systemic disability in patients with massive rotator cuff tears.

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