



The champagne toast position isolates the supraspinatus better than the Jobe test: an electromyographic study of shoulder physical examination tests



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Background: While Jobe's test is widely used, it does not isolate supraspinatus activity. Our purpose was to examine the electromyographic (EMG) activity within the supraspinatus and deltoid with resisted abduction to determine the shoulder position that best isolates the activity of the supraspinatus.

Methods: We performed EMG analysis of the supraspinatus, anterior head of the deltoid, and middle head of the deltoid in 10 normal volunteers. We measured EMG activity during resisted shoulder abduction in the scapular plane to both manual resistance and a standardized load in varying degrees of abduction and rotation. To determine which position best isolates supraspinatus activity, the ratio of supraspinatus to deltoid activity (S:D) was calculated for each position. Results were analyzed with a repeated-measures analysis of variance with Bonferroni correction. The posterior deltoid was excluded as it serves mostly to extend and externally rotate.

Results: Our study confirmed Jobe's findings of maximal supraspinatus activity at 90° of abduction. However, decreasing abduction significantly increased S:D for both resisted manual testing and testing against a standardized load ($P = .002$ and $.001$, respectively). The greatest S:D ratio (4.6 ± 3.4 for standardized load testing) was seen at the "champagne toast" position, i.e., 30° of abduction, mild external rotation, 30° of flexion, and 90° of elbow flexion. The smallest ratio (0.8 ± 0.6) was seen at Jobe's position.

Conclusions: Testing of abduction strength in the champagne toast position, i.e., 30° of abduction, mild external rotation, and 30° of flexion, better isolates the activity of the supraspinatus from the deltoid than Jobe's "empty can" position.

Level of evidence: Basic Science Study, Kinesiology, Electromyography.

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Keywords: Rotator cuff; supraspinatus; shoulder physical examination; electromyography; deltoid

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Rotator cuff disease is a common cause of shoulder disability.^{11,19} Testing of rotator cuff strength is among the most commonly performed musculoskeletal examination maneuvers.^{2,3,7} The overlap in function between shoulder

muscles makes physical examination difficult to interpret.^{3,16,21,24,26} Strength within the supraspinatus tendon is usually tested by the Jobe maneuver, in which abduction strength is measured with the shoulder abducted 90°, the shoulder forward flexed 30°, the shoulder maximally internally rotated, the elbow fully extended, and the forearm fully pronated.²⁰ This maneuver, also described as the "empty can" test, was originally described by Jobe and Moynes in 1982.²⁰ Based on unpublished electromyographic (EMG) data, this position was described to have a high level of supraspinatus activity.²⁰ Over time, this position and test have also become the de facto way to best isolate the supraspinatus from the remainder of the rotator cuff.

However, numerous studies have demonstrated Jobe's test (also referred to in the literature and in common communication as the empty can test) to be insensitive, nonspecific, and inaccurate.^{2,16,17,21,25,27,31} In some studies, the sensitivity is as low as 30%, the specificity is as low as 35%, and the accuracy is as low as 50%.^{2,21,25} Variations have been proposed, including the full can test and the drop arm sign. These tests work on a similar concept and at a similar shoulder position, and clinically these tests perform no better.^{2,16,25,27,32} Jobe's position can be painful to reach for patients, leading to apparent weakness due to pain-mediated reflex muscle inhibition. Patients with motion-limiting pathologic changes also may not be able to reach this position. Thus, patients with a wide variety of shoulder disorders can have false-positive Jobe's test results despite full supraspinatus strength and tendinous continuity.^{2,7}

To test supraspinatus strength, the examiner must isolate the supraspinatus from the abducting force of the deltoid. In normal shoulders, until the shoulder reaches 45° to 60° of elevation, almost all motion is provided by glenohumeral rotation without a significant scapulothoracic contribution.³³ During early elevation from adduction, the deltoid is nearly parallel to the long axis of the humerus, and thus the supraspinatus acts as the primary initiator of humeral abduction or scaption.^{1,15,28} Thus, in addition to its function as a humeral head depressor, the supraspinatus has a primary action in initiation of glenohumeral elevation.^{1,15,28} Lower degrees of abduction may thus better allow the examiner to isolate the supraspinatus from the deltoid. Analogously, the belly press test and lift-off tests perform well diagnostically because they position the humerus to isolate the subscapularis from the internal rotating and adducting power of the pectoralis major.³

The senior author's (G.P.N.) clinical experience has been that performing a resisted shoulder abduction test with the arm held in lower degrees of abduction allows more accurate and less painful assessment of supraspinatus strength. The desire was to know more definitively the activation patterns for those manual muscle testing positions commonly performed by the senior author for the shoulder and rotator cuff. Our aim was to perform a translational study to examine the EMG activity within the

supraspinatus and deltoid with resisted abduction to determine which shoulder position best isolates the abducting activity of the supraspinatus from the abducting activity of the deltoid. We hypothesized that resisted strength testing in lower degrees of abduction would provide better isolation of the supraspinatus from the deltoid.

Materials and methods

This is a controlled laboratory EMG study. We recruited 10 normal volunteers between 20 and 40 years old. Participants were not aware of the study hypothesis. We excluded those with a history of a shoulder injury, a history of rotator cuff disease, shoulder weakness, medical comorbidities, or any shoulder pain whatsoever in the past 6 months. Whereas all subjects were recreational athletes, none were overhead athletes. All subjects signed informed consent forms. We performed all testing in our human motion analysis laboratory.

Experimental setup

A single examiner placed all electrodes using a written protocol. We placed a fine-wire electrode into the supraspinatus using the previously described Basmajian technique.⁴ This electrode was placed midway between the posterolateral corner of the acromion and the medial border of the scapula 1 cm proximal to the scapular spine. The needle was inserted to the depth of the scapula and then withdrawn slightly to ensure that the tip of the electrode lay within the supraspinatus and not the trapezius. Published studies have demonstrated that after placement of wires using this technique, subjects are able to perform strenuous sports requiring full range of motion of the shoulder including baseball, golf, football, and track and field with no pain, discomfort, or limitation.^{4,14,15,18,22} We placed surface self-adhesive dual Ag/AgCl electrodes over the anterior head of the deltoid, the middle head of the deltoid, the trapezius, and the infraspinatus over the palpated muscle bellies (Fig. 1). Electrodes were placed in parallel with their muscle fibers at the midportion of each muscle, with the muscle held in midflexion for all subjects and connected to a TeleMyo transmitter and receiver (model 2400T/2400R; Noraxon Inc., Scottsdale, AZ, USA). Surface electrodes were placed by a senior orthopedic surgery resident experienced in electrode placement after a thorough review of the literature and the documentation provided by Noraxon.^{8,9} EMG signals were then preamplified (500×) near the electrodes, bandpass filtered between 10 and 500 Hz, and sampled at a rate of 1200 Hz.²⁹ We did not test various periscapular muscles including the posterior deltoid because of constraints within our laboratory and the findings of previous studies suggesting that the posterior deltoid is largely an extensor and external rotator of the shoulder and is only minimally important for abduction.⁶

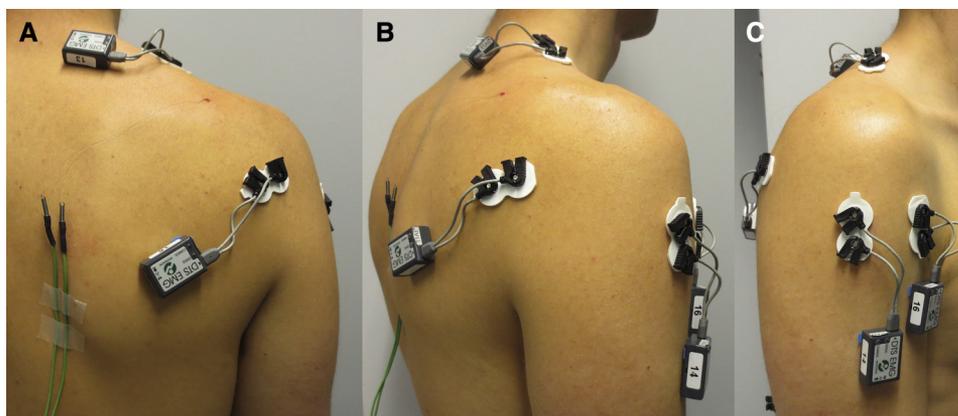


Figure 1 Electrode placement demonstrating the surface electrodes for the trapezius, infraspinatus, middle deltoid, and anterior deltoid. The entrance location for the supraspinatus can be seen as a *red dot* between the trapezius and infraspinatus electrodes. (A) Posterior view. (B) Oblique view. (C) Lateral view.

We normalized all EMG activities to maximal manual testing (MMT).¹² The MMT activity is defined as the highest 1 second of activity during 3 consecutive 3- to 5-second trials. Published studies have described MMT protocols for the deltoid and infraspinatus.⁹ For the trapezius MMT, the subject performs maximal scapuloclavicular elevation against resistance. For the supraspinatus MMT, the subject performs resisted abduction in Jobe's position.²⁰ Although the purpose of this study was to evaluate this position of testing, this position was used as the a priori MMT position because of Jobe's prior findings.²⁰ EMG signals were rectified and smoothed using a root-mean-square algorithm with a window of 300 ms. We defined the first 150 ms of activity as a baseline and subtracted it from all activity recordings.

Data collection

A single examiner performed all testing, making all attempts to replicate the same resistance and positions for each subject and trial (Fig. 2). To attempt to keep the protocol as translational as possible to the office setting, the senior author (G.P.N.) went through all physical examination manual muscle testing positions as if this were an office examination. This provided the single tester with repetitive experience in the shoulder examination for all testing positions before the study. We measured abduction position for each test with a large goniometer. We first performed manual testing with the examiner resisting abduction at the elbow, attempting to replicate the clinical situation of rotator cuff testing. To standardize resistance and to avoid bias, we then repeated each position with the subject isometrically resisting the downward gravitation force of two 1-liter saline bags affixed to the elbow with an ACE wrap (Medline, Chicago, IL, USA). The position of the examiner's hand in Figure 2, C to F mirrors the position of the saline bags. The subject actively resisted for 5 seconds in each setting and position. The middle 3 seconds of

activity was analyzed. Subjects rested for 20 seconds between tests. We tested both relative internal rotation (IR) and relative external rotation (ER) positions at 90°, 60°, 45°, and 30° of abduction. Testing at 90° of abduction was performed with both full elbow extension and 90° of elbow flexion. Otherwise we performed all testing at 90° of elbow flexion. We performed all testing at 30° of flexion, i.e., in the plane of the scapula (Fig. 2). These positions roughly replicate activities of daily living: 90° of abduction includes the empty can and full can positions, and 30° of abduction roughly replicates a polite "champagne toast" and "champagne pour" positions in ER and IR, respectively.

This methodology was developed to be translational. Our purpose was (1) to replicate the physical examination tests used for clinical testing and (2) to replicate familiar upper extremity positions used in activities of daily living, such as pouring into a glass or making a toast by raising a glass (Fig. 3). Thus, in the course of the trials, subjects were instructed to "make a toast" to position the shoulder in relative ER. Subjects were instructed to "pour a glass out onto the floor between their shoes" to position the shoulder in relative IR. Again, this was to attempt to provide a familiar activity cue to the patient for position and action.

Statistical methods

We combined the activity within the anterior deltoid and middle deltoid to create a mean deltoid activity. We calculated the ratio of supraspinatus to deltoid activity (S:D) to quantify how well each position isolated supraspinatus activity from deltoid activity. We tested data for normality using the Kolmogorov-Smirnov test. We tested the effect of elbow flexion using paired Student *t* tests within IR and ER positions. The effect of rotation and abduction on supraspinatus activity, mean deltoid activity, and S:D was calculated using a repeated-measures analysis of variance. Mauchly's test of sphericity was used.

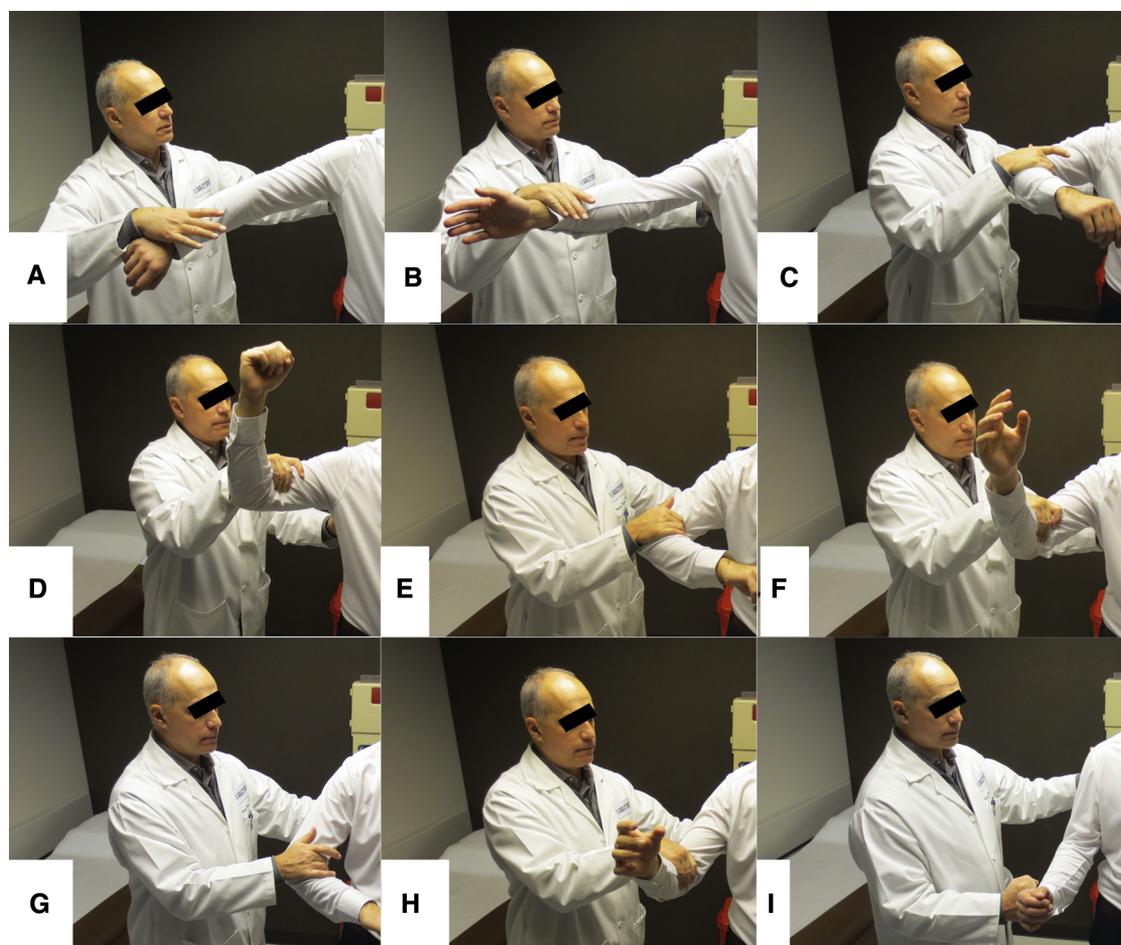


Figure 2 These clinical photographs demonstrate the testing positions. All testing was performed in 30° of flexion, i.e., within the plane of the scapula, and in all cases resisted abduction was tested. Unless otherwise specified, all testing was performed in 90° of elbow flexion. (A) At 90° abduction, full internal rotation, and full elbow extension, Jobe's position or the "empty can" test. (B) At 90° abduction, full external rotation, and full elbow extension, or the "full can" test. (C) At 90° abduction, internal rotation. (D) At 90° abduction, external rotation. (E) At 60° abduction, internal rotation. (F) At 60° abduction, external rotation. (G) At 30° abduction, internal rotation, or the "pour" position. (H) At 30° abduction, external rotation, or the "champagne toast" position. (I) Infraspinatus testing: resisted external rotation with the shoulder in full adduction and neutral rotation.

In those cases in which sphericity was violated, the Greenhouse-Geisser correction of the P value was used. Because 5 separate repeated-measures analysis of variance tests were performed, Bonferroni correction was used, and within these tests, P values of $<.01$ were considered significant; in all other cases, P values of $<.05$ were considered significant.

Results

Resisted manual testing

Shoulder abduction and rotation did not significantly affect supraspinatus activity ($P = .023$ and $.019$, respectively; [Supplementary Fig. 1](#) and [Table I](#)). Abduction and rotation significantly affected deltoid activity ($P < .001$ and $P = .009$, respectively). Deltoid activity increased in ER

over IR. Deltoid activity increased in higher degrees of abduction ([Supplementary Fig. 2](#) and [Table I](#)). Abduction and rotation significantly affected S:D ($P = .002$ and $.009$, respectively). The ratio increased in ER (toast) over IR (pour). The ratio increased in lower degrees of abduction ([Fig. 4](#) and [Table I](#)). The arm position that provided the most activation of the supraspinatus relative to the activation of the deltoid was 30° shoulder abduction and shoulder ER, i.e., the champagne toast position. The position that provided the least activation of the supraspinatus relative to the activation of the deltoid was 90° shoulder abduction and shoulder IR, i.e., Jobe's position.

Elbow flexion did not significantly affect mean deltoid activity or S:D in either ER or IR ($P = .204$ and $.946$ for the deltoid, respectively, and $P = .173$ and $.078$ for S:D; [Table I](#) and [Supplementary Fig. 3](#)). While elbow flexion did affect supraspinatus activity in IR ($P = .01$), it did not affect supraspinatus activity in ER ($P = .448$). Elbow flexion also



Figure 3 These clinical photographs demonstrate the activities of daily living that replicate the proposed testing positions. **(A)** Testing at 30° of abduction, 30° of forward elevation, 90° of elbow flexion, and mild internal rotation replicates a “pour” position. **(B)** Testing at 30° of abduction, 30° of forward elevation, 90° of elbow flexion, and mild external rotation replicates a “toast” position.

Table I Electromyographic activity with manually resisted abduction in each degree of shoulder abduction, shoulder rotation, and elbow flexion

Name	Abduction	Rotation	Elbow flexion	Supraspinatus (% MMT)	Deltoid (% MMT)	S:D	Infraspinatus (% MMT)	Trapezius (% MMT)
Jobe's empty can	90°	IR	0°	77 [65-90]	85 [71-99]	1.0 [0.7-1.3]	41 [29-52]	116 [89-143]
Full can	90°	ER	0°	86 [70-102]	60 [51-70]	1.6 [1.1-2.0]	30 [23-37]	109 [85-133]
	90°	IR	90°	60 [48-72]	84 [72-97]	0.7 [0.6-0.8]	33 [24-43]	115 [82-148]
	90°	ER	90°	82 [64-99]	65 [55-76]	1.4 [1.0-1.7]	30 [23-38]	114 [72-156]
	60°	IR	90°	52 [39-65]	47 [32-63]	1.3 [0.9-1.7]	27 [21-33]	63 [38-87]
	60°	ER	90°	64 [50-99]	46 [34-58]	1.6 [1.1-2.1]	25 [17-33]	68 [37-99]
	45°	IR	90°	52 [39-65]	47 [34-61]	1.3 [0.8-1.7]	26 [18-34]	69 [37-100]
	45°	ER	90°	64 [50-78]	41 [29-53]	1.9 [1.3-2.4]	23 [16-30]	58 [41-76]
Champagne pour	30°	IR	90°	53 [36-71]	48 [29-66]	1.4 [0.9-2.0]	29 [19-38]	60 [31-88]
Champagne toast	30°	ER	90°	65 [55-76]	38 [28-48]	2.1 [1.4-2.8]	26 [18-35]	56 [40-72]

Mean (95% confidence intervals) electromyographic activity within the supraspinatus, the anterior and middle heads of the deltoid, the ratio between the supraspinatus and deltoid activities (S:D), the infraspinatus, and the trapezius. Activities are expressed as a percentage of the maximum manual test (MMT). IR, internal rotation; ER, external rotation.

did not affect trapezius activity ($P = .917$ in IR and $.713$ in ER). Trapezius activity was not significantly affected by rotation ($P = .702$). Trapezius activity was significantly affected by abduction ($P < .001$), with activity increasing in higher degrees of abduction. In all cases, the infraspinatus had the highest level of activity with resisted ER in full adduction. During resisted ER, the supraspinatus was active as well (mean, 59%; 95% confidence interval, 45%-73%), confirming the role of the supraspinatus as a “centering” force for the humeral head.

Standardized weighted testing

Similar results were seen when testing was performed against a standardized weight instead of against resisted testing. Rotation significantly affected supraspinatus

activity ($P = .008$). Supraspinatus activity increased in ER over IR (Table II). Abduction did not affect supraspinatus activity ($P = .162$). Abduction significantly affected deltoid activity ($P < .001$). Deltoid activity increased at higher degrees of abduction (Table II). Rotation did not significantly affect deltoid activity ($P = .077$; Table II). Abduction significantly affected S:D ($P = .001$; Table II). Rotation did not significantly affect S:D ($P = .413$). Similar to resisted manual testing, the highest S:D was seen at 30° shoulder abduction and shoulder ER, i.e., the champagne toast position. The lowest S:D was seen at 90° shoulder abduction and shoulder IR, i.e. Jobe's position (Fig. 4, B).

Elbow flexion did not significantly affect supraspinatus activity in either IR or ER ($P = .139$ and $.333$, respectively; Table II). Elbow flexion did significantly affect deltoid activity in IR but not in ER ($P < .001$ and $P = .475$,

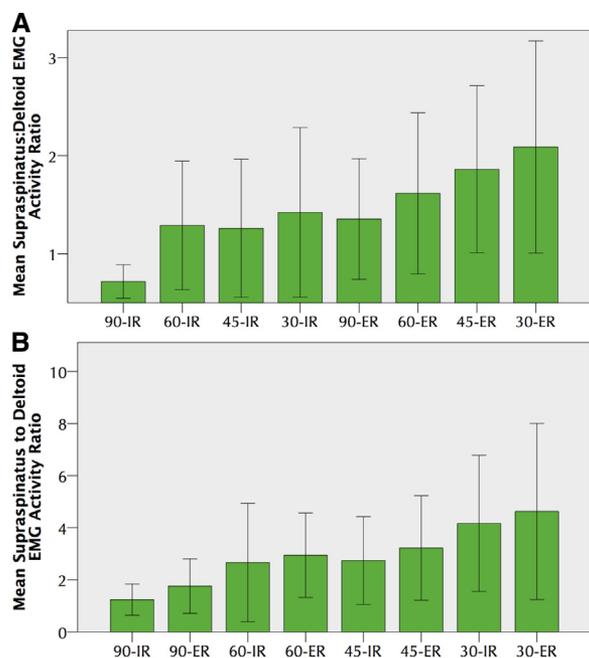


Figure 4 Mean ratio of activity within the supraspinatus to activity within the mean of the anterior and the middle heads of the deltoid in varying degrees of shoulder abduction and rotation. (A) Results with resisted manual testing. (B) Results with a standardized isometric load. Error bars show 1 standard deviation. Bars have been rank ordered from least to greatest. In all cases, testing was performed in full elbow extension. ER, external rotation; IR, internal rotation; EMG, electromyographic.

respectively; Table II). Elbow flexion did significantly affect S:D in IR but not in ER ($P = .002$ and $.359$, respectively; Table II).

Discussion

The purpose of this translational EMG study was to evaluate the activity within the periarticular glenohumeral musculature during physical examination manual muscle testing. Our results demonstrate that the position that best isolates the abducting activity of the supraspinatus from the abducting activity of the deltoid is 30° shoulder abduction and mild shoulder ER, i.e. the champagne toast position. Using supraspinatus to deltoid activity data from resisted abduction to a standardized load, this position provides 5.75-fold better supraspinatus isolation than the empty can of Jobe's position. Clinical use of the champagne toast position has the potential to improve the sensitivity and specificity of physical examination testing of the supraspinatus. Anecdotally, the senior author (G.P.N.) has successfully used this position clinically for many years because it avoids potential reflex inhibition due to impingement pain in Jobe's position.

Several published studies confirm our findings. Colachis and Strohm performed an examination of abduction force

after axillary nerve blocks and suprascapular nerve blocks. After an axillary nerve block, abduction strength loss increased linearly from 0° to 150° . In their study, at 90° , almost all abduction strength was provided by the deltoid, whereas at 30° , almost all abduction strength was provided by the supraspinatus.¹⁰ Ruckstuhl et al used magnetic resonance imaging data from normal shoulders to create computer simulations to measure the shoulder abduction moment arms of the deltoid and supraspinatus. These simulations determined that the supraspinatus moment arm progressively decreased with increasing abduction. The opposite was true for the deltoid. They additionally determined that IR further decreased the mechanical advantage of the supraspinatus.³⁰ Gerber et al performed abduction strength testing in various degrees of abduction after blockade of the suprascapular nerve and found that the decrease in abduction strength was not related to degree of abduction, similar to our findings that supraspinatus activity does not differ with degree of abduction.¹³ Boettcher et al measured activity in a wide variety of shoulder muscles, demonstrating significant activity in a variety of muscles with resisted abduction at 90° of abduction.⁵ Overall, these results confirm our findings that testing at 30° of abduction and relative ER, i.e., the champagne toast position, better isolates the supraspinatus than Jobe's position.

Three published EMG studies have shown that Jobe's position provides more deltoid than supraspinatus activation.^{1,23,28} Malanga et al performed EMG testing of the deltoid and supraspinatus at both Jobe's position and the Blackburn position, i.e., 100° of abduction and full ER. In their study, neither position isolated the supraspinatus from the deltoid.²³ Alpert et al examined EMG activity in the deltoid and supraspinatus in varying shoulder positions. Their study found deltoid activity to increase with abduction up to 90° and supraspinatus activity to be higher at lower degrees of abduction.¹ Reddy et al examined supraspinatus and deltoid activity in both normal subjects and subjects with subacromial impingement. Their study demonstrated that the supraspinatus is more active in lower degrees of abduction relative to the deltoid.²⁸ These results also suggest that testing at 30° of abduction in the champagne toast position better isolates the supraspinatus than Jobe's position does.

Determining the position for testing of the supraspinatus must account for the surrounding musculature. Our results confirm Jobe's findings that the supraspinatus is more active at 90° of abduction (mean of 86% in ER) than at 30° of abduction (65% in ER). However, active shoulder abduction relies on both the supraspinatus and the deltoid. With increasing degrees of abduction, the deltoid becomes increasingly active relative to the supraspinatus. With resisted abduction in lower degrees of abduction, the deltoid is deactivated and the abduction power of the supraspinatus is relatively isolated. Analogously, the belly press test and lift-off tests are sensitive and specific for subscapularis tears because they

Table II Electromyographic activity while isometrically resisting a standardized load in each degree of shoulder abduction, shoulder rotation, and elbow flexion

Name	Abduction	Rotation	Elbow flexion	Supraspinatus (% MMT)	Deltoid (% MMT)	S:D	Infraspinatus (% MMT)	Trapezius (% MMT)
Jobe's empty can	90°	IR	0°	22 [13-30]	29 [22-36]	0.8 [0.4-1.1]	10 [6-14]	29 [18-40]
Full can	90°	ER	0°	30 [19-41]	14 [11-17]	2.1 [1.4-2.7]	9 [4-14]	27 [14-40]
	90°	IR	90°	20 [12-27]	16 [12-20]	1.2 [0.9-1.6]	7 [4-11]	25 [14-35]
	90°	ER	90°	27 [16-38]	15 [11-19]	1.8 [1.1-2.4]	10 [4-15]	24 [13-35]
	60°	IR	90°	19 [9-29]	7 [5-9]	2.7 [1.3-4.1]	6 [2-10]	18 [10-27]
	60°	ER	90°	27 [14-41]	9 [6-12]	2.9 [1.9-3.9]	8 [3-13]	18 [10-27]
	45°	IR	90°	18 [10-27]	7 [5-9]	2.7 [1.7-3.8]	5 [2-8]	15 [8-22]
	45°	ER	90°	23 [14-33]	8 [6-10]	3.2 [2.0-4.5]	6 [3-9]	16 [8-23]
Champagne pour	30°	IR	90°	16 [9-22]	4 [3-5]	4.2 [2.5-5.8]	4 [1-7]	13 [7-19]
Champagne toast	30°	ER	90°	23 [13-33]	6 [4-7]	4.6 [2.5-6.7]	5 [3-8]	12 [7-18]

Mean (95% confidence intervals) electromyographic activity within the supraspinatus, the anterior and middle heads of the deltoid, the ratio between the supraspinatus and deltoid activities (S:D), the infraspinatus, and the trapezius. Activities are expressed as a percentage of the maximum manual test (MMT). IR, internal rotation; ER, external rotation.

maximally internally rotate the humerus to isolate the subscapularis from the internal rotating power of the pectoralis major.³ Because of the anatomic complexity of the shoulder, each muscle serves multiple functions and they frequently overlap, and thus resisted strength physical examination maneuvers must consider the activity of the surrounding musculature in addition to the activity within the tested muscle.

Our study has several strengths. Electromyography has been widely used and our laboratory has extensive experience with this technique.^{8,9} Our study design allows each subject to serve as an internal control, and values are normalized within each subject. In addition, we used both resisted manual testing to mimic the clinical scenario used for testing and resistance against a standardized weight to provide a repeatable load. Results were concordant with both methods of testing. Given that resisted manual testing submaximally stimulated the supraspinatus (activity with resisted manual testing at the MMT position was 77%), standardizing load is critical.

Our study has several limitations. The small sample size may limit generalizability. However, statistical significance was achieved for the primary hypothesis of the study, and thus the inclusion of more subjects is unnecessary. Surface EMG has shortcomings, largely due to potential interference from surrounding muscles. However, our results are consistent with multiple prior studies that used fine-wire electrodes.^{1,23,28} In addition, we did not test various periscapular muscles including the posterior deltoid because of constraints within our laboratory and the findings of previous studies suggesting that the posterior deltoid is largely an extensor and external rotator of the shoulder and is only minimally important for abduction.⁶ In addition, inclusion of another head of the deltoid would likely only have increased deltoid activity and thus would likely have exacerbated the S:D findings from the study, although it

may have affected deltoid activity in IR vs. ER. We did not test the subscapularis, which also provides abduction torque in some shoulder positions. We also did not include full adduction, which may have had even higher S:D ratios, given the observed trend. We also did not perform ultrasound, magnetic resonance imaging, or standardized strength measurements to quantify that these patients are normal, although all were younger than 40 years, free of known shoulder disease, painless, and healthy. Last, it remains unclear whether the findings of this controlled laboratory study in normal volunteers will translate to more sensitive and specific clinical testing in patients with rotator cuff tears. To attempt to maximize the clinical translation of the study, we performed both resisted manual testing and isometric testing against a standardized load with concordant results. Future clinical testing of the sensitivity and specificity of the champagne toast test is planned to address this shortcoming.

Conclusions

Testing of abduction strength in the champagne toast position, i.e., 30° of abduction, mild ER, and 30° of flexion, better isolates the activity of the supraspinatus from the deltoid than Jobe's empty can position.

Disclaimer

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Supplementary data

Supplementary data related to this article can be found online at <http://dx.doi.org/10.1016/j.jse.2015.07.031>.

References

- Alpert SW, Pink MM, Jobe FW, McMahon PJ, Mathiyakom W. Electromyographic analysis of deltoid and rotator cuff function under varying loads and speeds. *J Shoulder Elbow Surg* 2000;9:47-58.
- Bak K, Sørensen AK, Jørgensen U, Nygaard M, Krarup AL, Thune C, et al. The value of clinical tests in acute full-thickness tears of the supraspinatus tendon: does a subacromial lidocaine injection help in the clinical diagnosis? A prospective study. *Arthroscopy* 2010;26:734-42. <http://dx.doi.org/10.1016/j.arthro.2009.11.005>
- Bartsch M, Greiner S, Haas NP, Scheibel M. Diagnostic values of clinical tests for subscapularis lesions. *Knee Surg Sports Traumatol Arthrosc* 2010;18:1712-7. <http://dx.doi.org/10.1007/s00167-010-1109-1>
- Basmajian JV, Latif A. Integrated actions and functions of the chief flexors of the elbow: a detailed electromyographic analysis. *J Bone Joint Surg Am* 1957;39:1106-18.
- Boettcher CE, Ginn KA, Cathers I. The 'empty can' and 'full can' tests do not selectively activate supraspinatus. *J Sci Med Sport* 2009;12:435-9. <http://dx.doi.org/10.1016/j.jsams.2008.09.005>
- Boileau P, Watkinson DJ, Hatzidakis AM, Balg F. Grammont reverse prosthesis: design, rationale, and biomechanics. *J Shoulder Elbow Surg* 2005;14(Suppl S):147S-61S. <http://dx.doi.org/10.1016/j.jse.2004.10.006>
- Castoldi F, Blonna D, Hertel R. External rotation lag sign revisited: accuracy for diagnosis of full thickness supraspinatus tear. *J Shoulder Elbow Surg* 2009;18:529-34. <http://dx.doi.org/10.1016/j.jse.2008.11.007>
- Chalmers PN, Cip J, Trombley R, Cole BJ, Wimmer MA, Romeo AA, et al. Glenohumeral function of the long head of the biceps muscle: an electromyographic analysis. *Orthop J Sports Med* 2014;2. <http://dx.doi.org/10.1177/2325967114523902>
- Chalmers PN, Trombley R, Cip J, Monson B, Forsythe B, Nicholson GP, et al. Postoperative restoration of upper extremity motion and neuromuscular control during the overhand pitch: evaluation of tenodesis and repair for superior labral anterior-posterior tears. *Am J Sports Med* 2014;42:2825-36. <http://dx.doi.org/10.1177/0363546514551924>
- Colachis SC, Strohm BR. Effect of suprascapular and axillary nerve blocks on muscle force in upper extremity. *Arch Phys Med Rehabil* 1971;52:22-9.
- Colvin AC, Egorova N, Harrison AK, Moskowitz A, Flatow EL. National trends in rotator cuff repair. *J Bone Joint Surg Am* 2012;94:227-33. <http://dx.doi.org/10.2106/JBJS.J.00739>
- DiGiovine NM, Jobe FW, Pink M, Perry J. An electromyographic analysis of the upper extremity in pitching. *J Shoulder Elbow Surg* 1992;1:15-25.
- Gerber C, Blumenthal S, Curt A, Werner CM. Effect of selective experimental suprascapular nerve block on abduction and external rotation strength of the shoulder. *J Shoulder Elbow Surg* 2007;16:815-20. <http://dx.doi.org/10.1016/j.jse.2007.02.120>
- Glousman RE, Barron J, Jobe FW, Perry J, Pink M. An electromyographic analysis of the elbow in normal and injured pitchers with medial collateral ligament insufficiency. *Am J Sports Med* 1992;20:311-7.
- Hawkes DH, Alizadehkhayat O, Fisher AC, Kemp GJ, Roebuck MM, Frostick SP. Normal shoulder muscular activation and co-ordination during a shoulder elevation task based on activities of daily living: an electromyographic study. *J Orthop Res* 2011;30:53-60. <http://dx.doi.org/10.1002/jor.21482>
- Hegeudus EJ, Goode A, Campbell S, Morin A, Tamaddoni M, Moorman CT, et al. Physical examination tests of the shoulder: a systematic review with meta-analysis of individual tests. *Br J Sports Med* 2007;42:80-92. <http://dx.doi.org/10.1136/bjism.2007.038406>
- Hertel R, Ballmer F, Lambert S, Gerber C. Lag signs in the diagnosis of rotator cuff rupture I. *J Shoulder Elbow Surg* 1996;5:307-13.
- Illyés Á, Kiss RM. Electromyographic analysis in patients with multidirectional shoulder instability during pull, forward punch, elevation and overhead throw. *Knee Surg Sports Traumatol Arthrosc* 2006;15:624-31. <http://dx.doi.org/10.1007/s00167-006-0163-1>
- Jain NB, Higgins LD, Losina E, Collins J, Blazar PE, Katz JN. Epidemiology of musculoskeletal upper extremity ambulatory surgery in the United States. *BMC Musculoskelet Disord* 2014;15:4. <http://dx.doi.org/10.1186/1471-2474-15-4>
- Jobe FW, Moynes DR. Delineation of diagnostic criteria and a rehabilitation program for rotator cuff injuries. *Am J Sports Med* 1982;10:336-9.
- Kelly SM, Brittle N, Allen GM. The value of physical tests for subacromial impingement syndrome: a study of diagnostic accuracy. *Clin Rehabil* 2010;24:149-58. <http://dx.doi.org/10.1177/0269215509346103>
- Kido T, Itoi E, Lee SB, Neale PG, An KN. Dynamic stabilizing function of the deltoid muscle in shoulders with anterior instability. *Am J Sports Med* 2003;31:399-403.
- Malanga GA, Jenp YN, Growney ES, An KN. EMG analysis of shoulder positioning in testing and strengthening the supraspinatus. *Med Sci Sports Exerc* 1996;28:661-4.
- Michener LA, Doukas WC, Murphy KP, Walsworth MK. Diagnostic accuracy of history and physical examination of superior labrum anterior-posterior lesions. *J Athl Train* 2011;46:343-8.
- Östör AJ, Richards CA, Tytherleigh-Strong G, Bearcroft PW, Prevost AT, Speed CA, et al. Validation of clinical examination versus magnetic resonance imaging and arthroscopy for the detection of rotator cuff lesions. *Clin Rheumatol* 2013;32:1283-91. <http://dx.doi.org/10.1007/s10067-013-2260-0>
- Pandya NK, Colton A, Webner D, Sennett B, Huffman GR. Physical examination and magnetic resonance imaging in the diagnosis of superior labrum anterior-posterior lesions of the shoulder: a sensitivity analysis. *Arthroscopy* 2008;24:311-7. <http://dx.doi.org/10.1016/j.art.2007.09.004>
- Park HB, Yokota A, Gill HS, Rassi El G, McFarland EG. Diagnostic accuracy of clinical tests for the different degrees of subacromial impingement syndrome. *J Bone Joint Surg Am* 2005;87:1446-55. <http://dx.doi.org/10.2106/JBJS.D.02335>
- Reddy AS, Mohr KJ, Pink MM, Jobe FW. Electromyographic analysis of the deltoid and rotator cuff muscles in persons with subacromial impingement. *J Shoulder Elbow Surg* 2000;9:519-23.
- Rojas IL, Provencher MT, Bhatia S, Foucher KC, Bach BR, Romeo AA, et al. Biceps activity during windmill softball pitching: injury implications and comparison with overhand throwing. *Am J Sports Med* 2009;37:558-65. <http://dx.doi.org/10.1177/0363546508328105>
- Ruckstuhl H, Krzycki J, Petrou N, Favre P, Horn T, Schmid S, et al. Shoulder abduction moment arms in three clinically important positions. *J Shoulder Elbow Surg* 2009;18:632-8. <http://dx.doi.org/10.1016/j.jse.2008.10.021>
- Somerville LE, Willits K, Johnson AM, Litchfield R, LeBel M-E, Moro J, et al. Clinical assessment of physical examination maneuvers for rotator cuff lesions. *Am J Sports Med* 2014;42:1911-9. <http://dx.doi.org/10.1177/0363546514538390>
- Walch G, Boulahia A, Calderone S, Robinson AH. The 'dropping' and 'hornblower's' signs in evaluation of rotator-cuff tears. *J Bone Joint Surg Br* 1998;80:624-8.
- Walker PS, Poppen NK. Biomechanics of the shoulder joint during abduction in the plane of the scapula [proceedings]. *Bull Hosp Joint Dis* 1977;38:107-11.