The Influence of Arm and Shoulder Position on the Bear-Hug, Belly-Press, and Lift-Off Tests

An Electromyographic Study

Andrew T. Pennock,[*†] MD, W. Wesley Pennington,[*] MSc, Michael R. Torry,[*‡] PhD, Michael J. Decker,[§] PhD, Suketu B. Vaishnav,[*] MD, CDR Matthew T. Provencher,[||] MD, MC, USN, Peter J. Millett,[¶] MD, MSc, and Thomas R. Hackett,[¶#] MD
Investigation performed at the Biomechanics Research Department, Steadman-Philippon Research Institute, Vail, Colorado

Background: Clinical testing for the integrity of the subscapularis muscle includes the belly-press, lift-off, and bear-hug examinations. While these tests have been widely applied in clinical practice, there is considerable variation in arm positioning within each clinical examination.

Hypothesis: To determine the ideal arm and shoulder positions for isolating the subscapularis muscle while performing the bear-hug, belly-press, and lift-off tests.

Study Design: Controlled laboratory study.

Methods: The activity of 7 muscles was monitored in 20 healthy participants: upper and lower divisions of the subscapularis, supraspinatus, infraspinatus, latissimus dorsi, teres major, triceps, pectoralis major. Electromyogram data were collected and compared across each clinical test at varying arm positions: bear-hug (ideal position, 10° superior, 10° inferior to the shoulder line), belly-press (ideal position, maximum shoulder external rotation, and maximal shoulder internal rotation), and lift-off (ideal position, hand position 5 in. [12.7 cm] superior and 5 in. [12.7 cm] inferior to the midlumbar spine).

Results: Regardless of arm and shoulder position, the upper and lower subscapularis muscle activities were significantly greater than all other muscles while performing each test. No significant differences were observed between the upper and lower subscapularis divisions at any position within and across the 3 tests. There were no significant differences in subscapularis electromyogram activities across the 3 tests.

Conclusion: The level of subscapularis muscle activation was similar among the bear-hug, belly-press, and lift-off tests. The 3 tests activated the subscapularis significantly more than all other muscles tested but were not different from one another when compared across tests and positions. Although the bear-hug and lift-off tests have been described to activate differential portions of the subscapularis, the findings of this study do not support the preferential testing of a specific subscapular division across the 3 tests. As such, all 3 tests are effective in testing the integrity of the entire subscapularis muscle, although there does not appear to be an ideal position for selectively testing its divisions.

Clinical Relevance: Clinicians may feel comfortable in using any of the 3 tests, depending on the patient, to isolate the function of the subscapularis as a single muscle. Furthermore, clinicians should not solely focus on a patient's arm position when administering an examination but also compare the affected arm to the contralateral shoulder when appropriate.

Keywords: bear-hug; belly-press; lift-off; subscapularis; electromyography

Rotator cuff tears are a frequent and debilitating cause of shoulder disability. While the majority of rotator cuff tears involve the supraspinatus and infraspinatus muscles, an increased awareness and recognition of subscapularis tears has led to further investigations into the causes, diagnosis, and treatment of this entity. Acting as the largest and most powerful of the rotator cuff muscles, the subscapularis functions as the primary internal rotator of the humerus and stabilizes the humeral head in the glenoid cavity by resisting anterior, posterior, and inferior displacement.[11,24,28-30] Injury or weakness to the subscapularis may lead to an increased incidence of impingement and/or anterior instability during humeral elevation, abduction, and external rotation.[8,11,12,29,30] As such, it is important for clinicians to

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be able to properly identify, diagnose, and treat injuries of the subscapularis muscle.

The belly-press, lift-off, and bear-hug tests were all developed to identify subscapularis muscle injuries.[2,11,12] Validated by Gerber et al,[11,12] the belly-press and lift-off tests are the most common physical examinations used to clinically detect subscapularis tears. More recent in its conception, the bear-hug test was introduced by Barth et al.[2] While each test has been accepted as a reliable method to isolate the subscapularis muscle, significant variability exists among physicians in terms of how to perform each test. Moreover, patient factors including pain and shoulder stiffness can affect the clinical administration of these tests.

No study to date has examined the optimal arm or shoulder position during the execution of these tests, and it is unclear whether the means by which these tests are conducted may affect the integrity of the tests. Faulty arm position could theoretically yield results that are inconsistent with the true injury. Therefore, the purpose of this study was to utilize electromyography (EMG) to (1) determine the optimal arm and shoulder position for evaluating subscapularis function within the belly-press, lift-off, and bear-hug tests and (2) compare the efficacy of each clinical test in the isolation of the subscapularis muscle. Our hypothesis was that there would be no difference in subscapularis muscle activity when the arm is placed in varying positions for testing.

METHODS

Cohort

Twenty healthy men were recruited for this study. They were 18 to 45 years old (mean age, 28.1 years; mean height, 71.85 in. [183 cm]; weight, 182.5 lbs [82.8 kg]) with no history of surgery or shoulder, neck, or periscapular pain. All participants were provided with written informed consent approved by the Institutional Review Board of the Vail Valley Medical Center in accordance with the guidelines of the National Institutes of Health for human subjects.

Data Collection

For each participant, the EMG activities of 7 relevant muscles in the upper extremity were monitored throughout 3 clinical tests (bear-hug, belly-press, and lift-off), performed at 3 distinct positions.[4,8,11,13,27,31,32] Muscle activity was collected using surface and indwelling bipolar electrodes. With sterile technique, fine wire electrodes (0.07 mm, Teflon coated, nickel chromium alloy; VIASYS Healthcare, Madison, Wisconsin) were placed into the muscle bellies of the supraspinatus, infraspinatus, and subscapularis muscles.[3] Two of these indwelling electrodes were placed into the subscapularis, one each in the upper and lower divisions as previously described.[27] Self-adhering silver–silver chloride surface electrodes (Bagnoli-8, DelSys Corp, Boston, Massachusetts) were used to measure the muscle activity of the pectoralis major, teres major, latissimus dorsi, and the long head of the triceps. Each was placed in line with the muscle fibers, with an interelectrode distance of approximately 10 mm.[3] A fifth surface electrode was placed over the clavicle to serve as a reference electrode.[3,13] Standard anatomic references for the placement of the surface and indwelling electrodes have been described.[9,14,15,22] All electrode placements (Table 1) were confirmed by EMG using a manual muscle test for each muscle. Before testing, participants were asked to perform a series of 3 maximal voluntary contractions (MVCs) for each muscle under observation. Standard MVC procedures and protocols have been reported and are described in Table 1.[7,9,14,19]

The participants were instructed on how to perform each clinical examination: the bear-hug, belly-press, and lift-off tests. An acquisition period was allowed for them to practice each maneuver at the reported ideal position for each test. To standardize EMG activity, clinical examinations were maximally performed at each position for 3 trials, 3 seconds each. For the bear-hug and belly-press tests, a dynamometer (MicroFET[2], Hoggan Health Industries, West Jordan, Utah) was used to quantify and standardize the intensity of the resisted active internal rotation of each trial. For the bear-hug test, the dynamometer was placed under the palm of the hand, superior to the acromioclavicular joint, and for the belly-press test, under the palm of the hand, anterior to the abdomen. Before data collection, all shoulder positions were measured using a goniometer to ensure proper testing conditions and repeatability between participants. The testing order was randomized to prevent any potential order bias for both examination and position conditions.

Bear-Hug Test

The bear-hug test was performed according to the description provided by Barth et al.[2] The reported ideal position

[#]Address correspondence to Thomas R. Hackett, MD, The Steadman Clinic, 181 West Meadow Drive, Suite 1000, Vail, CO 81657 (e-mail: tomhackett@hotmail.com).

*Biomechanics Research Department, Steadman-Philippon Research Institute, Vail, Colorado.

[†]Pediatric Orthopaedic and Scoliosis Center, Rady Children's Hospital, San Diego, California.

[‡]College of Applied Science and Technology, Illinois State University, Normal, Illinois.

[§]AlignMed, LLC, Santa Ana, California.

[||]Naval Medical Center San Diego, Department of Orthopaedic Surgery, San Diego, California.

[¶]The Steadman Clinic, Vail, Colorado.

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TABLE 1
Electrode Placement and Maximal Voluntary Contraction Procedures by Muscle[3,7,8,13,15]

	Maximal Voluntary Contraction	
Electrode Position	Joint Position	Action
Upper subscapularis[a]		
Two finger breadths above the midpoint of the medial border of the scapula in the direction of the humeral head	Arm 45° abducted in the coronal plane, 90° elbow flexion, no shoulder flexion	Internal rotation
Lower subscapularis[a]		
Two finger breadths below the midpoint of the medial border of the scapula in the direction of the humeral head	Arm 45° abducted in the coronal plane, 90° elbow flexion, no shoulder flexion	Internal rotation
Supraspinatus[a]		
Midpoint of supraspinous fossa and 2 finger breadths anterior to the scapular spine	Arm 20° abducted in the coronal plane, 90° elbow flexion, no shoulder flexion	Concurrent external rotation and abduction
Infraspinatus[a]		
Midpoint of the infraspinous fossa and 2 finger breadths below and parallel to the medial portion of the scapular spine	Arm 45° abducted in the coronal plane, 90° elbow flexion, no shoulder flexion	External rotation
Teres major		
One-third of the way between the acromion and inferior angle of the scapula along the lateral border of the scapula	Arm 45° abducted in the coronal plane, 90° elbow flexion	Internal rotation
Triceps		
Dorsal aspect of the olecranon process of the ulna	Arm straight, abducted 30° in the coronal plane, and internally rotated	Extension of elbow
Pectoralis major		
Horizontal placement 4 finger breadths below the clavicle, medial to the anterior axillary border	Elbow flexed 90°, shoulder abducted 75°	Palm press, push medially
Latissimus dorsi		
Three finger breadths distal to and along the posterior axillary fold, parallel to the lateral border of the scapula	Arm straight, abducted 30° in the coronal plane, and internally rotated	Concurrent extension and internal rotation

[a]Tested using indwelling electrodes.

for this maneuver places the palm of the hand under examination on the acromioclavicular joint of the contralateral shoulder (Figure 1B). With the elbow in line with the shoulder and held in a position of maximal anterior translation, participants were instructed to maximally press down at the acromioclavicular joint by internally rotating the shoulder without dropping the elbow or moving the hand as the examiner applied an external rotation force perpendicular to the forearm at the wrist of the respective arm.[2,4] The second and third positions for the bear-hug test were performed in a similar manner; however, the elbow was positioned 10° superior to the shoulder line and 10° inferior to the shoulder line (Figures 1A, 1C). Clinically, a positive result of a bear-hug test occurs when the patient cannot maintain the proper arm or hand position or when the affected arm shows weakness when compared with the contralateral side.[2,4]

Belly-Press Test

The belly-press test was performed according to the description provided by Gerber et al.[11] For the reported ideal position, participants were instructed to position the palm of the hand (of the shoulder being examined) against the abdomen, just below the level of the xyphoid process (Figure 2B). With the elbow in line with the trunk in the sagittal plane, they were then asked to press maximally into the abdomen by internally rotating the shoulder without altering the position of the elbow.[11] For the second and third tested positions, the belly-press was performed with the elbow 10° in front of the midline of the body (maximum internal rotation) and 10° behind the midline of the body (maximum external rotation) (Figures 2A, 2C). Clinically, results of the belly-press test are considered positive if the patient shows a weakness in comparison with the contralateral shoulder or if he or she performs the respective motion by means of elbow or shoulder extension, allowing the elbow to drop posterior to the trunk in the sagittal plane.[2,11]

Lift-Off Test

The lift-off test was performed according to the description provided by Gerber and Krushell.[12] At the reported ideal position, participants were instructed to place the arm of the shoulder being examined behind the back, placing the dorsum of the hand just below the midlumbar spine (L2-L4) with the elbow anterior to the midline of the body (Figure 3B).[12,13] They were then asked to lift and hold the hand off the back maximally by internally rotating the shoulder. While anthropometric factors varied, individuals were instructed to achieve a position of maximum posterior extension with the respective hand within the constraints of the required elbow/arm positioning. The second and third positions of the lift-off test were performed with the dorsum of the hand positioned against the

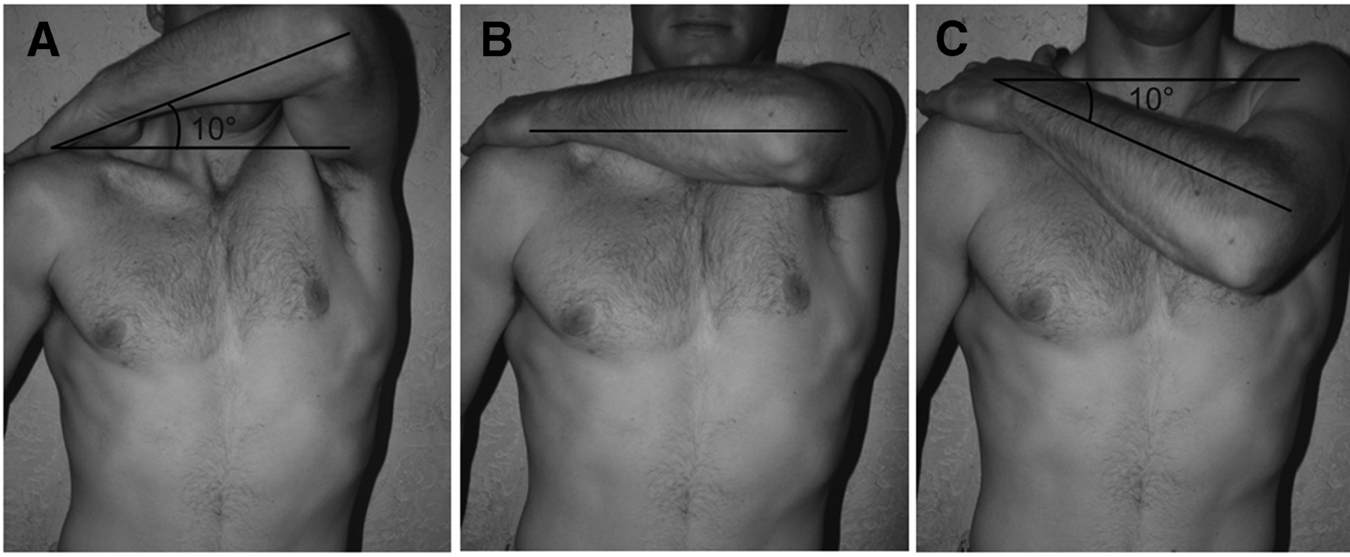

Figure 1. The varying positions of the bear-hug test: A, with the shoulder 10° superior to the shoulder line and held in a position of maximal anterior translation; B, at the reported ideal position, with the elbow in line with the shoulder and held in a position of maximal anterior translation; C, with the shoulder 10° inferior to the shoulder line and held in a position of maximal anterior translation.

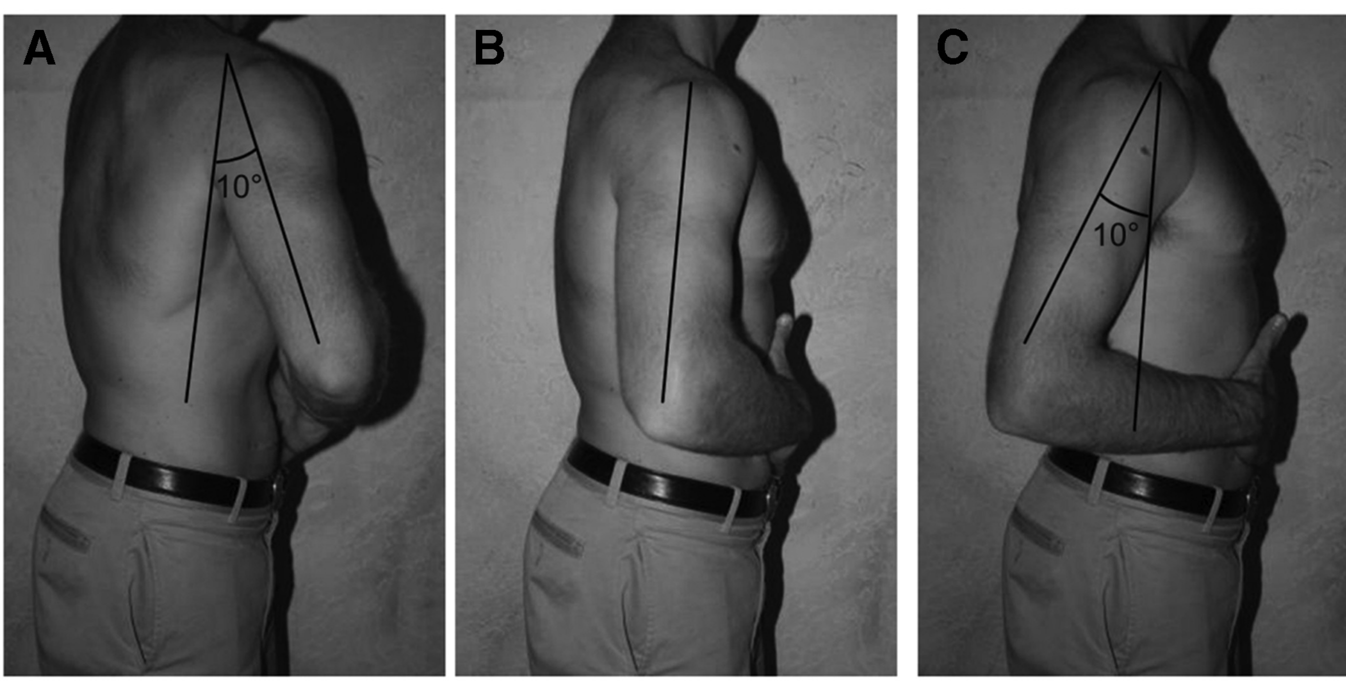

Figure 2. The varying positions of the belly-press test: A, with the arm positioned 10° in front of the midline of the body in the sagittal plane (maximum internal rotation); B, at the reported ideal position, with the elbow in line with the trunk in the sagittal plane; C, with the arm positioned 10° behind in the midline of the body in the sagittal plane (maximum external rotation).

back 5 in. (12.7 cm) superior the midlumbar spine and 5 in. (12.7 cm) inferior to the midlumbar spine (Figure 3A, 3C). Clinically, the lift-off test result is considered positive if a patient is unable to lift the arm posteriorly off the back or if he or she performs the lifting motion by extending the elbow or shoulder.[2,11,12]

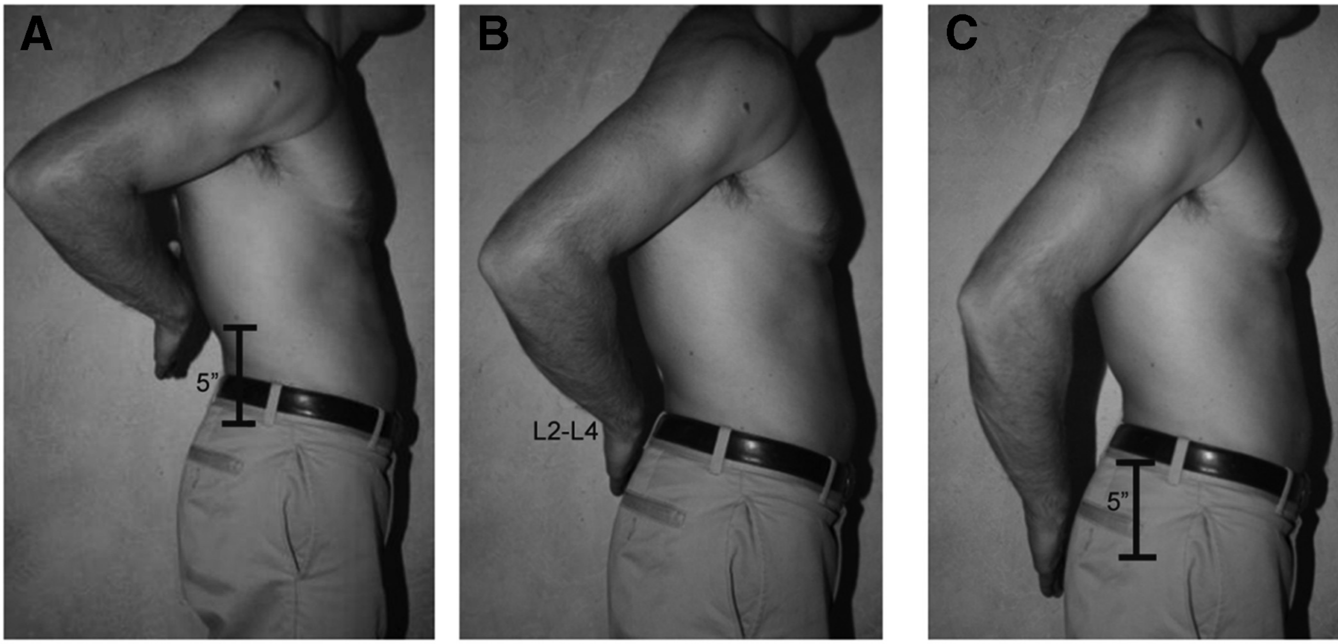

Figure 3. The varying positions of the lift-off test: A, with the dorsum of the hand located 5 in. (12.7 cm) superior to the midlumbar spine and the elbow anterior to the midline of the body in the sagittal plane; B, at the reported ideal position, with the dorsum of the hand just below the midlumbar spine (L2-L4) and the elbow anterior to the midline of the body in the sagittal plane; C, with the dorsum of the hand 5 in. (12.7 cm) inferior to the midlumbar spine and the elbow anterior to the midline of the body in the sagittal plane.

Data Reduction

The EMG data were collected (2400 Hz) with electromyographic hardware (Bagnoli-8, DelSys Corp) and a custom A/D board online with a motion capture system software package (Cortex, Motion Analysis, Santa Rosa, California). All EMG data were processed with custom software that used a 50-millisecond root mean square moving window algorithm.[7,27] Maximal EMG reference values were calculated for each muscle using the average of the 3 EMG signals obtained from their respective maximum voluntary contraction series. Average EMG amplitudes were calculated during the middle 50% of each trial for each examination-position condition and expressed as a percentage of maximum voluntary contraction (%MVC).[15,27]

Power Analysis and Statistics

Recruitment was based on previously reported statistics and pilot data collected in our laboratory.[8,13,15,25,26] With an α level (the probability of a false-positive test) of <.05 and a β level (the probability of a false-negative test) of <.20, the power ($1 - \beta$; ie, the ability to show a difference when one actually exists) was set at the accepted standard of $\pi = .80$.[5,6,20] In reference to our data and previous literature, an acknowledged medium-large effect size ($d = .63$) was calculated and used to represent the relationship of nominal clinical value between clinical examination and position conditions.[5,6,20] Using mean values from our previously published literature, a minimal detectable difference was set at 23 %MVC.[8,26] Based on these criterion, an a priori power analysis was used to identify the number of participants needed to observe a meaningful effect for muscle activation within and between clinical examination–position conditions.[8,26] Eighteen were determined to be adequate in achieving significance between arm/shoulder position conditions, whereas 16 were necessary to detect differences between the upper and lower divisions of the subscapularis.

Group means and standard errors were calculated for muscle activations from the 3 trials for each clinical examination–position condition. To identify any effects that position and clinical examination conditions had on muscle activation, an $8 \times 3 \times 3$ (muscle × exercise × position) mixed-factors repeated measures analysis of variance was used. Significant interaction terms were examined using 3×8 mixed-factors repeated measures analyses of variance to determine the effect of arm/shoulder position within an examination (position × muscle) and muscle activation across examinations (clinical examination × muscle). Significant omnibus F values were scrutinized using the Fisher least significant difference post hoc method with a corrected α level of .05.

RESULTS

Table 2 displays mean and standard error values for average EMG activity (%MVC) for all muscles at each position within a clinical examination. Regardless of arm and shoulder position, the upper and lower subscapularis

TABLE 2
Means (SE) Expressed as a Percentage of Maximal Voluntary Contraction for Average Electromyogram Amplitudes During the Bear-Hug, Belly-Press, and Lift-Off Tests[a]

	Bear-Hug			Belly-Press			Lift-Off		
	Superior	Ideal	Inferior	MaxIR	Ideal	MaxER	Superior	Ideal	Inferior
Up sub[b]	67 (11)	66 (8)	58 (6)	67 (8)	67 (8)	60 (8)	66 (9)	79 (11)	74 (11)
Lw sub[b]	70 (16)	72 (8)	64 (14)	64 (13)	66 (11)	70 (15)	83 (11)	88 (10)	81 (14)
Supra	34 (10)	31 (6)	21 (4)	6 (2)	5 (1)	4 (1)	4 (1)	4 (1)	4 (1)
Infra	4 (1)	4 (1)	4 (1)	2 (1)	2 (.3)	2 (.2)	3 (1)	3 (.3)	3 (.4)
Teres	11 (2)	12 (2)	11 (2)	20 (3)[c]	22 (3)[d]	32 (4)[c,d]	57 (5)[c]	52 (5)[d]	38 (5)[c,d]
Tri	6 (1)	7 (1)	7 (1)	7 (1)[c]	9 (1)[d]	16 (2)[c,d]	43 (5)[c]	29 (3)[c]	23 (4)[c]
Pec	25 (3)[c,d]	38 (6)[c]	42 (7)[d]	21 (3)[c]	26 (3)[c]	23 (3)	9 (1)	9 (1)	10 (1)
Lats	10 (1)[c]	13 (2)[c]	11 (1)	19 (3)[c]	29 (4)[c]	40 (4)[c]	47 (4)[c]	45 (4)[d]	29 (4)[c,d]

[a]Up sub, upper division of the subscapularis; Lw sub, lower division of the subscapularis; Supra, supraspinatus; Infra, infraspinatus; Teres, teres major; Tri, triceps; Pec, pectoralis major; Lats, latissimus dorsi; MaxIR, maximal internal rotation; MaxER, maximum external rotation.
[b]Significantly higher activation across all other muscles for each position of every examination ($P < .05$).
[c]Significantly different activation across positions and within an examination ($P < .05$).
[d]Significantly different activation across positions and within an examination ($P < .05$).

muscle activities were significantly greater than all other muscles while performing the lift-off, belly-press, and bear-hug tests ($P < .05$), although they did not differ from each other (Figures 4-6). Average amplitudes for the upper and lower subscapularis were greater than 58 ± 6, 64 ± 13, and 66 ± 9 %MVC for every position/exercise condition within the bear-hug, belly-press, and lift-off tests, respectively, whereas all other muscles were less than 42 ± 7, 40 ± 4, and 57 ± 5 %MVC for every position/exercise condition, respectively.

While no significant differences in muscle activation were observed between the upper and lower subscapularis muscle divisions at any arm or shoulder position within an examination, EMG activity in the remaining observed muscles varied significantly across positions ($P < .05$) (Table 2). For the bear-hug test, the pectoralis major was significantly more active with the arm at the ideal position and 10° inferior to the shoulder line than when the arm was 10° superior to the shoulder line. Similarly, the latissimus dorsi was significantly more active in the ideal position than when the arm was 10° superior to the shoulder line.

For the belly-press test, the teres major was significantly more active with the arm at maximal external rotation than at maximum internal rotation. The pectoralis major was significantly more active at the ideal position than when the arm was at maximum internal rotation. The triceps and latissimus dorsi were both significantly more active with the arm at maximum external rotation when compared with all other position conditions.

For the lift-off test, the teres major and latissimus dorsi were significantly more active at the elevated (5 in. [12.7 cm] above the midlumbar spine) and reported ideal positions than when the arm was 5 in. (12.7 cm) inferior to the midlumbar spine. The triceps was significantly more active when the arm was 5 in. (12.7 cm) above the midlumbar spine when compared with all other positions. While these differences are notable, the magnitude of these changes did not affect the preferential activation of the upper and lower subscapularis muscle divisions across all muscles at each position ($P < .05$).

Differential activity between the upper and lower subscapularis divisions were not appreciated across the 3 clinical examinations (Table 2). However, the upper subscapularis and lower subscapularis were observed to be significantly more active than all other muscles across all 3 clinical examinations ($P < .05$), indicating that each testing condition was effective in the isolation of the subscapularis muscle (Figure 7).

DISCUSSION

The results of this study demonstrate that the belly-press, lift-off, and bear-hug tests are all effective in isolating the subscapularis muscle from other shoulder muscles and internal rotators. Moreover, the position of the arm and shoulder during the performance of each clinical examination did not affect the efficacy of any test. The upper and lower subscapularis muscle divisions remained preferentially activated despite the controlled changes in arm and shoulder positioning. As such, there does not appear to be an ideal position for testing within the confines of this study. These findings have important clinical implications because they suggest that variations in testing techniques and patient limitations, such as decreased range of motion and pain, will not limit the capacity of these tests in the assessment of subscapularis muscle function.

There is dissonance in the literature regarding which clinical test is best in the assessment of the function and status of the subscapularis.[2,10-15,25-27] Sensitivity and specificity scores for these examinations have been reported to range between 18% to 60% and 92% to 100%, respectively.[2] While the bear-hug test was reported to be the most sensitive clinical examination for the detection of subtle injuries to the subscapularis complex,[2] it was the least specific of these examinations because 4 false-positive tests were

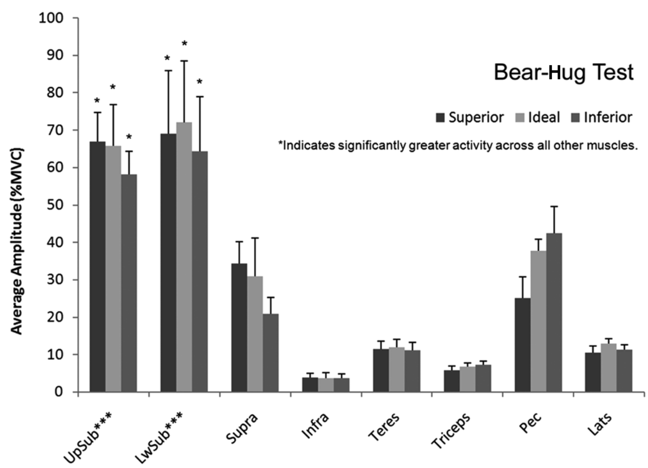

Figure 4. Muscle activity (percentage of maximum voluntary contraction [%MVC]) recorded across varying positions of the bear-hug examination. Each position activated the upper and lower divisions of the subscapularis significantly more than all other muscles tested ($P < .05$). No differences were observed for the upper and lower divisions of the subscapularis when comparing across positions. Similarly, differential muscle activation was not observed between the upper and lower divisions of the subscapularis at any of the 3 positions. Up sub, upper division of the subscapularis; Lw sub, lower division of the subscapularis; Supra, supraspinatus; Infra, infraspinatus; Teres, teres major; Pec, pectoralis major; Lats, latissimus dorsi.

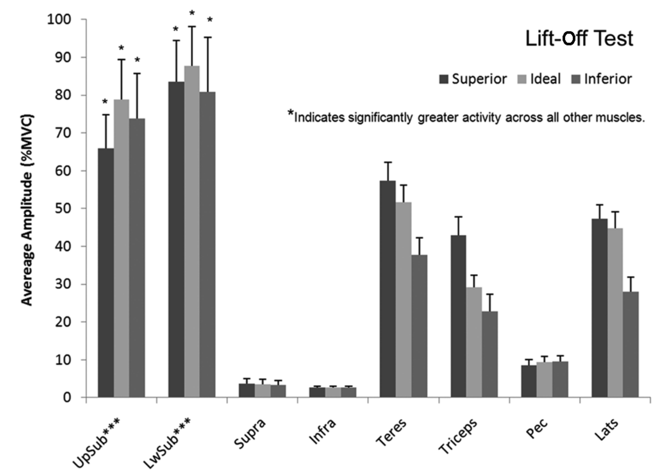

Figure 6. Muscle activity (percentage of maximum voluntary contraction [%MVC]) recorded across varying positions of the lift-off examination. Each position activated the upper and lower divisions of the subscapularis significantly more than all other muscles tested ($P < .05$). No differences were observed for the upper and lower divisions of the subscapularis when comparing across positions. Similarly, differential muscle activation was not observed between the upper and lower divisions of the subscapularis at any of the 3 positions. Up sub, upper division of the subscapularis; Lw sub, lower division of the subscapularis; Supra, supraspinatus; Infra, infraspinatus; Teres, teres major; Pec, pectoralis major; Lats, latissimus dorsi.

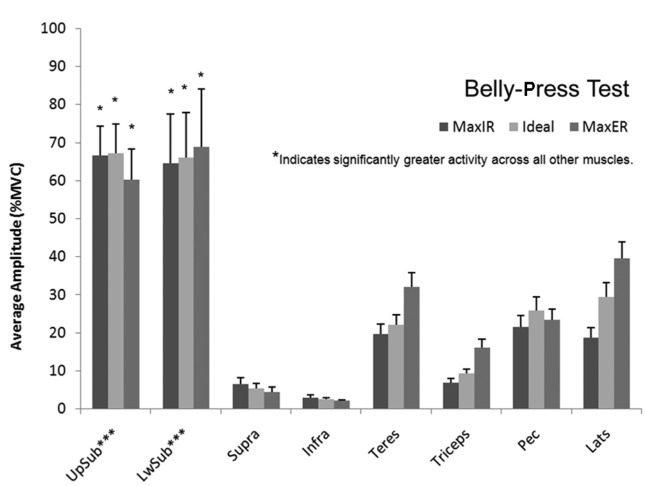

Figure 5. Muscle activity (percentage of maximum voluntary contraction [%MVC]) recorded across varying positions of the belly-press examination. Each position activated the upper and lower divisions of the subscapularis significantly more than all other muscles tested ($P < .05$). No differences were observed for the upper and lower divisions of the subscapularis when comparing across positions. Similarly, differential muscle activation was not observed between the upper and lower divisions of the subscapularis at any of the 3 positions. MaxIR, maximum internal rotation; MaxER, maximum external rotation; Up sub, upper division of the subscapularis; Lw sub, lower division of the subscapularis; Supra, supraspinatus; Infra, infraspinatus; Teres, teres major; Pec, pectoralis major; Lats, latissimus dorsi.

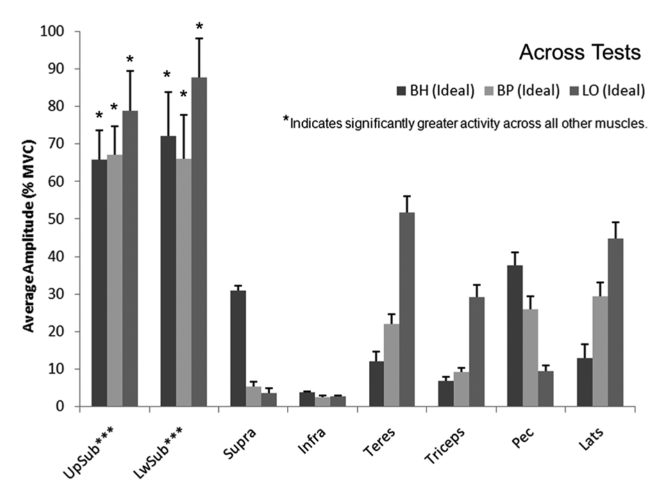

Figure 7. Muscle activity (percentage of maximum voluntary contraction [%MVC]) recorded across the 3 clinical examinations. Each examination activated the upper and lower divisions of the subscapularis significantly more than all other muscles tested ($P < .05$). No differences were observed for the upper and lower divisions of the subscapularis when comparing across clinical examinations. Similarly, differential muscle activation was not observed between the upper and lower divisions of the subscapularis at any of the 3 examinations. BH, bear-hug; BP, belly-press; LO, lift-off; Up sub, upper division of the subscapularis; Lw sub, lower division of the subscapularis; Supra, supraspinatus; Infra, infraspinatus; Teres, teres major; Pec, pectoralis major; Lats, latissimus dorsi.

identified. The false-positive examinations were attributed to underlying supraspinatus tears that were leading to weakness with increased amounts of shoulder flexion.[2] This conclusion was not validated, however, because the supraspinatus muscle was not monitored with EMG.[2] The results of this study support this conclusion as increased activities of the supraspinatus were observed with increasing shoulder flexion. However, the EMG activities of the supraspinatus were still significantly less than the upper or lower subscapularis, indicating that the bear-hug test was still clinically valid in this position. As such, this should be an important consideration when evaluating patients with potential rotator cuff tears involving both the supraspinatus and the subscapularis.

The lift-off test has been reported to be the most specific test for a complete subscapularis tear. However, it may be of limited value in patients who cannot bring the arm into the starting position because of pain or restricted range of motion. Using lower arm positions (dorsum of the hand 5 in. [12.7 cm] inferior to the midlumbar spine), Stefko et al[26] reported that other shoulder internal rotators and extensors—including the pectoralis major, triceps, and latissimus major—were increasingly recruited, which would limit the usefulness of this clinical maneuver. Interestingly, the results of our study did not support this finding, which suggests that patients with limited internal rotation secondary to pain or contracture may still be assessed with the lift-off test as long as they can get the dorsum of the hand to the sacral area.

Described as an alternative to the lift-off test, the belly-press is often used with patients who are unable to perform the lift-off test because of pain and limited range of motion.[11] Traditionally, the test result is considered positive when a patient's elbow falls behind the midline as he or she generates force by extending the shoulder and elbow instead of internally rotating the humerus.[11,27] In this study, this "positive" position was tested and compared with the reported ideal position. The results demonstrated that the subscapularis muscle was still preferentially activated over all other tested shoulder muscles and internal rotators. In this reported "positive" position (elbow positioned behind the midline of the body in maximum external rotation), we found an increased recruitment of the teres major, latissimus dorsi, and triceps muscles. However, the extents of these changes were clinically extraneous to the goal of this examination because they did not affect the preferential activation of the upper and lower subscapularis muscle divisions. This finding suggests that patients could be falsely diagnosed with subscapularis dysfunction if the clinician focuses on the patient's arm position and does not compare the strength of the belly-press to the contralateral shoulder. While this indication of a positive test result has been noted in the literature, most clinicians focus on the traditional descriptions of a positive clinical examination of the shoulder, which involves a patient's arm position.[2,4]

Various alterations in patients' arm positioning are reported to yield positive clinical examinations because they are associated with the motor compensation patterns that recruit muscles other than the subscapularis to achieve the respective motion. Interestingly, the results of this study show that even in varying arm/shoulder positions, the bear-hug, belly-press, and lift-off tests all work to effectively isolate the upper and lower subscapularis muscles, thereby indicating that visual cues such as changes in elbow positioning may be misleading and less specific than previously reported. The results of this study highlight the importance of supplementing clinical examinations with quantitative findings when appropriate. As such, tests that use resisted active motions, such as the bear-hug and belly-press, should always be expanded to include this comparison of strength between the affected shoulder and contralateral side. In doing so, these clinical examinations become more robust; not only do they provide the clinician with more relevant information but also help to prevent false-positive/negative examination results.

Another important finding is that the current study revealed no preferential testing for a specific division of the subscapularis muscle across any of the 3 positions within each clinical examination. While no study has explicitly tested varying positions within these 3 clinical examinations, this finding is refuted in the literature because several studies have reported differential EMG activity between the 2 divisions of the subscapularis muscle as a function of arm and shoulder position.[10,13,15,26,27] Furthermore, contrary to other authors, we found no differential EMG activity observed between the upper and lower divisions of the subscapularis muscle across the 3 tests.[4,13,15,23,27] Accordingly, the idea that the upper subscapularis and lower subscapularis are innervated as 2 distinct muscles remains questionable.[1,16-18,21,27]

Traditionally, the subscapularis has been regarded as a single muscle innervated by 2 nerves: the upper and lower subscapular nerves. However, recent anatomic studies evaluating the innervation of the subscapularis muscle have shown significant variability between specimens, thus suggesting a more complex innervation pattern.[16-18,21] McCann et al[21] showed that 82% of cadavers had 3 independent nerves going to the subscapularis, 16% had 4 independent nerves, and only 2% had the traditional 2-nerve pattern. This variable innervation pattern may help to explain the inconsistent outcomes seen among EMG studies, and it may imply that the commonly employed 2-muscle/2-electrode paradigm in the evaluation of the subscapularis function may be too simplistic.

These findings are important because most lesions of the subscapularis affect the upper division of the subscapularis tendon. While it is clinically difficult to differentiate dysfunction of the upper subscapularis from that of the lower subscapularis, these results imply that such distinctions might be superfluous because it appears that the subscapularis muscle effectively functions as a single unit. As such, clinical diagnostics can be simplified—that is, the bear-hug, belly-press, and lift-off tests can be not only used interchangeably but also compared across one another to formulate a more comprehensive clinical examination.

We recognize some limitations to this study. Particularly, our EMG hardware limited us to analyzing only 8 electrode-muscle pairs per participant. Thus, we chose to examine the rotator cuff muscles as well as secondary internal rotators, including the latissimus dorsi, teres major, and pectoralis major, in addition to the triceps. This decision was based on previous data obtained in our laboratory as well as published data.** Still, it would have been beneficial to add the posterior deltoid because it is known to contribute to shoulder extension.[31,32] Furthermore, while this study was limited to healthy participants, a future study is warranted examining the effects of shoulder and arm positions across these clinical examinations in symptomatic patients. Note, however, that the current study was conducted under more stringent controls than its predecessors—specifically, all arm/shoulder positions within each test were measured to ensure proper testing conditions and repeatability between participants.

From an electromyographic perspective, variations in the arm and shoulder position did not influence the efficacy of the belly-press, lift-off, or bear-hug test. Regardless of clinical examination and arm/shoulder positioning, the upper and lower subscapularis muscle divisions were preferentially activated over all other shoulder muscles and internal rotators tested within the confines of this study. In addition, there were no differences between upper and lower subscapularis muscle activities across the 3 examinations, implying that these tests may not distinctly isolate the upper and lower divisions of the subscapularis as previously reported.[27] In conclusion, the results suggest that there is no ideal testing position for the clinical examination of subscapularis injuries and that various clinical examination techniques may be used by the clinician to adequately assess subscapularis muscle function.

**References 2, 4, 11-13, 15, 23, 26, 27.

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