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Association of Strength Measurement with Rotator Cuff Tear in Patients with Shoulder Pain: The ROW Study

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Abstract

Objective—This study examines the association between strength measurements and supraspinatus tear in patients with shoulder pain. This study characterized determinants of abduction strength among patients with tears.

Design—Two-hundred and eight patients with shoulder pain (69 with and 110 without tear) were recruited. Strength was tested using hand-held dynamometer. Supraspinatus tears were diagnosed by combination of clinical assessment and blinded MRI review. Associations of supraspinatus tear with patient characteristics and strength measurements (abduction, internal rotation and external rotation) were assessed using multivariable logistic regression models.

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Results—Patients with supraspinatus tear had decreased abduction strength ($p=0.02$) and decreased external rotation strength ($p<0.01$). When adjusted for age, sex, tear laterality, and BMI, decreased abduction strength (OR= 1.18 per kg, 95% C.I.=1.06–1.32) and decreased external rotation strength (OR=1.29 per kg, 95% C.I.=1.14–1.48) were associated with supraspinatus tear. In patients with tear, age ≥ 60 years, female sex, and VAS pain score were significantly associated with decreased abduction strength but tear size, fatty infiltration, and atrophy were not.

Conclusions—Decreased abduction and external rotation strength were associated with supraspinatus tear in patients with shoulder pain. In this cohort, the abduction strength of patients with tears, was influenced by demographic factors but not tear characteristics.

Keywords

Rotator Cuff; Shoulder Pain; Muscle Strength Dynamometer

Introduction

Patients with rotator cuff tears present with shoulder pain, loss of range of motion, and/or loss of strength. The differential diagnosis of shoulder pain is broad; therefore, quantification of strength loss has the potential to aid clinical examination. Several physical examination maneuvers including special tests, strength measurement, and range of motion measurement have been described for the evaluation of the rotator cuff¹. However, data supporting the utility of physical examination maneuvers in the diagnosis of tear is sparse^{2–5}. This leads to uncertainty in making a diagnosis based on clinical findings alone. Evidence backing the utility for low cost, easily performed strength testing could support its use in diagnosis and counseling of patients with rotator cuff tear.

Shoulder strength can be objectively measured with a hand-held dynamometer which has been shown to be more reliable than manual muscle testing⁶. Hand-held dynamometry has been shown to detect weakness in shoulder external and internal rotation in rotator cuff muscles deemed normal by manual muscle testing⁷. The supraspinatus is a shoulder abductor that contributes to external rotation as part of the posterior rotator cuff⁸. Supraspinatus is the most commonly torn rotator cuff tendon⁹, particularly at the junction of the supraspinatus-infraspinatus muscles¹⁰. However, there is limited data on the clinical relevance of strength measurement using a hand-held dynamometer in the diagnosis of a supraspinatus or other rotator cuff tendon tears^{11–13}. Moreover, it is unclear whether structural characteristics of the rotator cuff such as tear size, fatty infiltration and atrophy are associated with loss of strength in patients with rotator cuff tears.

It was hypothesized that the presence of a supraspinatus tear would be associated with reduced abduction and external rotation strength, but not with internal rotation strength. The objective of this study was to 1) assess the association between the diagnosis of supraspinatus tear and strength measurements using a hand-held dynamometer in a cohort of patients presenting to orthopedic and physiatry clinics with shoulder pain and 2) assess the determinants of decreased abduction strength in patients with a supraspinatus tear to identify demographic and anatomic characteristics such as tear size and muscle quality that may be

associated with abduction strength in order to better diagnose and counsel patients in this setting.

Materials and Methods

Patient Population

The investigators recruited a longitudinal cohort of patients with shoulder pain (with and without rotator cuff tears) from orthopedic and physiatry clinics at two academic medical centers. This cohort study is termed the ROW (Rotator Cuff Outcomes Workgroup) study. The overall goal of the study was to assess prognostic factors for better outcomes with or without surgery.

Eligibility criteria for the ROW study included age 45 years and older and shoulder symptoms for at least 4 weeks. Exclusion criteria included current shoulder fracture, prior shoulder surgery, and evidence of cervical radiculopathy (assessed by history of neck pain radiating to the shoulder/arm/hand). All of the eligibility and exclusion criteria were applied to the symptomatic shoulder. In patients with bilateral shoulder involvement, the shoulder with a greater degree of pain was considered as the affected shoulder. All patients signed the Institutional Review Board approved informed consent prior to participation.

Two hundred and eight patients were recruited with shoulder pain. Patients completed a structured shoulder and general health questionnaire and underwent a standardized study testing protocol. The distribution of patients after enrollment is illustrated in Figure 1. STROBE guidelines for performance of cohort studies were followed.¹⁴

Strength Measurement

Patients underwent a standardized physical examination including strength testing with a hand-held dynamometer⁸. Isometric shoulder contraction was assessed in three planes - abduction, external rotation and internal rotation by trained research assistants in order to assess the strength of the rotator cuff muscles. Research assistants were trained to perform strength measurements by two of the investigators NJB and LDH and required to demonstrate proficiency in strength measurement using a dynamometer independently prior to performing the protocol on study subjects. Strength testing using a dynamometer has good intra-rater and inter-rater reliability for assessing shoulder strength⁶. Two trials of all maneuvers were performed on each upper extremity; there was a ten second break between the two measurements. The scores were then averaged for each tested movement. Strength was measured twice to increase the accuracy of measurement. If the patient was unable to perform strength testing due to profound weakness, their strength measurement was considered to be zero. This strength measurement protocol has been previously described and is presented below⁸.

For each test, after positioning the shoulder and with the patient sitting, the patient was asked to push as hard as possible, while the examiner held the hand held dynamometer stationary. Once an isometric contraction was achieved, the patient continued pushing into the hand held dynamometer with the tester maintaining positional equilibrium for a 5-second

period. The peak isometric force (in kilograms (kg)) generated during the 5 second hand held dynamometry trial was recorded and used for analysis.

Abduction measures the force of the supraspinatus muscle. With the shoulder in 90° of abduction in the plane of the scapula (45° of horizontal adduction from the coronal plane), elbows extended and palm facing down, the dynamometer was placed on the lateral humeral epicondyle.⁸

To measure external strength, the patient was instructed to sit with their arm at their side in neutral rotation with the elbow at 90° of flexion¹⁵. The forearm was positioned midway between supination and pronation, with the thumb pointed upward. The dynamometer was placed on the dorsum of the wrist just proximal to the ulnar styloid.

Internal rotation predominately measures the force of the subscapularis muscle. With the patient's arm at 90° of shoulder flexion, neutral rotation, and elbow at 90° of flexion, the dynamometer was placed proximal to the wrist joint on the volar aspect of the forearm. The tester placed one fingertip (of the hand not holding the dynamometer) on the olecranon to avoid the patient producing an adduction moment rather than desired internal rotation.

Strength measures were examined with and without normalization to body weight (strength in kilograms/percent kilogram of body weight). Normalization of strength eliminates the contribution of patient size to the strength measurement as previous studies suggest that body-weight influences baseline strength^{11,16}. Of various anthropometric variables that can be used to normalize shoulder strength data, body weight has been shown to yield the lowest variability and promote the most normal distribution¹⁷. We also assessed strength as a ratio of abduction to external rotation strength, as lower values of this ratio have been shown to be associated with tear diagnosis in asymptomatic patients⁷.

As a secondary analysis, in the subset of patients with unilateral shoulder pain, the ratio of asymptomatic/symptomatic shoulder strength was also calculated. The study's original study questionnaire did not elicit information on the contralateral shoulder. Hence, a survey was subsequently sent to all study participants to inquire whether their contralateral shoulder was symptomatic at the time of their clinic visit. Symptoms were defined in our study as any pain and/or any limitation in range of motion. Patients who did not respond to the survey were then called to obtain this information. Electronic medical records of patients who could not be reached by mail or phone were reviewed. If pain scale for the contralateral shoulder was marked as 0 and the functioning was marked at 100% in the electronic medical records, the patient was determined to have unilateral shoulder symptoms. In 28 patients, status (symptomatic or not) of the opposite shoulder could not be obtained.

Diagnosis of Rotator Cuff Tear

The determination of whether the patient had clinical evidence (based on history and physical exam) of a rotator cuff tear was made using a stringent protocol. One of four fellowship trained shoulder/sports medicine attending physicians evaluated the patient (performing assessment of range of motion, strength, and special tests) and judged whether the patient's symptoms were attributable to a rotator cuff tear. The clinical assessment

included marking the degree of certainty on a scale from 0 to 100 that the patient's symptoms were attributable to a rotator cuff tear. Clinical assessment was performed based on history and physical examination findings only. If the degree of certainty was ≥ 50 , the clinical assessment was considered to be indicative of a rotator cuff tear diagnosis. Next, a blinded review of the patient's magnetic resonance imaging (MRI) determined whether the patient had structural evidence for a rotator cuff tear. The MRI was ordered to aid in diagnosis of rotator cuff tear as well as guide ongoing treatment including surgical planning or referral given patients were under the care of the evaluating provider. The MRI also determined tendon(s) involved. Additional features assessed during the blinded MRI review included tear size, the presence of fatty infiltration, and/or atrophy. Both clinical and MRI diagnostic conditions had to be met for the diagnosis of a cuff tear in this study. MRI was not always performed in the no-tear group as a patient with compelling clinical picture of no tear did not have an indication for MRI.

Statistical Analyses

Descriptive statistics and cross-tabular frequencies were calculated for strength outcomes, patients' characteristics variables and MRI feature variables to determine the data distributions. Bivariate associations between supraspinatus tear and patient characteristics were assessed (including demographics, clinical factors and strength measures) using Wilcoxon Rank Sum Test (for continuous variables) and Fisher's Exact Test (for categorical variables). The study's principle analysis was to evaluate whether decreased strength was associated with supraspinatus tear when adjusting for other factors known to influence strength. Multivariable logistic regression was performed to assess whether each of the dynamometry strength measurements (abduction, internal rotation and external rotation) were associated with supraspinatus tear after adjusting for potential confounders such as age, sex, laterality of tear, and body mass index (BMI). These analyses were repeated for strength/kilogram body weight and the ratio of abduction to external rotation strength¹¹.

As a secondary analysis, in patients with unilateral shoulder symptoms, strength was analyzed as the ratio of asymptomatic to symptomatic side in multivariable logistic regression models.

Finally, the determinants of abduction strength were analyzed in patients with a diagnosis of supraspinatus tear using linear regression. Patient characteristics including sex, age, and VAS pain score as well as anatomic characteristics of the tear including fatty infiltration, atrophy, and tear size were evaluated for their association with strength in those diagnosed with a supraspinatus tear.

Results

Of the 179 patients in our study, 69 (39%) had a supraspinatus tear (henceforth, referred to as a tear). Patients without tears had a diagnosis of glenohumeral osteoarthritis, labral tears, impingement syndrome (without tear), acromioclavicular joint disorders, and adhesive capsulitis (Table 1). The average age was 62.7 years in patients with tear versus 59.6 years without tear ($p = 0.04$). Average visual analog pain score (VAS) was similar in patients with

tear (55.1, SD=22.4) as compared to those without tear (50.1, SD=24.1). Sixty-three percent of all study patients had right-sided shoulder symptoms.

In an unadjusted analysis, subjects with supraspinatus tear had significantly decreased abduction strength (3.9 kgs with tear versus 5.3 kgs without tear; $p=0.02$) and decreased external rotation strength (4.8 kg with tear versus 6.7 kgs without tear; $p<0.01$) (Table 2). Internal rotation strength was not significantly different in patients with and without supraspinatus tear (5.7 versus 6.2 kgs; $p=0.29$). The ratio of abduction to external rotation strength was not significantly associated with the diagnosis of rotator cuff tear either.

When adjusted for age, sex, laterality, and BMI, decreased abduction (OR= 1.18 per kg, 95% C.I.=1.06–1.32) and external rotation (OR=1.29 per kg, 95% C.I.=1.14–1.48) strengths were associated with higher odds of a supraspinatus tear (Table 3). Our results were consistent when strength was normalized to body weight (strength/kilogram of body weight*100) (Table 4).

In the subpopulation of patients with an asymptomatic contralateral shoulder ($n=39$), the mean abduction strength of the affected shoulder was 4.8 kg (95% C.I.=3.5 – 6.1) as compared with the unaffected shoulder (mean abduction strength=7.4; 95% C.I.= 6.0 – 8.9). However, when assessed in a multivariable model, abduction strength ratio of unaffected/affected arm was not significantly associated with rotator cuff tear (OR = 1.06, 95% C.I. = 0.61–1.85). Similar results were obtained when the internal rotation and external rotation strength ratios of unaffected versus affected sides were used.

When determinants of strength measurement were assessed only in patients with supraspinatus tears, age 60 ($\beta = -2.3$ 95% C.I.=−3.9, −0.7), female sex ($\beta = -1.8$ 95% C.I.= −3.3 −0.2) and increasing VAS pain scores ($\beta = -0.05$ 95% C.I.= −0.09, −0.02) were associated with decreased abduction strength (Table 5).

Discussion

This study evaluated the association of supraspinatus tear with strength measurements using a hand-held dynamometer in a population of patients presenting with shoulder pain to specialty clinics as its primary objective. In our study, decreased shoulder abduction and external rotation strength were significantly associated with the diagnosis of supraspinatus tear after adjusting for potential confounders. This association persisted even when strength was normalized to percent body weight. As a second objective, the study also found that in patients with supraspinatus tears, non-structural characteristics of the cuff such as patient age, female sex, and VAS pain scores were associated with decreased abduction strength. After adjusting for age, size of tear and supraspinatus muscle characteristics such as fatty infiltration and atrophy were not significantly associated with abduction strength.

The supraspinatus functions primarily as an abductor of the arm, and assists with external rotation as part of the posterior rotator cuff⁸. In a sheep model, there was measurable loss of strength and contractile force of the rotator cuff tendon when torn¹⁸. In humans, most studies to date have focused on the loss of strength from rotator cuff tear in primarily asymptomatic populations^{11,13,19}. In a study of 237 asymptomatic patients, 17% with rotator

cuff tear demonstrated by an ultrasound, isometric strength testing using a dynamometer revealed that large-to-massive full-thickness tears were associated with significantly decreased abduction strength. The ratio of abduction strength to external rotation strength was also significantly decreased in those with large-to-massive full thickness tears as compared to those without tears¹¹. Age and weight were associated with abduction strength and external rotation strength respectively¹¹. The current study similarly identified association of supraspinatus tear with decreased abduction and external rotation strength, but did not find a similar association for the ratio of abduction to external rotation strength in the symptomatic population, however this study lacked the sample size to evaluate the subgroup of large-to-massive tears in isolation.

Symptomatic and asymptomatic rotator cuff tears have previously been shown to differ in their association with strength. In a study of 283 full thickness rotator cuff tears identified by ultrasound in 211 Japanese mountain villagers, 65.4% of the tears were asymptomatic²⁰. Asymptomatic tears were associated with normal abduction and external rotation strength. In contrast, symptomatic tears demonstrated weakness in abduction and external rotation in 40.8% and 36.7% of patients, respectively²⁰, similar to this study's findings. In a cohort study of 61 symptomatic patients scheduled for surgery, abduction strength of less than 50% compared with the contralateral arm was associated with a large or massive rotator cuff tear¹². This study's data did not show a significant association of supraspinatus tear when strength of the affected shoulder was compared with the contralateral shoulder. These results need further assessment due to limited sample size of patients with an asymptomatic contralateral shoulder in the present study. Moreover, the contralateral shoulder was not the focus of clinical and imaging assessment in our study and it has been previously reported that in patients presenting with painful, full thickness rotator cuff tear, the contralateral shoulder has an asymptomatic tear 56% of the time²¹. It is possible the present study included contralateral shoulders that, while asymptomatic, also had rotator cuff pathology.

In patients with supraspinatus tear, this study found that age $\geq$ 60 years, female sex, and VAS pain scores were associated with decreased abduction strength but structural characteristics of the supraspinatus such as size of tear, fatty infiltration, and muscle atrophy were not significantly associated with abduction strength. Prior studies have found age, sex, and weight to be associated with strength^{11,16,22}. Dominance has been associated with strength in women¹¹. McCabe et al. found that tear size was associated with decreased shoulder abduction strength in patients with severe symptoms warranting surgery¹¹. One systematic review found no evidence that tear size influences functional outcome after rotator cuff repair but larger tear size did have a negative influence on the integrity of the cuff at post-operative followup²³. Age greater than 60, fatty infiltration, and larger tear size have been associated with tear progression²⁴. While increasing tear width and area were associated with asymptomatic tears becoming symptomatic in one study, no difference in external rotation strength was identified between groups²⁵.

In this study's cohort, patients with rotator cuff tears had decreased strength as compared to those without tears but structural characteristics such as size of the tear and muscle quality did not influence shoulder strength in those with tears. Discussions in the literature have focused on the implications of tear size and its progression, and fatty infiltration of the

cuff^{24–30}. Prior studies have reported the relevance of anatomic features in radiologic diagnosis³¹, onset of pain symptoms²⁵, tear progression²⁴ and consideration for surgical treatment of rotator cuff tears^{25,32–34}. In contrast, one recent study suggests anatomic features do not correlate with pain²⁹. Although the current study does not provide data on the relationship of progression of tear size and fatty infiltration with change in shoulder strength, it provides cross-sectional data that a bigger tear size and more severe fatty infiltration are not associated with more abduction strength loss in patients with symptomatic supraspinatus tears. With clinical parallels to the lumbar spine, the findings of this study suggest clinicians could counsel patients with supraspinatus tear that their MRI findings do not clearly correlate with their clinical presentation, and that weakness on exam may be more related to age and pain than tear features found on imaging.

Clinicians often use manual muscle testing to assess strength. However, there is variability in the cut-off for clinically relevant weakness to diagnose a cuff tear³⁵. Manual muscle testing is also prone to false negatives since muscle groups with normal strength on manual muscle testing were shown to have reduced strength when tested with a dynamometer⁷. This is likely because most patients with rotator cuff tears have more subtle loss of strength that is difficult to detect with manual muscle testing. Although our study may not be generalized to patient populations in the primary care setting, the diagnosis of rotator cuff tear has more practical implications in a specialty setting where decisions for surgery or ordering advanced imaging are made. Dynamometry is a relatively efficient and low cost test that can guide further clinical decisions.

The limitations of this study include possible variations in strength measurement. The protocol for obtaining strength measurements in our study was standardized and good inter-rater and intra-rater reliability for strength measurement using a dynamometer has been shown⁶; however there may still be variations among examiners. There are limitations to the isolation of the desired muscles with chosen testing positions. Our protocol tested the supraspinatus with the palm down, in the scapular plane with the shoulder positioned at 90 degrees of abduction. In this position, there is contribution of the deltoid to abduction strength which can compensate for the rotator cuff³⁶. While evaluating the ratio of abduction to external rotation may correct for this, the subset of analysis examining this ratio did not identify any significant differences in strength ratios. There is also no clear way of knowing if substitution of other non-rotator cuff muscles such as the trapezius or bicep occurred during strength assessment. Limitations of the testing technique also include static test position and the absence of fatigue measures. Further, we did not analyze data on duration of tear history, which can affect the patient's compensation and pain. The subpopulation with unilateral shoulder symptoms was established based on responses from patients after their initial encounter and therefore prone to recall bias. The small sample size is a limitation of the study, specifically, there were not enough patients to stratify by BMI or tear size. The literature review reveals a recurring association between loss of strength and massive rotator cuff tear, however this study's sample size did not allow this specific subgroup to be individually studied.

This study's results demonstrate that, as might be expected anatomically, decreased abduction and external rotation strength were associated with an increased likelihood of

supraspinatus tear in patients with shoulder pain. This association could be used in specialty clinics to help differentiate supraspinatus tear from other shoulder disorders in patients presenting with shoulder pain. The study also found that in patients with supraspinatus tears, decreased abduction strength was associated with female sex, increasing VAS pain score, and age 60 years. However, anatomic characteristics of the rotator cuff including tear size, muscle atrophy, and fatty infiltration were not associated with abduction strength after adjusting for age in patients with supraspinatus tears; thus, implying that in a cross-section of patients with tears, a bigger tear size and more severe fatty infiltration do not result in more loss of abduction strength. These are important considerations in counseling patients on strength loss in the context of supraspinatus tear. However, the subgroup of large-to-massive tears was not evaluated in isolation and given the findings of previous studies, may demonstrate unique findings. This provides a direction for future investigation within the symptomatic rotator cuff tear population. This study demonstrates that dynamometry serves a role in identifying supraspinatus tears in patients presenting with shoulder pain and provides context for counseling patients about the findings of weakness on dynamometry.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Flowchart of Analysis of Data for Patients Presenting with Shoulder Pain

Table 1

Baseline Characteristics of the ROW Cohort.

	Supraspinatus Tear N (%) or Mean (SD [*])		P value
	Yes	No	
Age			
< 60 years	26 (37.7%)	57 (51.8%)	0.07
60 years	43 (62.3%)	53 (48.2%)	
Sex (% female)	29 (42%)	57 (52%)	0.22
Body Mass Index (kg/meter ²)	28.8 (5.2)	27.7 (5.4)	0.13
Duration of symptoms (months)	29.2 (59.6)	30.7 (57.1)	0.52
Laterality (%right)	48 (70%)	64 (58%)	0.15
Hand-Dominance (%right)	59 (88%)	100 (92%)	0.72
Visual Analog Scale Pain Score	55.1 (22.4)	50.1 (24.1)	0.32
Diagnosis			
Glenohumeral osteoarthritis	5 (7%)	33 (30%)	
Adhesive capsulitis	1 (1%)	21 (19%)	
Labral tear	0 (0%)	6 (5%)	
Biceps tendonitis/tenosynovitis	21 (30%)	36 (33%)	
AC joint arthritis	5 (7%)	8 (7%)	
Impingement	3 (4%)	3 (3%)	

* Standard deviation

n for missing data: BMI=7; duration=11; hand-dominance=3; VAS=2

Table 2

Strength Measurement using a Hand-Held Dynamometer in Patients with and without Supraspinatus Tear.

	Supraspinatus Tear		P value
	Yes	No	
	Mean (C.I. [*])		
Abduction strength (kg)	3.9 (3.1 – 4.8)	5.3 (4.6 – 6.1)	0.02
External rotation strength (kg)	4.8 (4.1 – 5.6)	6.7 (6.1 – 7.3)	<0.01
Internal rotation strength (kg)	5.7 (4.9 – 6.5)	6.2 (5.6 – 6.8)	0.29
Abduction relative to body weight [#]	4.5 (3.6 – 5.3)	6.8 (5.8 – 7.8)	<0.01
External rotation relative to body weight [#]	5.8 (4.8 – 6.7)	8.5 (7.8 – 9.3)	<0.01
Internal rotation relative to body weight [#]	6.7 (5.8 – 7.6)	8.0 (7.2 – 8.9)	0.05
Abduction strength ratio ^{**}	1.9 (1.3 – 2.5)	1.9 (1.3 – 2.5)	0.24
External rotation strength ratio ^{**}	3.1 (0.7 – 5.4)	1.3 (1.2 – 1.4)	0.15
Internal rotation strength ratio ^{**}	1.3 (1.1 – 1.5)	1.4 (1.1 – 1.5)	0.80

Kg=kilograms

* C.I.: Confidence Interval

strength as a percentage of body weight (strength/body weight * 100)

** Ratio was calculated as unaffected/affected side in patients with unilateral symptoms

n for missing data: normalized for body weight 5, abduction strength ratio 2; external rotation strength ratio 1

Table 3

Adjusted Associations between Supraspinatus Tear and Decreasing Strength in a Cohort of Patients with Shoulder Pain

	Abduction Strength (kg)	External Rotation Strength (kg)	Internal Rotation Strength (kg)
	Odds Ratio (95% C.I. [*])	Odds Ratio (95% C.I. [*])	Odds Ratio (95% C.I. [*])
Strength (kg)	1.18 (1.06 – 1.32)	1.29 (1.14 – 1.48)	1.08 (0.97 – 1.21)
Age (< 60 years) ^{**}	1.57 (0.81 – 3.05)	1.34 (0.68 – 2.67)	1.82 (0.96 – 3.46)
Sex (Female) [†]	0.57 (0.27 – 1.18)	0.41 (0.19 – 0.91)	0.67 (0.32 – 1.39)
Laterality ^{***} (left)	0.59 (0.29 – 1.19)	0.63 (0.31 – 1.31)	0.63 (0.32 – 1.26)
Body Mass Index (kg/m ²) [°]			
25–30	1.61 (0.67 – 3.85)	1.39 (0.57 – 3.35)	1.30 (0.56 – 3.03)
>30	1.51 (0.67 – 3.39)	1.41 (0.61 – 3.22)	1.46 (0.66 – 3.23)

^{*} C.I.: Confidence Interval

^{**} age < 60 is reference

[†] male is reference group

^{***} right-handed is reference group

[°]BMI < 25 is reference group

Table 4

Adjusted Associations between Supraspinatus Tear and Decreasing Strength per Percent Body Weight in a Cohort of Patients with Shoulder Pain

	Abduction Strength (kg)/percent body weight	External Rotation Strength (kg)/ percent body weight	Internal Rotation Strength (kg)/ percent body weight
	Odds Ratio (95%C.I. [*])	Odds Ratio (95%C.I. [*])	Odds Ratio (95%C.I. [*])
Strength [#]	1.14 (1.05 – 1.24)	1.23 (1.12 – 1.36)	1.09 (1.00 – 1.18)
Age (< 60) ^{**}	1.62 (0.84– 3.13)	1.45 (0.73 – 2.85)	1.81 (0.96 – 3.44)
Sex (Female) [†]	0.57 (0.29 – 1.14)	0.48 (0.24 – 0.98)	0.66 (0.34 – 1.28)
Laterality (left) ^{***}	0.66 (0.33 – 1.31)	0.72 (0.35 – 1.48)	0.69 (0.35 – 1.37)

* C.I.: Confidence Interval

[#] as a percentage of kg body weight

^{**} age < 60 is reference

[†] male is reference

^{***} right-handed is reference

Table 5

Determinants^{**} of Abduction Strength (kg) in Patients with Supraspinatus Tear

	Beta coefficient (95%C.I.[*])
Age 60 (years)	-2.3 (3.9, -0.7)
Female Sex	-1.8 (-3.3 -0.2)
Visual Analog Scale pain score	-0.05 (-0.09, -0.02)

* C.I.: Confidence Interval

** After adjusting for age, tear size, fatty infiltration, and muscle atrophy were not significantly associated with abduction strength and hence not included in this model

N = 62