

New Paradigms in Rotator Cuff Retraining

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Abstract: Rotator cuff strengthening exercises are frequently prescribed to address various shoulder dysfunctions and pain syndromes. The primary function of the rotator cuff muscles is to compress, stabilize and provide fine tune control at the glenohumeral joint. Most exercise programs focus on general strengthening and not on the fine tune control function of these muscles. The purpose of this article is to introduce clinicians to new concepts in rotator cuff retraining that focus on therapeutic exercises to assist these muscles in regaining their functional role as dynamic stabilizers of the glenohumeral (GH) joint.

Key Words: Rotator cuff, Shoulder, Instability, Impingement syndrome.

Rotator cuff (RC) retraining / strengthening is a routine treatment option for many Physical Therapists. Many papers and reviews hypothesize the value of RC retraining for individuals presenting with various shoulder dysfunctions, including impingement syndromes, glenohumeral (GH) instability and post surgical interventions¹⁻².

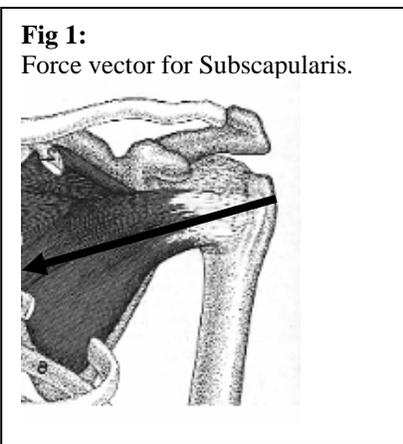
The purpose of this paper is two-fold.

- 1) To introduce and discuss four paradigm shifts in RC retraining
- 2) To review the techniques for retraining of the RC muscles considering the new paradigm shifts

Although clinicians are well aware of the value of RC retraining, it is the author's belief that most prescribed RC exercise regimes are not specific enough, in that they do not address the functional role of this group of muscles as stabilizers of the GH joint.

The RC muscles include the subscapularis, supraspinatus, infraspinatus and the teres minor muscles. The subscapularis is described as a medial rotator of the shoulder, however looking at it logically it would seem that it is a relatively "insignificant" medial rotator, compared to the powerful pectoralis major, teres major, latissimus dorsi and the anterior deltoid muscles. If we appreciate the force-vector angle of the subscapularis muscle we can see that it is extremely close to the GH joint line

to produce medial rotation (MR) torque at the GH joint (Fig 1).

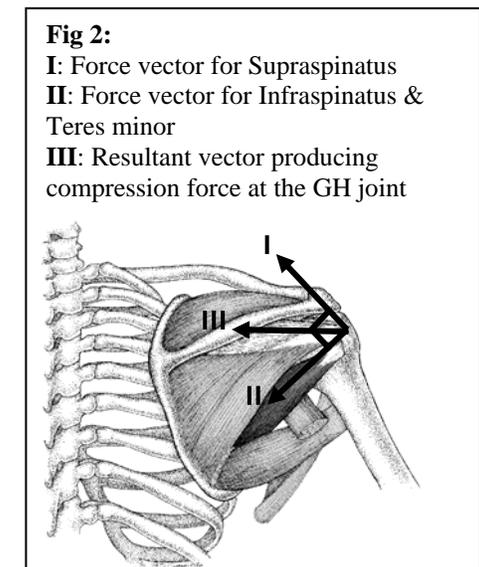


It can however be appreciated that the primary function of the subscapularis muscle is not to medially rotate the shoulder, but to compress the humeral head into the glenoid fossa and prevent excessive anterior and superior translations of the humeral head during functional activities (Fig. 1). Both anterior and superior translations of the humeral head are leading biomechanical causes of RC impingement syndromes³.

The supraspinatus muscle is most commonly described as an abductor of the shoulder. Considering its size and position, it is a relatively "insignificant" abductor compared to the powerful deltoid muscle. If we appreciate the force-vector angle of the supraspinatus muscle we can see that it is extremely close to the GH joint line

resulting in relatively poor moment arm to produce an abduction torque at the GH joint (Fig. 2). It can however be appreciated that the primary function of the supraspinatus is not to abduct the shoulder, but to compress the humeral head into the glenoid fossa and prevent excessive superior translation of the humeral head during functional activities.

The infraspinatus and the teres minor are both described as lateral rotators of the shoulder, however it can be appreciated that the primary function of the infraspinatus and the teres minor is not only to laterally rotate the shoulder, but to compress the humeral head into the glenoid fossa and prevent excessive superior and posterior translations of the humeral head during functional activities (Fig. 2).



Many of the concepts outlined in this paper are based on a single research study by David et al “Rotator cuff muscle performances during gleno-humeral joint rotations: An Isokinetic, Electromyographic and Ultrasonographic Study”, which was presented at the *Manipulative Physiotherapists Association of Australia Conference* in Melbourne Australia in 1997. The remainder of this clinical commentary will focus on four paradigm shifts, supportive evidence, clinical relevance and the clinical application for each of the new paradigms.

Paradigm shift #1:

Old paradigm: Supraspinatus muscle weakness and loss in size is due to disuse atrophy and therefore requires strengthening. Strengthening the supraspinatus using general resisted pulley and dumbbell exercises will increase the cross sectional area (CSA) and the stabilizing function of the muscle.

New paradigm: Supraspinatus muscle weakness and loss in size is due to selective neural inhibition and therefore requires specific retraining. To restore the primary function of the supraspinatus muscle, the focus of rehabilitation must be on specific neural control retraining, and not on a generic strengthening program.

Evidence to support the paradigm shift: Using ultrasonography, David et al measured the supraspinatus muscle CSA at rest. They found a strong positive correlation between supraspinatus CSA and isokinetic lateral rotation (LR) torque productions and LR/MR strength ratios. In other words, the bigger the supraspinatus muscle, the greater the torque production into LR and the greater the LR/MR strength ratio. Other studies have found the LR/MR strength ratio to be significantly less in subjects with shoulder pain and dysfunction⁸.

It may be hypothesized that the supraspinatus muscle may undergo selective neural inhibition following a shoulder injury or pain episode, which may reduce its CSA. The hypothesis of supraspinatus neural inhibition following shoulder pain syndromes is indirectly

based on the findings from the studies on the lumbar multifidus following lumbar injury. It has been demonstrated that patients with low back pain have selective neural inhibition with significant reductions in the CSA of their lumbar multifidus muscles⁵. It has also been demonstrated that specific multifidus retraining in isolation of the superficial muscles can increase the multifidus CSA⁶ and may dramatically reduce the risk of low back pain recurrences in the long term⁷.

Clinical relevance: It is hypothesized that the more effective supraspinatus is as a stabilizer of the GH joint, the stronger the shoulder is during LR, which would also increase the LR/MR strength ratio. The loss of supraspinatus CSA may decrease its effectiveness at producing compressive forces at the GH joint, which in turn may reduce GH joint stiffness. Specific neural control retraining of the supraspinatus (similar to that suggested for the deep fibers of the lumbar multifidus⁶) may help increase its tonic activation, neural control and eventually its CSA. This may be essential for some individuals presenting with persistent shoulder pain syndromes.

Clinical application: To specifically retrain the supraspinatus in isolation of the superficial muscles, instruct the patient to self-palpatate and with open or shut eyes visualize their own supraspinatus muscle. They are then instructed to “think about” and pull their humeral head into its socket and simultaneously “swell up” / contract the supraspinatus muscle (Fig.3). This may be performed in sitting with the shoulder abducted 60-80 degrees in the scapular plane while the ulnar border of the hand rests on a table or desk. It must be appreciated that only a subtle contraction of the supraspinatus is expected and that no scapular or GH joint movement is to take place. Strong contractions palpated over the suprascapular region during this exercise is most likely to be due to unwanted over activity of the upper fibers of trapezius. This mental imagery exercise is performed until the therapist and the patient are able to consistently palpate five repetitions of

gentle isometric supraspinatus contractions held for 10 seconds. It may take a few minutes to a few weeks to achieve this goal.



Fig. 3: Supraspinatus activation facilitated by self-palpatation and mental imagery.

Several studies have used functional MRI to compare the effects of mental imagery with actual execution of simple motor tasks. These studies have demonstrated dramatic overlapping of the motor and pre-motor cortex activity during visualization and actual physical performance of an activity⁹⁻¹⁰. The cortical activity that occurs at the thought of a movement is very similar to the cortical activity when the movement actually occurs¹¹.

Many scientific papers have demonstrated that overuse, lack of use or injuries to specific musculoskeletal structures can alter cortical representation¹²⁻¹⁴. It may be hypothesized that mentally focusing on specific and isolated supraspinatus contraction, may help increase the patients’ awareness of the “existence” of the muscle and enhance its cortical representation. Repeated tonic contractions of the supraspinatus may rejuvenate the neural pathways required for its activation and fine tune control. This clinical hypothesis is similar to what has been demonstrated with the deep fibers of the lumbar multifidus muscles⁶⁻⁷.

Paradigm shift #2:

Old paradigm: The supraspinatus muscle should primarily be strengthened by resisted GH abduction with the shoulder maintained in medial rotation.

New paradigm: The supraspinatus muscle may also be effectively retrained with resisted GH lateral rotation with the shoulder maintained at various angles of abduction.

Evidence to support the paradigm shift: Using electromyography (EMG), David et al studied infraspinatus, supraspinatus and subscapularis activities during isokinetic LR and MR at 45° of abduction. Surprisingly, EMG activity was very high in both the infraspinatus and supraspinatus muscles during LR.

Clinical relevance: Clinicians frequently prescribe resisted shoulder abduction in medial rotation in order to strengthen the supraspinatus muscle. However, since this exercise is often painful and may further contribute to an impingement syndrome, exercises focusing on LR may be more comfortable, functional and effective.

Clinical application: Many individuals with persistent shoulder pain syndromes need to begin their RC retraining using only isometric exercises, irrespective of their age or physical fitness level. Lateral rotation may be resisted isometrically at 20-30° of shoulder abduction (Fig. 4). The slight degree of abduction may be achieved by placing a folded pillow between the humerus and the body, which often increases comfort during the exercise. Once the isometric exercises are performed correctly, they can be progressed into resisted LR at various angles of abduction, using elastic tubing or pulley resistance. It is essential to focus on performing the lateral rotation exercises very slowly, especially during the eccentric phases. Each eccentric phase of contraction should ideally take approximately 5-10 seconds to complete; therefore the patient must be instructed not to simply “snap back”, but to slowly control the return from the end range of LR.

Many functional and recreational activities such as swimming, tennis, baseball and weight training require shoulder abduction with end range LR. Although stability is most essential in this position, ironically the lateral rotators are often weak / insufficient in end range LR. It is therefore crucial to

clinically focus on retraining the GH lateral rotators in their inner range or shortened position. Compromised stability during GH abduction and end range LR predisposes the shoulder to recurrent dislocations and to developing impingement syndromes¹.

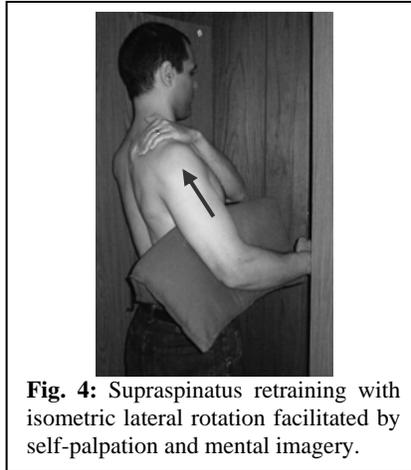


Fig. 4: Supraspinatus retraining with isometric lateral rotation facilitated by self-palpation and mental imagery.

It is also imperative to avoid aberrant scapular movement when training the RC muscles, as scapular motion tends to substitute for “pure” GH rotation when there is poor control of the RC muscles.

Paradigm shift #3:

Old paradigm: All resisted lateral rotation exercises will strengthen the infraspinatus and teres minor muscles, which may help improve GH joint stability.

New paradigm: Resisted lateral rotation without deltoid muscle contraction is required for retraining the infraspinatus and the teres minor muscles. Strengthening is not the focus of the exercises, as the timing and the ability of the RC muscles to contract in isolation of the deltoids is the key to improving GH joint stability.

Evidence to support the paradigm shift: Using EMG, David et al demonstrated that during isokinetic lateral rotation, supraspinatus, infraspinatus and teres minor were active 80-190 milliseconds prior to the initiation of actual movement and 10-120 milliseconds prior to the activation of the delto-pectoral muscle groups⁴.

These findings support the hypothesis that shoulder LR may involve pre-setting the supraspinatus, infraspinatus and teres minor before execution of the actual movement.

These findings are very similar to the findings from the EMG studies on the lumbar spine. It has been demonstrated that during limb movement, the transversus abdominis (TrA) muscle also activates 30-110 milliseconds prior to the other superficial abdominal muscles^{16,18}.

Since TrA activation also consistently preceded the activation of the muscle responsible for limb movement, it is hypothesized that TrA must be pre-programmed by the central nervous system to stabilize the spine prior to movement initiation¹⁵⁻¹⁶. In patients with low back pain, the activation of the TrA was significantly delayed and failed to occur in the pre-movement period¹⁷.

Many studies now support the concept that the TrA and the deep lumbar multifidus muscles are controlled independently of other trunk muscles and should be trained separately from the other trunk muscles¹⁸⁻¹⁹.

Now let us relate the studies on the lumbar spine to the glenohumeral joint. It may be hypothesized that the RC muscles are also controlled independently of the other shoulder girdle muscles and should therefore be trained separately from the other shoulder muscles.

Clinical relevance: During RC exercises, clinicians frequently do not monitor for excessive compensation by the superficial muscles. In fact many clinically prescribed RC strengthening programs strengthen the deltoid and the pectoral muscles far more than RC muscles.

Clinical application: The key to achieving isolated activation of the RC muscles is learning to avoid unwanted contractions of the deltoid muscle. In order to monitor over-activity of the deltoid muscle, an EMG biofeedback unit or a simple deltoid palpation technique may be used (Fig. 5).

Encouraging gentle shoulder adduction during the lateral rotation exercises may minimize deltoid contractions. Placing a folded pillow or a towel roll between the arm and the body may encourage this adduction.

The therapist must instruct the patient to visualize or “think about” pulling the humeral head into its socket throughout the exercise. It is essential to palpate for any posterior deltoid contractions during this exercise. Over-activity of the deltoid muscle may indicate poor isolated control of the supraspinatus and infraspinatus muscles. If this exercise is performed correctly with each eccentric contraction phase lasting 5-10 seconds, most individuals will fatigue within 5-10 repetitions with only 1-3 Kg of resistance.

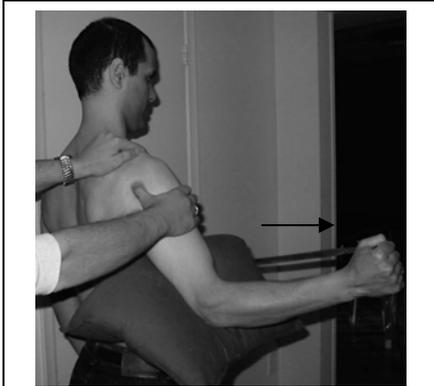


Fig. 5: Resisted lateral rotation in maximum lateral rotation range with palpation of the posterior fibers of the deltoids monitoring for over-activity.

Paradigm shift #4:

Old paradigm: Resisted medial rotation will strengthen the subscapularis muscle, which is important for improving GH joint stability. A strong subscapularis muscle helps resist excessive anterior translation of the humeral head.

New paradigm: Resisted medial rotation without delto-pectoral muscle contraction is required for retraining the subscapularis muscle. The ideal subscapularis exercise program should not focus on strengthening it as a medial rotator, but retraining it independently of the superficial muscles as a posterior translator of the humeral head.

Evidence to support the paradigm shift: David et al also demonstrated that

the subscapularis was active 10-120 milliseconds prior to the other delto-pectoral muscles during isokinetic medial rotation⁴.

These findings support the hypothesis that shoulder medial rotation involves pre-setting the subscapularis before execution of the actual movement and activation of the superficial muscles.

Clinical relevance: Subscapularis strengthening exercises typically involve some form of resisted medial rotation, however these exercises primarily engage the dominating latissimus dorsi, pectoralis major, teres major and anterior deltoid muscles, which do not have significant “fine tune” control over the GH joint. Resisted medial rotation exercises focus on the function of the subscapularis as a medial rotator, when in fact focus needs to be on the function of the subscapularis as a preventor of excessive anterior translation of the humeral head. An alternative method of retraining the subscapularis is therefore essential.

Clinical application: An effective method of retraining the subscapularis as a posterior translator of the humeral head is by “thinking about it”!

With the arm simply resting on the arm of a chair, or while performing the lateral rotation exercises, the patient can be instructed to visualize and “think about” pulling his/her humeral

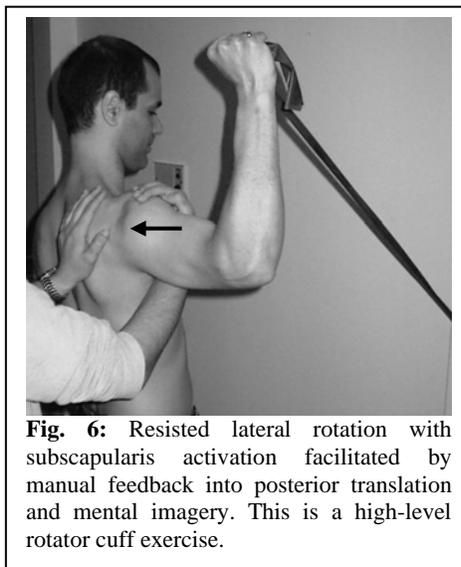


Fig. 6: Resisted lateral rotation with subscapularis activation facilitated by manual feedback into posterior translation and mental imagery. This is a high-level rotator cuff exercise.

head back into its socket. The Therapist may facilitate this exercise by providing a feedback using a gentle manual posterior glide of the humeral head (Fig. 6).

Clinical example: Instruct a patient with GH instability or RC impingement related to an anteriorly translated humeral head to...

Step #1: Actively abduct their arm (note level of pain & ROM) and bring the arm back down

Step #2: This time prior to abducting, visualize taking the shoulder (humeral head) back into its socket

Step #3: Hold that position, and reattempt the abduction

Step #4: Try to keep the “joint back” and slowly bring the arm down from the abducted position

Many patients with symptoms related to excessive anterior translation of the humeral head respond favourably to this simple test and potential treatment technique.

Summary

The four paradigm shifts introduced in this paper include:

- 1) Supraspinatus muscle insufficiency may be due to selective neural inhibition, hence exercises should initially focus on specific neural control retraining, not strengthening.
- 2) The supraspinatus muscle may be more functionally and effectively retrained with resisted GH lateral rotation at varying angles of abduction instead of with resisted GH abduction in medial rotation.
- 3) The infraspinatus and teres minor muscles may be more effectively retrained with resisted outer range lateral rotation with focus on slow eccentric contractions and in isolation of the deltoid muscle.
- 4) The subscapularis muscle may be more effectively retrained with focus on its function as a posterior translator of the humeral head, rather than its function as a medial rotator of the shoulder.

It is crucial to keep in mind that all RC retraining exercises must be pain-free which may be achieved by modifying the degree of GH abduction, the amount of resistance and the number of repetitions. Although scapular stabilization, manual

therapy techniques, acupuncture and other modalities were not discussed in this paper, they are often required for reducing symptoms before the RC exercises can be commenced.

The concepts reviewed in this article are primarily based on direct clinical experience and further studies and clinical trials are essential to either support or negate the new paradigms presented in this paper.

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