for your Exercise Buck:
Which Exercises Best Activate the Scapular and Rotator Cuff Muscles

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• Thanks to GLATA for allowing us to exchange information!

• Speakers have no conflicts of interest
  • We do discuss the use of Theraband; however, neither speaker has direct involvement with Hygenic Corporation
Objectives

• Explain the role of the scapular upward rotators and the rotator cuff in proper shoulder mechanics.

• Identify which exercises demonstrate a higher percent maximal voluntary isometric contraction (%MVIC) of the serratus anterior and lower trapezius while concurrently demonstrating a lower %MVIC of the upper trapezius.

• Compare various rotator cuff exercises, and, based upon electromyographical (EMG) findings, identify which exercises preferentially activate the supraspinatus, infraspinatus, teres minor and subscapularis.

• After observation, demonstrate appropriate performance of exercises for the scapular upward rotators and the rotator cuff.
Before we talk scapula......

• We need to talk thoracic spine!

• Thoracic spine mobility is important and critical for mobility of the UQ
  • “thread the needle”
  • Mobilization
  • Foam rolling

No change
Kardouni, Man Ther, 2015
Rosa, J Manipulative Physiol Ther, 2013

Improvement
Go, J Phys Ther Sci, 2016
Haider, J Pak Med Assoc, 2018
Wassinger, Man Ther, 2016
Let’s Start with the Foundation: Scapular Mechanics

- During overhead movement, the rotator cuff and the periscapular musculature must work together to stabilize the glenohumeral joint and scapulothoracic articulation for pain-free movements (especially overhead).

  The rotator cuff musculature provides dynamic compression to seat the humerus vs. the glenoid.
  If not, superior migration will cause subacromial pain.

  The scapula muscles must upwardly rotate the scapula (3D) in order to create space and an optimal position to “seat” the humeral head in the first place.
Scapular Movement

- Upward rotators: Trapezius (UT, MT, LT), serratus anterior (SA)

- An optimal interaction (timing and activity) is needed so that efficient glenohumeral movement can occur

- “Force couple”
Force Couple for Upward Rotation

- UT: scapular upward rotation and elevation
- MT: retracts and externally rotates the scapula
- LT: upward rotation and depression of the scapula; inferomedial-directed fibers may contribute to posterior tilt and external rotation of the scapula
- SA: upward rotation and protraction; also posteriorly tilts and externally rotates the scapula during elevation; stabilizes the medial border of the scapula against the thorax

Castelein, J Hand Ther, 2017
Downward Rotators

- Pectoralis minor (Pm): protraction, anterior tilt, depression, and downward rotation

- Levator scapulae (LS): elevate the scapula and to rotate the scapula downward

- Rhomboid major (Rm): stabilize the medial border of the scapula, retracts the scapula, and works together with the LS to rotate the scapula downward
Upper part of trapezius

Serratus anterior

Lower part of trapezius

Rhomboids

Levator scapulae

Pectoralis minor

Upward rotators of the scapula

Downward rotators of the scapula
Downward Rotators

- Typically not the issue, the issue is LACK of eccentric control of the upward rotators as the arm is lowered.
Scapular Dyskinesis

Abnormality in scapular motion or resting position of the scapula

Subacromial Pain
Subacromial Pain

- Subacromial pain syndrome: “dynamic” vs. “static” anatomical phenomenon
  - Typically no pain at rest, pain with elevation/overhead movements

- Group of symptoms; has been considered to be an umbrella of various shoulder conditions

- Many diagnoses may be associated with subacromial pain
  - Rotator cuff pathology, shoulder instability, scapular dysfunction, biceps pathology, SLAP lesions

Castelein, J Hand Ther, 2017
However......

- A Systematic Review of 22 papers

- Determine whether evidence exists of differences in EMG characteristics between subjects with and without subacromial pain

- For the majority of muscles, regardless of task, load or arm position, significant differences were not demonstrated between the 2 groups

Kinsella, Shoulder & Elbow, 2017
We want minimal activation of the downward rotators

- Excessive activation of the pec minor may impede normal posterior tipping (ie-keep the scapular anteriorly tipped) that is necessary during humeral elevation

- Upward rotation may be inhibited by excessive activation in the levator scapulae and/or rhomboid major

Cricchio, J Hand Ther, 2011
Patients with subacromial pain have....

- Reduced upward rotation, reduced posterior tilting, and increased internal rotation
- Increased EMG of the UT and decreased activity of the LT and SA
Scaption

- The most efficient plane for movement
- Stabilizes the humeral head in the glenoid
- Patients with scapular dysfunction show lower MT, LT and SA EMG activity, even in scaption, vs. healthy subjects

Ludewig, Phys Ther, 2000
30-45°
Based on all of this, what we know:

• Need LT, SA (and UT) to fire in synchrony

• A tight pec minor causes the scapula to be tilted (tipped) anteriorly, and that is bad

• We need minimal (to no) activation of the pec minor, levator scapula or rhomboids to get the scapula upwardly rotated

• Which exercises are best?
Castelein, J Hand Ther, 2017

Scapulohumeral Muscle Dysfunction

- Lack of soft tissue flexibility
  - Pectoralis minor
  - Levator scapulae
  - Upper trapezius
  - Rhomboidei
  - Middle trapezius
  - Lower trapezius
  - Serratus anterior

- Lack of muscle performance (control or strength)

Scapular Rehabilitation Program

Treatment

- Stretching and mobilization
  - Home stretching
  - Trigger point therapy
  - Manual soft tissue techniques
  - Mobilization
  - Manual stretching and mobilization with movement

- Strength training

- Neuromuscular coordination training

- Functional training
  - Strength/endurance training
  - Balance-ratio training
  - Conscious muscle control
The Landmark Study

- 4 exercises was shown to make up the core of a scapular muscle strengthening program.
  - press-up
  - push-up with a plus
  - scapular plane elevation
  - rowing

- N=9 healthy young subjects, but fine wire EMG

Press up                         Push up with a plus             Elevation in scaption                 Rowing

Then along came Ekstrom, Soderberg and Donatelli.

- We are comparing all these exercises to MVIC (good thing!)
- Is the position we are testing in REALLY the best position?
- Went back to various MMT positions to see which REALLY produced high levels of EMG of the SA, UT, MT and LT
- sEMG in n = 30

Ekstrom, Journal Electromyo Kines, 2005
Serratus Anterior MMT

Shoulder flexed to 125° as resistance is applied above the elbow and at the inferior angle of the scapula attempting to de-rotate the scapula with the subject sitting in an erect posture with no back support.

%MVIC: 91 ± 13

Ekstrom, Journal Electromyo Kines, 2005
Serratus Anterior MMT

Shoulder abducted to 125° in the plane of the scapula as resistance is applied above the elbow and at the inferior angle of the scapula attempting to de-rotate the scapula with the subject sitting in an erect posture with no back support.

%MVIC: 89 ± 11

*THM: MVIC is almost identical as flexion; if patient has impingement, abduct the GH a bit!

Ekstrom, Journal Electromyo Kines, 2005
Serratus Anterior MMT

Scapula protracted at 90° of shoulder flexion as resistance is applied over the hand and at the elbow with the subject in the supine position.

%MVIC: 57 ± 20

Ekstrom, Journal Electromyo Kines, 2005
Middle Trap MMT

Shoulder horizontally abducted and externally rotated as resistance is applied above the elbow with the subject in the prone position.

%MVIC: 94 ± 12

Ekstrom, Journal Electromyo Kines, 2005
Middle Trap MMT

Arm raised above the head in line with the lower trapezius muscle fibers as resistance is applied above the elbow with the subject in the prone position.

%MVIC: 87 ± 13
Lower Trap MMT

Arm raised above the head in line with the lower trapezius muscle fibers as resistance is applied above the elbow with the subject in the prone position.

%MVIC: 95 ± 11

Ekstrom, Journal Electromyo Kines, 2005
Lower Trap MMT

Shoulder horizontally abducted and externally rotated as resistance is applied above the elbow with the subject in the prone position.

%MVIC: 80 ± 16

Ekstrom, Journal Electromyo Kines, 2005
Take Home Message:

- Had 2–3 MMT positions that elicited high MVICs
- Consider testing and (you can extrapolate) treating with exercises in >1 position

Ekstrom, Journal Electromyo Kines, 2005
Scapular EMG during 6 exercises

- N= 21 healthy subjects
- Fine wire: LS, PM, RM
- Surface EMG: UT, MT, LT and SA
- 3 exercises:
  - Scaption
  - Towel wall slide
  - Elevation with ER (Tband)
  - All exercises with and without load
Scaption

Castelein, JOSPT, 2016
Towel wall slide

Castelein, JOSPT, 2016
Elevation with ER (Tband)
External Load

• The external load was the same for every exercise

• The amount of load of the dumbbell was determined in a pilot study to find an external load that achieved a moderate load of ±15 repetition maximum for both male and female subjects (2 kg-5 kg)

Castelein, JOSPT, 2016
**FIGURE 4.** Visualization of mean electromyographic activity (percent MVIC) of each scapulothoracic muscle during the different elevation exercises for each load condition. For specific values, see **TABLE 2.** Abbreviations: LS, levator scapulae; LT, lower trapezius; MT, middle trapezius; MVIC, maximum voluntary isometric contraction; PM, pectoralis minor; SA, serratus anterior; RM, rhomboid major; UT, upper trapezius.
<table>
<thead>
<tr>
<th></th>
<th>No Additional Load</th>
<th>Elevation Plus External Rotation</th>
<th>Additional Load</th>
<th>Elevation Plus External Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Scation</td>
<td>Wall Slide</td>
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<tr>
<td>Upper trapezius</td>
<td>15.9 ± 4.0&lt;sup&gt;t&lt;/sup&gt;</td>
<td>13.6 ± 4.7</td>
<td>12.0 ± 4.0</td>
<td>39.5 ± 10.2&lt;sup&gt;t&lt;/sup&gt;</td>
</tr>
<tr>
<td>Middle trapezius</td>
<td>9.1 ± 4.0</td>
<td>7.3 ± 7.6</td>
<td>19.1 ± 12.2</td>
<td>26.6 ± 12.9&lt;sup&gt;t&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lower trapezius</td>
<td>12.0 ± 5.6</td>
<td>7.4 ± 4.5</td>
<td>22.5 ± 7.5&lt;sup&gt;t&lt;/sup&gt;</td>
<td>29.2 ± 10.7&lt;sup&gt;t&lt;/sup&gt;</td>
</tr>
<tr>
<td>Serratus anterior</td>
<td>25.1 ± 12.2</td>
<td>26.8 ± 10.3</td>
<td>22.5 ± 11.4</td>
<td>55.2 ± 16.0</td>
</tr>
<tr>
<td>Levator scapulae</td>
<td>17.7 ± 10.5</td>
<td>13.9 ± 13.6</td>
<td>24.7 ± 17.1</td>
<td>371 ± 17.6&lt;sup&gt;t&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pectoralis minor</td>
<td>13.4 ± 6.7</td>
<td>15.7 ± 9.0&lt;sup&gt;t&lt;/sup&gt;</td>
<td>13.7 ± 9.0</td>
<td>28.3 ± 13.5</td>
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<tr>
<td>Rhomboid major</td>
<td>21.7 ± 12.9&lt;sup&gt;t&lt;/sup&gt;</td>
<td>11.6 ± 6.3</td>
<td>33.9 ± 25.0&lt;sup&gt;t&lt;/sup&gt;</td>
<td>41.1 ± 16.1&lt;sup&gt;t&lt;/sup&gt;</td>
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</table>

*Values are mean ± SD percent maximal voluntary isometric contraction.

<sup>t</sup>Exercises that show significantly higher activity than the other 2 exercises (P<.05).

<sup>t</sup>Exercises that show significantly higher activity than the exercise with the lowest value (P<.05).
Elevation with ER (Tband)
Towel Wall Slide

- All scapular retractors (MT, LT, LS, RM) are activated to a lesser degree than during the other elevation exercises

- Pectoralis minor and SA showed the highest EMG activity, potentially caused by the “pushing” movement that is required to keep the towel against the wall
High SA and LT activity and low UT and PM.

Castelein, J Hand Ther, 2017
High SA and low UT activity.

Castelein, J Hand Ther, 2017
Sidelying forward flexion

Sidelying external rotation

Prone horizontal abduction with external rotation

Prone extension

All have high MT and LT with low UT activity.

Castelein, J Hand Ther, 2017
High SA activity and low PM activity

Castelein, J Hand Ther, 2017
High MT, LT, and RM activity

Castelein, J Hand Ther, 2017
CAUTION
THIS SIGN HAS
SHARP EDGES
DO NOT TOUCH THE EDGES OF THIS SIGN
High SA activation with low PM(Major) activation

- 24 males with winging scapula

- Forward flexion, scaption, and wall push-up plus with and without isometric horizontal abduction using Thera-Band

- sEMG pectoralis major and serratus anterior

- Anytime you protract scapula for SA, you get PM firing. How can we quiet the PM?
Fig. 4. Comparison of the PM/SA EMG activity ratio during the SA activation exercises with and without IHA (PM: pectoralis major, SA: serratus anterior, IHA: isometric horizontal abduction). $p < 0.008$. significant simple effect.
High SA activation with low PM(Major) activation

• + PM EMG activity was significantly lower during forward flexion and wall push-up plus with isometric horizontal abduction

• + SA EMG activity was significantly greater with isometric horizontal abduction

• THM: Use a Thera-band to facilitate SA activity and reduce PM activity during exercises for activating serratus anterior

Park, J Electromyo Kines, 2013
Review Article

- 22 articles

- Exercises aimed to efficiently and maximally recruit rotator cuff and periscapular musculature

- Authors were able to establish a useful series of exercises to promote glenohumeral stability and foster normal scapulohumeral rhythm
<table>
<thead>
<tr>
<th>Exercise</th>
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<tr>
<td>Prone extension</td>
<td>Middle trapezius</td>
<td>Prone shoulder extension with elbow in full extension</td>
</tr>
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<td>Horizontal extension (abduction) with external rotation at 90°</td>
<td>Middle trapezius</td>
<td>Prone horizontal abduction at 90° with full ER.</td>
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<tr>
<td>Overhead arm raise at 125°</td>
<td>Middle and low trapezius</td>
<td>Prone horizontal abduction (extension) at 125° with full ER.</td>
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<tr>
<td>Inferior glide</td>
<td>Low trapezius, serratus anterior</td>
<td>Seated with arm abducted to 90°, wrist neutral position, elbow extended, and fist clenched on a full supportive surface.</td>
</tr>
<tr>
<td>Isometric row</td>
<td>Low trapezius, serratus anterior</td>
<td>Subject stands in front of an immovable surface. The patient places hand on the edge of the surface with the palm facing posteriorly. Apply pressure to the surface; retract and depress the scapula.</td>
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<td>Lawnmower</td>
<td>Low trapezius, serratus anterior</td>
<td>Start with trunk flexed and rotated to the opposite side from the affected arm at the contralateral patella. Rotate trunk toward affected arm, while extending the hip and trunk to vertical. Affected arm then simultaneously retracts the scapula with elbow flexed.</td>
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<td>Push-up plus</td>
<td>Serratus anterior</td>
<td>Subject prone with hands shoulder width apart and chest near the ground; subject then extends elbows to a standard push-up position, then continue to rise up by protracting the scapula.</td>
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<td>Dynamic hug</td>
<td>Serratus anterior</td>
<td>Horizontal flexion of humerus at a constant 60° of humeral elevation while hands follow an imaginary arc until maximum protraction is attained.</td>
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<td>Wall slide</td>
<td>Serratus anterior</td>
<td>Subject stands facing wall with dominant foot at the base of the wall with opposite foot shoulder width and behind dominant foot. Ulnar portion of arms in contact with smooth wall with shoulder and elbow flexed at 90°; subject instructed to slide forearms up and down the wall.</td>
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Let’s wrap this up
These are a good start!

Press up  Push up with a plus  Elevation in scaption  Rowing

Serratus Anterior: think hand

Ekstrom, Journal Electromyo Kines, 2005
Middle Trap and Lower Trap: Getting both at the same time

Ekstrom, Journal Electromyo Kines, 2005
High SA and LT activity and low UT and PM

Castelein, J Hand Ther, 2017
High SA and low UT activity

Castelein, J Hand Ther, 2017
High MT and LT with low UT activity

Sidelying forward flexion

Sidelying external rotation

Prone horizontal abduction with external rotation

Prone extension

Castelein, J Hand Ther, 2017
High MT, LT, and RM activity

Castelein, J Hand Ther, 2017
Use a Theraband to increase SA activity

Park, J Electromyo Kines, 2013
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Thanks!
Let’s talk Rotator Cuff

THE CLOSE CALL

NO BROKEN BONES, BUT YOU’VE SERIOUSLY TORN THE ANTERIOR LIGAMENT OF YOUR ROTATOR CUFF.

SUPERMAN’S LESSER-KNOWN POWER: MRI-VISION.
First……

- EMG is typically expressed as a %MVIC (percentage of the maximal voluntary isometric contraction)
  - Low-level muscle activation: 0–20% MVIC
  - Moderate-level activation: 21–40% MVIC
  - High-level activation: 41–60% MVIC
  - Very high-level activation: > 60% MVIC

- Contaminate the desired muscle’s EMG signal with that of nearby muscles (i.e., cross-talk)
Rotator Cuff Muscles

- Supraspinatus
- Subscapularis
- Infraspinatus
- Teres minor
- Biceps tendon
Anatomy

The rotator cuff muscles

Back view

Front view

supraspinatus
teres minor
infraspinatus
subscapularis

Acromion
Supraspinatus
Infraspinatus
Subscapularis
Teres minor
Humerus
Biceps tendon (long head)
Rotator Cuff Muscles: \textit{Supraspinatus}

- **Medial Attachment:** Supraspinous fossa of scapula
- **Lateral Attachment:** Greater tubercle of humerus
- **Innervation:** Suprascapular nerve
- **Action:** Initially abducts the arm, stabilizes humeral head

https://rad.washington.edu/muscle-atlas/supraspinatus/
Rotator Cuff Muscles: **Infraspinatus**

- **Medial Attachment**: Infraspinous fossa of scapula
- **Lateral Attachment**: Greater tubercle of humerus
- **Innervation**: Suprascapular nerve
- **Action**: Laterally rotates arm; stabilizes humeral head

https://rad.washington.edu/muscle-atlas/supraspinatus/
Rotator Cuff Muscles: *Subscapularis*

- **Medial Attachment:** Subscapular fossa of scapula
- **Lateral Attachment:** Lesser tuberosity of humerus
- **Innervation:** Subscapular nerve
- **Action:** Medially rotates arm and addducts; stabilizes humeral head

https://rad.washington.edu/muscle-atlas/supraspinatus/
Rotator Cuff Muscles: **Teres Minor**

- **Proximal Attachment**: Inferior facet on greater tuberosity of humerus
- **Distal Attachment**: Superior part of lateral border of scapula
- **Innervation**: Axillary nerve
- **Action**: Laterally rotates arm, stabilizes humeral head

https://rad.washington.edu/muscle-atlas/supraspinatus/
Rotator Cuff MMTs

**Supraspinatus:** Abduction against resistance
**Infraspinatus:** Lateral rotation against resistance
**Subscapularis:** Medial rotation against resistance
**Teres Minor:** Lateral rotation against resistance
Clinical Pearl

- Compared to other body regions which often rely on ligamentous and passive support from bony structures, scapular stability is achieved actively by supporting musculature.
- This includes the upper, middle and lower trapezius and the serratus anterior (UT, MT, LT and SERR, respectively).
- AND, the rotator cuff which is critical in maintaining glenohumeral stability by compressing the humeral head congruently against the scapular glenoid.

These two muscle groups (rotator cuff and periscapular muscles) work concurrently to create a functional kinetic chain.

- Rotator Cuff Muscles account for 66-85% of all shoulder cases evaluated.
Rotator Cuff Importance

Rotator cuff muscle provide dynamic compressive forces to keep the humeral head seated in the concave glenoid fossa.

- Supraspinatus
- Infraspinatus
- Subscapularis
- Teres Minor

Cricchio et al, J Hand Ther, 2011
Which Exercises?
Reminder

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Escamilla, JOSPT, 2010
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- Supraspinatus
- Infraspinatus
- Subscapularis
- Teres Minor
Rotator Cuff Muscles

There are a variety of studies highlighting the Muscle-within-a-Muscle Theory throughout exercises and varying levels of MVIC associated with the breakdown of those muscles-within-a-muscle:

• Supraspinatus Anterior and Posterior
• Infraspinatus Superior and Middle
• Subscapularis Upper and Lower

“Muscle with-in a muscle Theory”
Which suggests that different segments of the same muscle may have different functions.

Alenabi et al, J Electromyogr Kinesiol, 2018
Rotator Cuff Muscles: *Supraspinatus*

- 4 pairs of fine wire EMG electrodes
- 31 healthy participants
- 18 isometric resistance exercises against a force cube in flexion, scaption and abduction at 30, 90 and 150 degrees

*Supraspinatus “Anterior” was significantly more active during abduction and scaption and in higher elevation angles.*

Alenabi et al, J Electromyogr Kinesiol, 2018
Rotator Cuff Muscles: *Supraspinatus*

- 15 MVIC, randomized order, held for 5s with 1-2min rest in between
- 9 testing postures were examined at 3 elevations
- Participants completed 1 maximum voluntary force (MVF) and 1 submaximal force (50% MVF) at each posture

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion (90°)</td>
<td>Seated, arm flexion in 90° is resisted</td>
</tr>
<tr>
<td>Abduction (90°)</td>
<td>Seated, arm abduction in 90°'s resisted</td>
</tr>
<tr>
<td>Prone Ext (90°)</td>
<td>Prone lying, arm abducted 90°, externally rotated, palm up, and arm elevation is resisted</td>
</tr>
<tr>
<td>Fullan (60°)</td>
<td>Seated, arm elevated 60° in scapular plane, thumb is up; resistance is applied downward on the arm</td>
</tr>
<tr>
<td>Fullan (90°)</td>
<td>Seated, arm elevated 90° in scapular plane, thumb up; resistance is applied downward on the arm</td>
</tr>
<tr>
<td>Emptycar (60°)</td>
<td>Seated, arm elevated 60° in scapular plane, thumb down; resistance is applied downward on the arm</td>
</tr>
<tr>
<td>Emptycar (90°)</td>
<td>Seated, arm elevated 90° in scapular plane, thumb down; resistance is applied downward on the arm</td>
</tr>
<tr>
<td>Sit ER (0°)</td>
<td>Seated, arm in 90° abduction, elbow flexed 90°, external rotation is resisted</td>
</tr>
<tr>
<td>Sit ER (45°)</td>
<td>Seated, arm in 90° abduction, elbow flexed 90°, external rotation is resisted</td>
</tr>
<tr>
<td>Sit ER (90°)</td>
<td>Seated, arm in 90° abduction, elbow flexed 90°, external rotation is resisted</td>
</tr>
<tr>
<td>Prone ER (90°)</td>
<td>Prone lying, arm abducted 90°, palm facing the floor; external rotation is resisted</td>
</tr>
<tr>
<td>Side ER (0°)</td>
<td>Left side lying, arm close to the body, elbow flexed 90°, external rotation is resisted</td>
</tr>
<tr>
<td>Side Abduction (10°)</td>
<td>Left side lying, arm abducted 10°, resistance applied downward on the right arm</td>
</tr>
<tr>
<td>Side Abduction (45°)</td>
<td>Left side lying, arm abducted 45°, resistance applied downward on the right arm</td>
</tr>
</tbody>
</table>

ER = external rotation, Ext = extension.
* - reported by Alenabi et al. (2018).
Rotator Cuff Muscles: Supraspinatus

![Diagram of rotator cuff muscle actions](image)

Fig. 1. Experiment design with robotic arm. The participants exerted force perpendicular to the midpoint of the force transducer.

Alenabi et al, J Electromyogr Kinesiol, 2018
Rotator Cuff Muscles: \textit{Supraspinatus}

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Angle 30°</th>
<th>Angle 90°</th>
<th>Angle 150°</th>
<th>Plane Abduction</th>
<th>Plane Flexion</th>
<th>Plane Scaption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supraspinatus Anterior</td>
<td>28 (1.8)</td>
<td>41.9 (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supraspinatus Posterior</td>
<td>38.4 (2.6)</td>
<td>42.6 (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infraspinatus Superior</td>
<td>22.5 (2.1)</td>
<td>27.9 (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infraspinatus Middle</td>
<td>26.6 (2.9)</td>
<td>28.7 (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textit{T. Alenabi et al.}

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Angle 30°</th>
<th>Angle 90°</th>
<th>Angle 150°</th>
<th>Plane Abduction</th>
<th>Plane Flexion</th>
<th>Plane Scaption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supraspinatus Anterior</td>
<td>47.4 (2.9)</td>
<td>66.7 (3.3)</td>
<td>65.4 (3.9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supraspinatus Posterior</td>
<td>63 (4.7)</td>
<td>65.8 (4.1)</td>
<td>60.3 (3.9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infraspinatus Superior</td>
<td>44.1 (4)</td>
<td>52.2 (3.3)</td>
<td>47.4 (4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infraspinatus Middle</td>
<td>41.2 (3.7)</td>
<td>51.4 (4.5)</td>
<td>54.9 (4.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textit{“High” Category}

\textit{“Very High” Category}

Alenabi et al, J Electromyogr Kinesiol, 2018
Rotator Cuff Muscles: *Supraspinatus*

- **Take Home:**
  - Anterior region of the Supraspinatus accounts for over 75% of the supraspinatus muscle
  - More relative activation at 90% elevation
  - Abduction and scaption could generate more activation than flexion

*Maximally resisted abduction or scaption at 90 degrees (Full Can Posture) can better elicit more supraspinatus anterior activation.*

Alenabi et al, J Electromyogr Kinesiol, 2018
Rotator Cuff Importance

Rotator cuff muscle provide dynamic compressive forces to keep the humeral head seated in the concave glenoid fossa.

- Supraspinatus
- Infraspinatus
- Subscapularis
- Teres Minor

Cricchio et al, J Hand Ther, 2011
Rotator Cuff Muscles: *Supraspinatus* and *Infraspinatus*

- Intramuscular EMG for supraspinatus (anterior and posterior) and infraspinatus (superior and middle)
- 27 right handed healthy volunteers
- 4 elastic band exercises (Y, T, W and L)

*Joseph et al, Am J of Phy Med & Rehab, 2018*
Rotator Cuff Muscles: *Supraspinatus* and *Infraspinatus*

- Mean activations of all rotator cuff partitions (supraspinatus anterior and posterior AND infraspinatus superior and middle) were all over 40% MVIC.
- *EXCEPT:* Infraspinatus Middle during T-exercise.

Joseph et al, Am J of Phy Med & Rehab, 2018
Rotator Cuff Muscles: *Supraspinatus* and *Infraspinatus*

Joseph et al, Am J of Phy Med & Rehab, 2018
Rotator Cuff Muscles: 

Supraspinatus and Infraspinatus

“High” Category
Rotator Cuff Muscles: *Supraspinatus* and *Infraspinatus*

**Take Home:**
- All four exercises highly activated both partitions within supraspinatus muscles and the superior partition of infraspinatus.
- The middle partition of infraspinatus showed high activation in Y and L exercises.

YTWL banded exercises induce high activation in supraspinatus and infraspinatus partitions. YTWL exercises are appropriate for strengthening of some rotator cuff for late stages of shoulder rehabilitation.

Joseph et al, Am J of Phy Med & Rehab, 2018
Rotator Cuff Importance

Rotator cuff muscle provide dynamic compressive forces to keep the humeral head seated in the concave glenoid fossa.

- Supraspinatus
- Infraspinatus
- Subscapularis
- Teres Minor
Rotator Cuff Muscles: *Infraspinatus*

- 4 pairs of fine wire EMG electrodes
- 31 healthy participants
- 18 isometric resistance exercises against a force cube in flexion, scaption and abduction at 30, 90 and 150 degrees

*Infraspinatus Middle activation was higher at 90 degrees during flexion.*

Alenabi et al, J Electromyogr Kinesiol, 2018
Rotator Cuff Muscles: *Infraspinatus*

### Table 3
Mean rotator cuff muscle activation (%MVE) at 50% MVF collapsed across planes and angles. A significant difference between means is shaded in grey and further noted by a letter. The bolded values indicate the means that are significantly higher, the letter “a” indicates a significantly larger mean than that at 30° of elevation. The letter “b” indicates a significantly larger mean than that in the abduction plane.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>30°</th>
<th>90°</th>
<th>150°</th>
<th>Abduction</th>
<th>Flexion</th>
<th>Scaption</th>
</tr>
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<td>38.9 (2.2)</td>
<td>35.5 (2.3)</td>
<td>40.7 (2.4)</td>
</tr>
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<td>42.1</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infraspinatus Superior</td>
<td>22.5 (2.1)</td>
<td>27.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infraspinatus Middle</td>
<td>26.6 (2.9)</td>
<td>28.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4
Mean rotator cuff muscle activation (%MVE) at 100% MVF collapsed across planes and angles. A significant difference between means is shaded in grey and further noted by a letter. The bolded values indicate the means that are significantly higher, the letter “a” indicates a significantly larger mean than that at 30° of elevation. The letter “b” indicates a significantly larger mean than that in the abduction plane.

<table>
<thead>
<tr>
<th>Muscle</th>
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<th>90°</th>
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</tr>
<tr>
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</tr>
<tr>
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<td>43.9 (3.6)</td>
<td>52.6 (3.8)</td>
<td>50.9 (3.8)</td>
</tr>
<tr>
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<td>54.9 (4.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

“Moderate” Category

“High” Category

Alenabi et al, J Electromyogr Kinesiol, 2018
Rotator Cuff Muscles: *Infraspinatus*

- **Take Home:**
  - More relative activation at 90% flexion
  - Consider shoulder flexion at 90 degrees another exercise to use to strengthen the Infraspinatus Middle.
  - More research to look specifically at infraspinatus tendon during flexion.

*Infraspinatus Middle muscle assists in shoulder flexion (although primarily an ext rotator) due to its tendon overlapping the Supaspinatus anatomically.*

Alenabi et al, *J Electromyogr Kinesiol*, 2018
Rotator Cuff Muscles: *Infraspinatus*

- Describe a testing method for the infraspinatus while decreasing signal of the posterior deltoid
- 34 right handed healthy volunteers
- Surface electrodes

- EMG was recorded during resisted ER in 4 different testing positions
  - Seated active adduction
  - Seated passive adduction
  - Side-lying active adduction
  - Side-lying passive adduction

Rotator Cuff Muscles: *Infraspinatus*

Forbush et al, Int J Sports Phys Ther, 2018
Rotator Cuff Muscles: *Infraspinatus*

- **Take Home:**

  Increased activation of the Infraspinatus (with quieting of the posterior deltoid concurrently) was achieved with 0 degrees of adduction with resisted external rotation in BOTH side-lying and seated testing positions.

**Forbush et al, Int J Sports Phys Ther, 2018**
Rotator Cuff Importance

Rotator cuff muscle provide dynamic compressive forces to keep the humeral head seated in the concave glenoid fossa.

- Supraspinatus
- Infraspinatus
- Subscapularis
- Teres Minor

Cricchio et al, J Hand Ther, 2011
Rotator Cuff Muscles: *Supraspinatus*, and *Infraspinatus*

- Out of 13 active-assisted exercises, 9 were identified as suitable to load the *supraspinatus* and 10 as suitable to load the *infraspinatus* early after surgery.

- All exercises were placed in a theoretical-continuum model

- Recommendations could be made for prescription in patient’s post rotator cuff repair in early stages of rehab.

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Edwards et al, J Ortho S Phys Ther, 2017
Rotator Cuff Muscles: Supraspinatus

“Low-Moderate” Category

“High” Category

“Very High” Category

Edwards et al, J Ortho S Phys Ther, 2017
Rotator Cuff Muscles: *Supraspinatus*

Rotator Cuff Muscles: *Supraspinatus*

Rotator Cuff Muscles: *Supraspinatus*

Push Up Plus/Forward Punch

Rotator Cuff Muscles: *Supraspinatus*

Prone horizontal abduction at approximately 100°

Reinhold et al, J Orthop Sports Phys Ther, 2004
Rotator Cuff Muscles: Infraspinatus

“Low-Moderate” Category

“High” Category

“Very High” Category

Edwards et al, J Ortho S Phys Ther, 2017
Rotator Cuff Muscles: *Infraspinatus*

Rotator Cuff Importance

Rotator cuff muscle provide dynamic compressive forces to keep the humeral head seated in the concave glenoid fossa.

- Supraspinatus
- Infraspinatus
- Subscapularis
- Teres Minor
Rotator Cuff Muscles: *Subscapularis* and *Teres Minor*

- All exercises were placed in a theoretical-continuum model
- Majority of studies were looking specifically at the supra/infraspinatus. Few looked at the subscap or teres minor
- The following are the studies that included subscap and teres minor

Edwards et al, J Ortho S Phys Ther, 2017
Rotator Cuff Muscles: Subscapularis

“Low-Moderate” Category

“High” Category

“Very High” Category

**FIGURE 5.** Subscapularis pooled means (range) of percent MVIC ranking of exercise. Abbreviations: ABD, abduction; MVIC, maximal voluntary isometric contraction.

Edwards et al, J Ortho S Phys Ther, 2017
FIGURE 4. Teres minor pooled means (range) of percent MVIC ranking of exercises. Abbreviations: ABD, abduction; ER, external rotation; MVIC, maximal voluntary isometric contraction.

Edwards et al, J Ortho S Phys Ther, 2017
Rotator Cuff Muscles:

**Take Home:**

- This review highlights the large variety of studies that have investigated strengthening exercises in the shoulder.

- Many of the studies included in this review evaluated primarily the supraspinatus and infraspinatus, and very few evaluated the subscapularis and the teres minor muscles.

- Therefore, caution must be taken when applying the guidelines in this review to patients presenting with repairs of the subscapularis and teres minor.

Edwards et al, J Ortho S Phys Ther, 2017
Rotator Cuff Importance

Rotator cuff muscle provide dynamic compressive forces to keep the humeral head seated in the concave glenoid fossa.

- Supraspinatus
- Infraspinatus
- Subscapularis
- Teres Minor
Rotator Cuff Muscles: *Subscapularis* and *Teres Minor*

- Surface and fine-wire EMG
- 15 physically active healthy males
- Performed 12 rubber-tubing exercises in random order

Myers et al, J Athl Train, 2005
Rotator Cuff Muscles: Subscapularis and Teres Minor

- Shoulder EXT, shoulder FLEX
- Scapular Punch
- Throwing acceleration, throwing deceleration
- External rotation at 90° of abduction, scapular punches
- High or low scapular rows

Myers et al, J Athl Train, 2005
Rotator Cuff Muscles: *Subscapularis* and *Teres Minor*

Myers et al, J Athl Train, 2005
Rotator Cuff Muscles: *Subscapularis* and *Teres Minor*

Myers et al, J Athl Train, 2005
Rotator Cuff Muscles: **Teres Minor**

"Very High" Category

Myers et al, J Athl Train, 2005
Rotator Cuff Muscles: *Subscapularis* and *Teres Minor*

Myers et al, J Athl Train, 2005
Rotator Cuff Muscles: *Subscapularis* and *Teres Minor*

Myers et al, *J Athl Train*, 2005
Rotator Cuff Muscles: *Subscapularis* and *Teres Minor*

Myers et al, J Athl Train, 2005
Rotator Cuff Muscles: *Subscapularis* and *Teres Minor*

- Take Home:
  - These 7 exercises (for timing purposes only showed 5 or 7) could be used for a warm up throwing or overhead athlete.

*More research needs to be completed but preliminary results suggest that these exercises are very effective in activating rotator cuff muscles.*

Myers et al, J Athl Train, 2005
Rotator Cuff Importance

Rotator cuff muscle provide dynamic compressive forces to keep the humeral head seated in the concave glenoid fossa.

- Supraspinatus
- Infraspinatus
- Subscapularis
- Teres Minor
Rotator Cuff Muscles: \textit{Subscapularis}

- IM fine-wire EMG
- 20 healthy participants
- Subscapularis Muscle
  - Upper Subscapularis
  - Lower Subscapularis

The upper and lower segments of subscapularis muscle have different roles in glenohumeral joint functioning

Sangeeta Rath\textsuperscript{a}, C, \textsuperscript{a, b}, Nicholas F. Taylor \textsuperscript{b}, Rodney A. Green \textsuperscript{a}

Rathi et al, J Biomechanics, 2017
Rotator Cuff Muscles: *Subscapularis*

Fig. 1. Testing positions; (A) shoulder in neutral position with examiner applying anterior directed force at the humerus; (B) shoulder in 90° abducted position with examiner applying posterior directed force at the humerus.

Rathi et al, J Biomechanics, 2017
Rotator Cuff Muscles: *Subscapularis*

“Very High” Category

“High” Category

Table 1. EMG amplitude (mean ± standard deviation) (%MVIC, maximal of three trials) for each muscle segment in each of three MVIC testing positions (n = 20).

<table>
<thead>
<tr>
<th>Muscles</th>
<th>Internal rotation*</th>
<th>External rotation*</th>
<th>Abduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper subscapularis</td>
<td>89.2 ± 20.8</td>
<td>25.3 ± 23.2</td>
<td>61.8 ± 36.0</td>
</tr>
<tr>
<td>Lower subscapularis</td>
<td>68.4 ± 31.2</td>
<td>54.9 ± 31.7</td>
<td>75.5 ± 28.9</td>
</tr>
</tbody>
</table>

%MVIC, percentage maximum voluntary isometric contraction.

Rathi et al, J Biomechanics, 2017
Rotator Cuff Muscles: *Subscapularis*

**Take Home:**

- High MVIC for USUB in IR contractions and its lack of response to ANT/POST---reinforces the notion that this muscle may have a greater role as an *agonist for internal rotation rather than as a stabilizer.*

- Higher MVIC of LSUB during all ER conditions can only be attributed to its *stabilizer role* potentially against posterior deltoid in the abducted position.

*To restore normal function, should add ER and ABD exercises to focus on LSUB and IR strengthening exercises for USUB.*

Rathi et al, J Biomechanics, 2017
Rotator Cuff Importance

Rotator cuff muscle provide dynamic compressive forces to keep the humeral head seated in the concave glenoid fossa.

- Supraspinatus
- Infraspinatus
- Subscapularis
- Teres Minor

Cricchio et al, J Hand Ther, 2011
Rotator Cuff Muscles: *Infraspinatus*, *Supraspinatus* and *Teres Minor*

- IM fine-wire EMG
- 10 physically active healthy males

Electromyographic Analysis of the Rotator Cuff and Deltoid Musculature During Common Shoulder External Rotation Exercises

- AUTHORS
  Michael M. Reinold, DPT, ATC\(^1\), Kevin E. Wilk, PT\(^2\), Glenn S. Fleisig, PhD\(^3\), Nigel Zheng, PhD\(^4\), Steven W. Barrentine, MS\(^5\), Terri Chmielewski, PT, PhD\(^6\), Rayden C. Cody, MD\(^7\), Gene G. Jameson, MA\(^5\), James R. Andrews, MD\(^8\)

- ACKNOWLEDGEMENTS

Reinhold et al, J Ortho and Sport Phys Ther, 2004
Rotator Cuff Muscles: **Infraspinatus, Supraspinatus** and **Teres Minor**

- 7 Shoulder Exercises:
  - Prone horizontal abduction at 100° of abduction and full external rotation (ER)
  - Prone ER at 90° of abduction
  - Standing ER at 90° of abduction
  - Standing ER in the scapular plane (45° abduction, 30° horizontal adduction)
  - Standing ER at 0° of abduction
  - Standing ER at 0° of abduction with a towel roll
  - Sidelying ER at 0° of abduction

*Electromyographic Analysis of the Rotator Cuff and Deltoid Musculature During Common Shoulder External Rotation Exercises*

- Authors
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  - Rayden C. Cody, MD
  - Gene G. Jameson, MA
  - James R. Andrews, MD

*Reinhold et al, J Ortho and Sport Phys Ther, 2004*
Rotator Cuff Muscles: **Supraspinatus**

**TABLE 3.** Mean (±SD) electromyographic (EMG) activation of the supraspinatus expressed as a percentage of maximum voluntary isometric contraction (MVIC) for 7 shoulder exercises. Intraclass correlation coefficients (ICC_{3,1}) are also provided.

<table>
<thead>
<tr>
<th>Exercise*</th>
<th>% MVIC</th>
<th>ICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Prone horizontal abduction at 100° with full external rotation</td>
<td>82 ± 37</td>
<td>0.97</td>
</tr>
<tr>
<td>2. Prone external rotation at 90° of abduction</td>
<td>68 ± 33</td>
<td>0.97</td>
</tr>
<tr>
<td>3. Standing external rotation at 90° of abduction</td>
<td>57 ± 32</td>
<td>0.94</td>
</tr>
<tr>
<td>4. Standing external rotation at 0° of abduction</td>
<td>51 ± 47</td>
<td>0.87</td>
</tr>
<tr>
<td>5. Standing external rotation at 0° of abduction with a towel roll</td>
<td>41 ± 37</td>
<td>0.71</td>
</tr>
<tr>
<td>6. Standing external rotation at 0° of abduction without a towel roll</td>
<td>41 ± 38</td>
<td>0.94</td>
</tr>
<tr>
<td>7. Standing external rotation in the scapular plane (45° abduction, 30° horizontal adduction)</td>
<td>32 ± 24</td>
<td>0.93</td>
</tr>
</tbody>
</table>

* The 1-way repeated-measures ANOVA indicated a significant main effect across exercises (F = 8.802, P < .001).

Reinhold et al, J Ortho and Sport Phys Ther, 2004

“Very High” Category
Rotator Cuff Muscles: *Infraspinatus*

“Very High” Category

“High” Category

Reinhold et al, J Ortho and Sport Phys Ther, 2004
Rotator Cuff Muscles: *Teres Minor*

**TABLE 2.** Mean (±SD) electromyographic (EMG) activation of the teres minor expressed as a percentage of maximum voluntary isometric contraction (MVIC) for 7 shoulder exercises. Intraclass correlation coefficients (ICC$_{3,1}$) are also provided.

<table>
<thead>
<tr>
<th>Exercise*</th>
<th>% MVIC</th>
<th>ICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sidelying external rotation at 0° of abduction</td>
<td>67 ± 34$^1$</td>
<td>0.87</td>
</tr>
<tr>
<td>2. Standing external rotation in the scapular plane (45° abduction, 30° horizontal adduction)</td>
<td>55 ± 30</td>
<td>0.79</td>
</tr>
<tr>
<td>3. Prone external rotation at 90° of abduction</td>
<td>48 ± 27</td>
<td>0.97</td>
</tr>
<tr>
<td>4. Standing external rotation at 0° of abduction with a towel roll</td>
<td>46 ± 21</td>
<td>0.90</td>
</tr>
<tr>
<td>5. Prone horizontal abduction at 100° with full external rotation</td>
<td>44 ± 25</td>
<td>0.97</td>
</tr>
<tr>
<td>6. Standing external rotation at 90° of abduction</td>
<td>39 ± 13</td>
<td>0.97</td>
</tr>
<tr>
<td>7. Standing external rotation at 0° of abduction without a towel roll</td>
<td>34 ± 13</td>
<td>0.90</td>
</tr>
</tbody>
</table>

* The 1-way repeated-measures ANOVA indicated a significant main effect across exercises ($F = 3.726, P = .004$).

$^1$ Exercise 1 is significantly different than exercise 6 ($P = .014$) and exercise 7 ($P = .003$).

**FIGURE 7.** Sidelying external rotation.

“Very High” Category

Reinhold et al, J Ortho and Sport Phys Ther, 2004
Rotator Cuff Muscles: *Infraspinatus*, *Supraspinatus* and *Teres Minor*

- **Take Home:**
  - The highlighted exercises not only have the highest MVIC for the rotator cuff they are also exercises that recruit each specific muscle while quieting the deltoid muscle
    - The ensures less chance for subacromial impingement
  - There could also be suggestion that if an exercise recruits deltoid muscle while also recruiting rotator cuff muscles it could be due to the assistive compressive force on the humerus
    - Considerations when selecting external rotation exercises may be made based on the amount of infraspinatus and teres minor activity as well as the amount of desired concomitant activity of the supraspinatus and deltoid musculature.

Reinhold et al, J Ortho and Sport Phys Ther, 2004
Rotator Cuff Importance

Rotator cuff muscle provide dynamic compressive forces to keep the humeral head seated in the concave glenoid fossa.

- Supraspinatus
- Infraspinatus
- Subscapularis
- Teres Minor

Cricchio et al, J Hand Ther, 2011
Rotator Cuff Muscles: Systematic Review

- Summary of glenohumeral and scapular muscle activity (normalized by a maximum voluntary isometric contraction [MVIC]) during numerous open and closed chain shoulder exercises commonly used in rehabilitation.

Escamilla et al, Sports Med, 2009
Rotator Cuff Muscles: Systematic Review

Seeing a theme here yet?

Escamilla et al, Sports Med, 2009
Rotator Cuff Muscles: *Systematic Review*

Seeing a theme here yet?

“Very High” Category

Escamilla et al, Sports Med, 2009
This study looks at similar exercises but in standing. Could be a modification for someone who could do them on a table just yet?

Escamilla et al, Sports Med, 2009
Rotator Cuff Muscles: *In Conclusion*

- There are far more studies looking at the muscle activation of the infraspinatus and the supraspinatus compared to the teres minor and subscapularis.

- Infraspinatus, Supraspinatus and Subscapularis could all be part of the “muscle with in a muscle” theory. Things to keep in mind when picking exercises.

- Most of the research and findings from the study are not knew news to us....if anything, it’s a reassurance and “pat on our backs” because we are doing the right exercises!

- These studies and the exercises I highlighted we should continue to use in our rehab programs.
So Alyson...Which Exercises?

If you are looking for the cliff notes, quick reference version of this talk….pay attention now!
Rotator Cuff Muscles: *Supraspinatus*
Rotator Cuff Muscles: *Supraspinatus* and *Infraspinatus*  

*Figure 1*

Joseph et al, Am J of Phy Med & Rehab, 2018
Rotator Cuff Muscles: *Infraspinatus*

Forbush et al, Int J Sports Phys Ther, 2018
Rotator Cuff Muscles:

- **Supraspinatus**
  - "Low-Moderate" Category
  - "High" Category
  - "Very High" Category

Edwards et al, J Ortho S Phys Ther, 2017
Rotator Cuff Muscles: *Supraspinatus*

Rotator Cuff Muscles: *Supraspinatus*

**Dynamic Hug**

**Diagonal**

Rotator Cuff Muscles: *Supraspinatus*

Push Up Plus/Forward Punch

Rotator Cuff Muscles: *Supraspinatus*

Prone horizontal abduction at approximately 100°

Reinhold et al, J Orthop Sports Phys Ther, 2004
Rotator Cuff Muscles:

- **Infraspinatus**

  - **“Low-Moderate” Category**
  - **“High” Category**
  - **“Very High” Category**

Edwards et al, J Ortho S Phys Ther, 2017
Rotator Cuff Muscles: *Infraspinatus*

Rotator Cuff Muscles: *Subscapularis*

“High” Category

“Very High” Category

“Low-Moderate” Category
Rotator Cuff Muscles: *Teres Minor*

"Low-Moderate" Category

- Prone horizontal abduction: 100°
- Standing ER: 0° with towel
- Standing ER: scapular plane

"High" Category

- Prone horizontal abduction: 90°
- Standing ER: 0° without towel
- Prone ER at 90°

"Very High" Category

- Standing ER: 90°
- Forward punches
- Internal rotation: 0° of ABD
- Middle row
- Low row
- High row
- Resisted shoulder flexion

Edwards et al, J Ortho S Phys Ther, 2017
Rotator Cuff Muscles: *Subscapularis* and *Teres Minor*

- Shoulder EXT, shoulder FLEX
- Scapular Punch
- Throwing acceleration, throwing deceleration
- External rotation at 90° of abduction, scapular punches
- High or low scapular rows

Myers et al, J Athl Train, 2005
Rotator Cuff Muscles: *Subscapularis*

To restore normal function, should add ER and ABD exercises to focus on LSUB and IR strengthening exercises for USUB.

Rathi et al, J Biomechanics, 2017
Rotator Cuff Muscles: *Infraspinatus*, *Supraspinatus* and *Teres Minor*

- 7 Shoulder Exercises:
  - Prone horizontal abduction at 100° of abduction and full external rotation (ER)
  - Prone ER at 90° of abduction
  - Standing ER at 90° of abduction
  - Standing ER in the scapular plane (45° abduction, 30° horizontal adduction)
  - Standing ER at 0° of abduction
  - Standing ER at 0° of abduction with a towel roll
  - Sidelying ER at 0° of abduction

Electromyographic Analysis of the Rotator Cuff and Deltoid Musculature During Common Shoulder External Rotation Exercises

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  - Terri Chmielewski, PT, PhD
  - Rayden C. Cody, MD
  - Gene G. Jameson, MA
  - James R. Andrews, MD

Reinhold et al, J Ortho and Sport Phys Ther, 2004
Rotator Cuff Muscles: *Infraspinatus*, *Supraspinatus* and *Teres Minor*

**FIGURE 1.** Prone horizontal abduction at 100° with full external rotation.

**FIGURE 7.** Sidelying external rotation.

Electromyographic Analysis of the Rotator Cuff and Deltoid Musculature During Common Shoulder External Rotation Exercises

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Reinhold et al, J Ortho and Sport Phys Ther, 2004
Which Exercises?

What are your thoughts? Comments? Ideas?
Questions? Ideas?
Thank you!
Throwers 10 Program

• What the research says about each exercise...

Nuanes et al, 2015
Throwers 10 Program

• What the research says about each exercise...

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• What the research says about each exercise...

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Throwers 10 Program

- What the research says about each exercise...

Nuanes et al, 2015

9A. Elbow Flexion: Standing with arm against side and palm facing inward, bend elbow upward turning palm up as you progress. Hold 2 seconds and lower slowly. Perform _____ sets of _____ repetitions _____ times daily.


10A. Wrist Extension: Supporting the forearm and with palm facing downward, raise weight in hand as far as possible. Hold 2 seconds and lower slowly. Perform _____ sets of _____ repetitions _____ times daily.

10B. Wrist Flexion: Supporting the forearm and with palm facing upward, lower a weight in hand as far as possible and then curl it up as high as possible. Hold for 2 seconds and lower slowly.