Shoulder impingement (FS-22)

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Shoulder Impingement Syndrome (SIS)

How does opinion regarding aetiology influence treatment?

Assoc Prof Karen Ginn

Prof Ann Cools  Assoc Prof Jean-Sebastien Roy

Prof Jeremy Lewis
Rotator cuff (RC) dysfunction as a primary cause of SIS

Associate Professor Karen Ginn
Minimal passive support for humeral head

Guyot “Atlas of Human Limb Joints”
Springer-Verlag 1981
RC muscles centre humeral head on glenoid fossa

Guyot “Atlas of Human Limb Joints”
Springer-Verlag 1981

supraspinatus
infraspinatus
teres minor

posterior RC

anterioR RC

subscapularis
Normal RC muscle function

- rotate the humerus
  - internal rotator - anterior RC (subscapularis)
  - external rotators - posterior RC (infraspinatus, teres minor & supraspinatus)

Boettcher et al 2010

Dark et al 2007
Reinold et al 2004
Ballantyne et al 1993
Kronberg & Nemeth 1993
McCann et al 1993
Normal RC muscle function

- supraspinatus does NOT initiate abduction

Reed et al 2013

Inman et al 1944
van Linge & Mulder 1963
Normal RC muscle function

- are minimally active during shoulder adduction

Reed et al 2010
Normal RC muscle function

- stabilise the shoulder joint
  - take up slack in shoulder joint capsule
  - during abduction co-contract to:
    - globally compress the humeral head to provide dynamic stability
    - depress the humeral head to prevent it gliding superiorly

Global compression force of all RC

\[ \downarrow \]

Co-ordinate to prevent unwanted rotation

Deltoid contraction to produce abduction at the shoulder will cause the humeral head to glide superiorly

\[ \uparrow \]

Co-ordinate with deltoid to prevent superior glide of humeral head

- inferior part of subscapularis
- inferior part of infraspinatus
- teres minor
Normal RC muscle function

- stabilise the shoulder joint
  - during flexion & extension reciprocally contract:
    - subscapularis are significantly more active during extension
    - infraspinatus & supraspinatus are significantly more active during flexion
Normal RC muscle function

Dynamic tasks

Wattanapraporkul et al 2011
Implications for rehabilitation of RC in treatment of SIS

- In order to accurately position the humeral head to prevent SIS the RC muscles:
  - Must co-ordinate with each other to prevent unwanted rotation
  - Must stabilise against destabilising forces created by other shoulder muscles:
    - RC muscles prevent muscles that move the humerus from translating humeral head on glenoid fossa
    - Must train RC to “react” to destabilising muscle forces
  - Are reliant on correct positioning of the scapula:
    - Axioscapular (AS) muscles must:
      - Accurately position the scapula
      - “Stabilise” the scapula against RC (& deltoid) forces

- To rehabilitate the “stabiliser” function of RC to prevent SIS:
  - Not desirable to isolate RC muscles
  - Must “teach” RC muscles to co-ordinate with each other & muscles moving the humerus
    - Recruitment timing is crucial
  - Progress exercises by increasing complexity of recruitment pattern
Example: RC exercises for the treatment of SIS

RC - rotator role
AS - stabiliser role

RC - rotator role
AS - positioning & stabiliser roles
Example: RC exercises for the treatment of SIS

RC - rotator role

AS - positioning & stabiliser++ roles

RC – rotator roles
- RC co-ordination

AS - positioning & stabiliser roles
Example: RC exercises for the treatment of SIS

RC - rotator & stabiliser++ roles
- RC co-ordination

AS - positioning & stabiliser++ roles
Rehabilitation of scapular dyskinesis in patients with impingement related shoulder pain (SIS)

Ann Cools, PT, PhD

Ann Cools – Ghent University - Belgium
Role of the scapula in normal shoulder function

Ann Cools – Ghent University - Belgium
Normal scapular movement and muscle recruitment patterns

Ann Cools – Ghent University - Belgium
Scapular dyskinesis in relation to shoulder pain (Ludewig et al. JOSPT 2009)

### TABLE 2

<table>
<thead>
<tr>
<th>Group</th>
<th>Healthy</th>
<th>Impingement or Rotator Cuff Disease</th>
<th>Glenohumeral Joint Instability</th>
<th>Adhesive Capsulitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary scapular motion</td>
<td>Upward rotation</td>
<td>Lesser upward rotation</td>
<td>Lesser upward rotation</td>
<td>Greater upward rotation</td>
</tr>
<tr>
<td>Secondary scapular motion</td>
<td>Posterior tilting</td>
<td>Lesser posterior tilting</td>
<td>No consistent evidence for alteration</td>
<td>No consistent evidence for alteration</td>
</tr>
<tr>
<td>Accessory scapular motion</td>
<td>Variable internal/external rotation</td>
<td>Greater internal rotation</td>
<td>Greater internal rotation</td>
<td>No consistent evidence for alteration</td>
</tr>
<tr>
<td>Presumed implications</td>
<td>Maximize shoulder range of motion and available sub-acromial space</td>
<td>Presumed contributory to subacromial or internal impingement</td>
<td>Presumed contributory to lesser inferior and anterior joint stability</td>
<td>Presumed compensatory to minimize functional shoulder range-of-motion loss</td>
</tr>
</tbody>
</table>

Ann Cools – Ghent University - Belgium
Abnormal muscle recruitment patterns in patients with shoulder pain
(Struyff et al. 2014)

Conclusion: Patients with SIS and glenohumeral instability display numerous variations in scapulothoracic muscle activity compared to healthy controls. In the SIS-group, the LT and SA muscle activity is decreased. In addition, the UT muscle activity is increased among the SIS patients, whereas no clear change is seen among patients with glenohumeral instability. Although the scapulothoracic muscle activity changed, no consensus could be made regarding muscle recruitment timing.
Need for a science based rehabilitation program (Cools et al. BJSM 2014)

Rehabilitation of scapular dyskinesis: from the office worker to the elite overhead athlete

Br J Sports Med published online May 18, 2013
doi: 10.1136/bjsports-2013-092148
Scapular Rehabilitation Algorithm
(Cools et al. BJSM 2014)

Lack of Soft-tissue flexibility
- Scapular muscles
  - Pectoralis minor
  - Levator scapulae
  - Rhomboid
- GH muscles/capsule
  - Infraspinatus
  - Posterior capsule
  - Latissimus dorsi

STRETCHING & MOBILISATION
- Manual soft tissue techniques
- Manual stretching and MWM
- Home stretching

Lack of Muscle performance
- Muscle Control
  - co-contraction
  - force couples
- Muscle Strength
  - lower/middle trap
  - serratus anterior

NEUROMUSCULAR COORDINATION
- Conscious muscle control
- Advanced control During basic activities
- Advanced control During sports

STRENGTH TRAINING
- Conscious muscle control
- Balance -ratio
- Endurance/strength
Examples of exercises: increasing flexibility: stretching pect min & post shoulder

Examples of exercises: improving local muscle control: “low load functional movements”

(Mottram at al. Man Ther 2009, Castelein et al. Subm JOSPT 2015)
Examples of exercises: improving muscle strength and inter/intra muscular balance: “high load strengthening exercises”

(Cools et al. AJSM 2007, Castelein et al. Subm Man Ther 2015)
Examples of exercises: implementation of the kinetic chain into scapular rehabilitation exercises – create diagonals!

(Maenhout et al. BJSM 2009, De Mey et al. IJSM 2012)

Ann Cools – Ghent University - Belgium
Scientific Evidence?
Scapular rehabilitation program….

- Improves intramuscular trapezius muscle balance in patients with impingement (De Mey et al. AJSM 2012)
- Increases (isokinetic) scapular muscle strength and endurance in healthy swimmers (Vandevelde et al. JAT 2010)
- Increases (isometric) external rotator strength in healthy volleyball players (Merolla et al. JSES 2010)
- Improves self-reported pain and disability in patients with impingement (Struyff et al. Clin Reumat. 2013)
Shoulder Impingement Syndrome
How does opinion regarding aetiology influence treatment?
Central neural changes

Jean-Sébastien Roy, PT, PhD
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Centre interdisciplinaire de recherche en réadaptation et en intégration sociale (CIRRIS)
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Best interventions
The evidence

- **Laser Therapy** – Low to moderate evidence that laser therapy may reduce pain in the **short term**, but **not function**.
- **Ultrason** – Low to moderate evidence that **US does not provide any benefit** compared to a placebo or advice, to laser therapy or when combined to exercises.
- **TENS** – No conclusion can be drawn.
- **Manual Therapy** – Low level evidence that **MT alone is not effective** in reducing pain or improving function; low level evidence that adding **MT to an exercise program may** decrease pain.
- **Taping** – Insufficient evidence regarding the efficacy of NET or KT alone or in conjunction with another intervention.
Best interventions
The evidence

Exercises (Hanratty et al. 2012, Semin Arthritis Rheum)

- Strong evidence that exercise decreases pain and improves function in short-term.
- Moderate evidence that exercise results in long-term improvement in function.
- Low to moderate evidence that acromioplasty is no more effective than exercises (Toliopoulos et al. 2014)
• Evidence suggests that exercise is the most efficient rehabilitation intervention to decrease pain and improve self-reported function
• Not surprising given the deficits described in this population
Shoulder Impingement Syndrome

- Coracoacromial pathology
- Capsuloligamentous / musculotendinous stiffness
- Postural abnormality
- RC and scapular muscles performance deficits
- Abnormal muscular activation
- Abnormal S/C, S/T and G/H kinematics

Anatomical studies of the shoulder
Leonardo da Vinci
Abnormal muscular activation and kinematic or Movement Deficits


- ↓ upward rotation of the scapula (Borstad et al. 2002, Ludewig et al. 2000)

- ↑ anterior translation of the humeral head (Ludewig et al. 2002)

- Superior migration of the humeral head (Hallström & Karrholm, 2006)

- ↓ muscular activity of the serratus anterior (Wadsworth et al. 1997)

- ↓ muscular activity of the infraspinatus and subscapularis (Reddy et al.)

↓ Acromiohumeral distance
Adaptation to pain

Adaptation to pain (Hodges & Tucker 2011):

1. Redistribution of activity within and between muscles
2. Changes in the mechanical behaviour such as modified movement and stiffness
3. Protection from further pain or injury
4. Short-term benefit but has potential long-term consequences due to factors such as increased load, decreased movement, and decreased variability
Movement Deficits

- Central changes may explain these motor deficits
  - repetition of impaired movements can result in a cortical reorganization
  - lead to a change in motor programs
- This “learned maladaptation” could be consecutive to (Montgomery & Connolly 2003):
  - Pain
  - Muscular fatigue
  - Surgery
  - Inadequate workstation
Central changes

• Changes in M1 in a number of MSK conditions
  • Patellofemoral pain: Amplitude of motor evoked potentials (MEPs) in quadriceps increased (On et al, 2004)
  • Low back pain: Center of gravity (CoG) of motor cortical map of TrA more posterior and lateral (Tsao et al, 2008)
  • Shoulder impingement: Changes in corticospinal excitability for infraspinatus (Ngomo et al, 2014)
Central changes

Significant difference for active motor threshold (aMT) ($P = 0.005; n=39$)

Decreased corticospinal excitability for the affected shoulder

(MSO = Maximum stimulator output) Ngomo, Mercier, Bouyer & Roy; Clinical Neurophysiology 2014
Central changes

Decreased corticospinal excitability for the affected shoulder

$r = 0.55; P = 0.01; n=39$
Movement Deficits

• Strong evidence that movements are planned in advance via motor program.
• Motor program:
  • set of motor commands that is pre-structured and that defines the essential details of a skilled action;
  • developed with experience, practice and interaction with environment.
• Central changes
  • Can lead to changes in the motor program
  • May explain movement deficits observed in persons with MSK disorders (On et al. 2004; Flor et al. 2003; van Vliet et al. 2006).

Shumway-Cook & Woollacott, 2001
Movement Deficits

• Functional organization of M1 can change in response to movement training-relearning (Tyc et al. 2005)

• Movement training can:
  • Induce change in the cortical organization
  • Contribute to the improvement of the motor performance

• Movement training should be based on the best strategies
  • amount of practice – most important variable for motor learning
  • patient must be actively involved in solving the motor problem

• Factors that promote motor learning:
  • use of instruction
  • demonstration
  • extrinsic feedback
Rehabilitation Program

• Movement Training
• Strengthening
  • Scapulothoracic muscles
  • Glenohumeral muscles
• Core
• Education
Movement Training

The training phases are graded according to:
1. the level of resistance applied on the shoulder during arm elevation;
2. the use or non use of feedback during the movement

1. Passive elevation
   Final position actively kept for 5 seconds
   Active return with manual feedback if needed

2. Active assisted elevation
   Final position actively kept for 5 seconds
   Active return with manual feedback if needed

3. Active elevation with manual feedback if needed
   Final position actively kept for 5 seconds
   Active return with manual feedback if needed

4. Phase 3, but without manual feedback

5. Phase 4, but without visual feedback

6. Phase 5, but with the elevation performed faster, and then with a load

Roy et al., Manual Therapy 2009
Movement Training

- At each session: exercises in diagonal planes
- Functional & work related movements
- When proper control achieved with supervision, exercises performed as home exercises

Roy et al., Manual Therapy 2009
Strengthening

3 steps  (Tate et al. 2011)

• Step 1 – Improve depressor function of RC muscles
  • X’s performed with humerus in neutral position

• Step 2 – Strengthening in elevation and of scapular muscles
  • RC muscles
  • Serratus anterior, trapezius

• Step 3 – Endurance, Core & stability

4 strengthening exercises at home (once a day).
• From two to three series of 10.
• When three series easily performed without pain, resistance increased.
Education

- Education regarding posture and body mechanics
- Instruction on preferred positioning of the shoulder during
  - sleeping
  - activities
  - work
  - sports
- Activity guidelines aimed at avoiding positions likely to provoke pain.
Movement training for the subacromial space

Baseline evaluation
- Sociodemographic data
- Symptomatology data
- DASH / WORC
- Ultrasonographic measure of AHD

Rehabilitation program
- 10 sessions supervised by a PT
- Home exercises program
- 6 weeks

Follow-up evaluation
- DASH / WORC
- Ultrasonographic measure of AHD

25 individuals with shoulder impingement syndrome
- Mean age: 42 ± 6
- Gender: 15 men, 10 women

Savoie et al., Manual Therapy 2015
Results – Symptoms and functional limitations

**DASH**
- P < 0.001
- Mean improvement: 18 points (MDC = 10.8 points; CID = 10.2 points)
- 60%: change greater than CID

**WORC**
- P < 0.001
- Mean improvement: 30 points (MDC = 12 points; CID = 13 points)
- 88%: change greater than CID

**NPRS**
- P < 0.001
- Mean improvement: 3.2 points (MDC = 3 points; CID = 1.1 points)
- 84%: change greater than CID

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![Graphs showing improvement in DASH, WORC, and NPRS scores with asterisks indicating significance.](image-url)
Results – Acromiohumeral Distance

* Significant increase in AHD at 45° and 60° at post treatment compared to pre-treatment P < 0.05
Mean increase: 0.9 mm at 0°; 1.4 mm at 45°; 1.6 mm at 60°
MDC : 0.9 mm
Results – Acromiohumeral Distance

* Significant increase in AHD at 45° and 60° at post treatment compared to pre-treatment
P < 0.05
Shoulder Impingement Syndrome

The following consistent responses were reported on the questionnaire distributed to participants prior to the face-to-face meeting:

- Priorities and focus during the initial assessment: to evaluate shoulder strength deficits and quality of active movements
- Short/medium term PT treatment aims should be achieved primarily by active exercises
- Start with:
  - Unloaded proceeding to loaded exercises
  - Simple exercises, e.g. targeting one force couple at a time, proceeding to more complex movements involving multiple force couples
  - Slow proceeding to faster exercises
  - Exercises performed in a conscious manner and progressively, by gradually decreasing feedback, to more subconscious / automatic exercise performance
- The number of exercises should be limited to a maximum of four
- Dose and progressions relate to the goal of each exercise and should be adjusted in relation to the individual patient.
Shoulder Impingement Syndrome

Movement Training

Strengthening

Stretching

Education
Research funding:

Salary award:

Collaborators:
• François Desmeules
• Catherine Mercier
• Laurent Bouyer
• Hélène Moffet
• Brad McFadyen
• Luc J Hébert

Graduate students:
• Suzy Ngomo
• Alexandre Savoie
• Corinne St-Pierre

Merci !