Rotator cuff assessment & treatment

*Does recent evidence support current practice?*

A/Professor Karen Ginn
Normal rotator cuff muscle function

- rotate the humerus
  - infraspinatus & teres minor = external rotators
  - subscapularis = internal rotator

- abduct the humerus
  - supraspinatus initiates abduction

- stabilise the shoulder joint
  - take up slack in shoulder joint capsule
  - co-contract to:
    - globally compress the humeral head to provide dynamic stability
    - depress the humeral head to prevent it gliding superiorly
    - block humeral head translation
      - anteriorly - subscapularis
      - posteriorly - infraspinatus
EMG methodology

› 15 normal subjects
  - no pain in last 2 years
  - never sought treatment for shoulder pain
  - normal range and rhythm
  - no pain on maximal isometric rotation tests

› 13 muscle sites
  - rotator cuff muscles
    - supraspinatus, infraspinatus, upper & lower subscapularis
  - scapulothoracic muscles
    - upper, mid & lower trapezius, serratus anterior
  - axio/scapulohumeral muscles
    - anterior, middle & posterior deltoid, pectoralis major, latissimus dorsi

› normalised to “Shoulder Normalisation Tests”
  - 4 or 5 standard maximal voluntary contractions


Ginn et al (2011) “Revision of the shoulder normalisation tests is required to include rhomboid major & teres major.” J Orthop Res 29(12):1846-1849
Does supraspinatus initiate abduction?

Anatomy textbooks state that supraspinatus has an action to initiate abduction.

- Does supraspinatus contract before abduction movement and before other shoulder muscles?
  - Reed et al. “Does supraspinatus initiate shoulder abduction” J Electromyogr Kinesiol (revisions submitted)

- full range abduction at 25%, 50%, 75% maximum load
- muscle activation = x3 SD above baseline activity
Does supraspinatus initiate abduction?

**Conclusion**

Because supraspinatus **does not** contract before other shoulder muscles, the statement that supraspinatus initiates abduction is **misleading**.
The “empty can” and “full can” tests are used as clinical tests to diagnose supraspinatus pathology (Ellenbecker 2004, Kelly et al 1996, Jobe & Moynes 1982)

- Do these tests isolate activity in supraspinatus?

- maximum isometric “empty can” and “full can” tests
“Empty can” and “full can” tests

Activation (%MVC)

Muscles

- supraspinatus
- infraspinatus
- teres minor
- lower trapezius
- middle trapezius
- serratus anterior
- anterior deltoid
- middle deltoid
- posterior deltoid
- latissimus dorsi
- pectoralis major
- upper subscapularis
- lower subscapularis
Conclusions

- The ‘empty can’ and ‘full can’ tests do NOT specifically activate supraspinatus.
  - highly activate many muscles of the shoulder including:
    - subscapularis
    - infraspinatus
    - deltoid
    - trapezius
    - serratus anterior

- are not valid tests of specific supraspinatus function and therefore, problematic for the clinical diagnosis of supraspinatus pathology
Which is the optimal exercise to strengthen supraspinatus?

- “elicit the greatest amount of supraspinatus activity while minimizing the surrounding muscular activity, particularly the deltoid”  
  (Reinold et al 2007)


- 5 maximum isometric exercises

- “can” exercises

- external rotation at 0  
  (Dark et al 2007) in prone at 90 abduction  
  (Ballantyne et al 1993, Reinold et al 2004)

- prone abduction  
  (Blackburn et al 1990, Worrell et al 1992)
Conclusion

Based on stated criteria, **external rotation exercises** are more valid than “can” exercises to specifically strengthen supraspinatus in normal subjects.
Shoulder rotation exercises are commonly used to rehabilitate the RC muscles

- How specifically do these exercises recruit RC muscles?
- Are the RC muscles recruited as stabilisers during these exercises?

- rotation exercises:
  - pendant position - dynamic
    - resistance applied using a pulley system and elastic load at low, medium & high load levels
  - 90° abduction unsupported – isometric
    - 20%, 30%, 40%, 50%, 60%, 100% maximum load
### Rotation exercises

#### Dynamic external rotation (% MVC)

<table>
<thead>
<tr>
<th>muscles</th>
<th>low load</th>
<th>medium load</th>
<th>high load</th>
</tr>
</thead>
<tbody>
<tr>
<td>infraspinatus</td>
<td>40%</td>
<td>57%</td>
<td>70%</td>
</tr>
<tr>
<td>supraspinatus</td>
<td>15%</td>
<td>35%</td>
<td>51%</td>
</tr>
<tr>
<td>posterior deltoid</td>
<td>6%</td>
<td>15%</td>
<td>31%</td>
</tr>
</tbody>
</table>

<6% MVC activity in shoulder internal rotators

#### Dynamic internal rotation (% MVC)

<table>
<thead>
<tr>
<th>muscles</th>
<th>low load</th>
<th>medium load</th>
<th>high load</th>
</tr>
</thead>
<tbody>
<tr>
<td>subscapularis</td>
<td>16%</td>
<td>32%</td>
<td>51%</td>
</tr>
<tr>
<td>pectoralis major</td>
<td>23%</td>
<td>39%</td>
<td>51%</td>
</tr>
<tr>
<td>latissimus dorsi</td>
<td>10%</td>
<td>23%</td>
<td>28%</td>
</tr>
</tbody>
</table>

<6% MVC activity in shoulder external rotators
Rotation exercises

isometric rotation

- **Internal Rotation**
- **External Rotation**

![Graph showing muscle contraction levels for different muscles during internal and external rotation exercises.](image-url)
- **Conclusions**
  - *shoulder external rotation* is a primary action of supraspinatus (Kronberg & Nemeth 1990, McCann et al 1993, Reinold 2004)

- **rotation exercises in the pendant position**
  - recruit **all** shoulder rotation torque generators in a systematic fashion
  - lack specificity to rehabilitate the dynamic stabilising function of the RC muscle
    - do not produce the RC co-contraction necessary to accurately position the humeral head during movement

- **rotation exercises in the unsupported at 90° abduction position**
  - specifically recruit the rotator cuff muscles as major rotation torque generators
  - lack specificity to rehabilitate the dynamic stabilising function of the RC muscle
    - do not produce the RC co-contraction necessary to accurately position the humeral head during movement
  - ? recruit deltoid in a stabiliser role
Does dynamic stability require RC co-contraction?

- Do the RC muscles co-contract to provide stability during shoulder flexion and extension movements?

- flexion and extension
  - isometric maximum flexion, extension and abduction

- dynamic flexion and extension - 20%, 50%, 70% maximum load
Does dynamic stability require RC co-contraction?

Muscle Activation (%MVC)

- supraspinatus
- infraspinatus
- upper subscapularis
- lower subscapularis

Exercise

- Extension
- Flexion 90°
- Flexion 0°
- Abduction 0°

isometric tasks
Does dynamic stability require RC co-contraction

![Bar chart showing average EMG (%MVC) for different muscle groups under various movement conditions. The muscles listed include supraspinatus, infraspinatus, subscapularis, upper trapezius, lower trapezius, serratus, anterior deltoid, and latissimus dorsi. The chart compares flexion and extension movements at 70%, 50%, and 20% of maximum voluntary contraction (MVC). The dynamic tasks are highlighted with stars.](chart.png)
Does dynamic stability require RC co-contraction?

› Conclusions

- during maximum isometric **abduction**
  - anterior RC (subscapularis) and posterior RC (supraspinatus, infraspinatus) co-contract
    - globally compressing shoulder joint articular surfaces
    - counter-balancing the superior translation of the humeral head cause by deltoid
- during isometric and dynamic **flexion and extension**
  - RC muscle(s) do not co-contract at similar levels
    - RC on the opposite side of shoulder joint to the muscles producing torque are activated at significantly higher levels
      - subscapularis are significantly more active during **extension**
      - infraspinatus & supraspinatus are significantly more active during **flexion**
  - employing a more specific joint stabilizing strategy than gross global compression
  - not acting as barriers to humeral head translation

  counterbalancing the antero-posterior translation of the humeral head caused by flexion-extension torque producing muscles respectively
Shoulder adduction tests/exercises are used to identify RC muscle dysfunction and strengthen the RC muscles (Allingham 1995, Reinold 2004)

- Does shoulder adduction:
  - recruit the RC muscles at high levels?
  - and at higher levels than other shoulder muscles?


- isometric adduction in the scapular plane
  - 30, 60 and 90 abduction
  - 25%, 50%, 75% and 100% load
Adduction as a test/exercise for RC muscles

Maximum (100%) load
Conclusions

- shoulder adduction is **NOT** an optimal exercise to strengthen the RC muscles
  - does not satisfy either criterion (Reinold et al 2004)
    - high levels of activity from target muscle(s)
    - minimal surrounding muscle activity
  - "classical explanation" to support adduction as a diagnostic test for RC dysfunction **NOT** valid
    - decrease in shoulder impingement pain during adduction test:
      - **NOT** due to activation of RC muscles as depressors of the humeral head
      - due to *deltoid inactivity* not generating a superior translatory force

- shoulder adduction lacks **functional specificity** to retrain RC muscles as humeral head depressors
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**counterbalance potential translation of humeral head by muscles producing movements of humerus**
Dr Ian Cathers
Dr Mark Halaki
Dr Craig Boettcher
Dr Duanjai Wattanaprapakornkul
Mr Darren Reed
Ms Alanna Dark

Thank you!