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FACULTY OF MEDICINE AND HEALTH SCIENCES

Birgit Castelein

Annual meeting of the Danish Society for Surgery of the shoulder and of the elbow

April 21 2017
Aarhus, Denmark

Prof. Dr. Birgit Castelein
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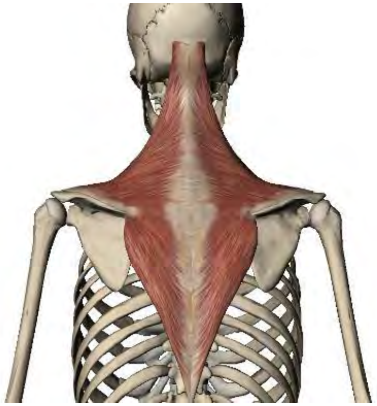
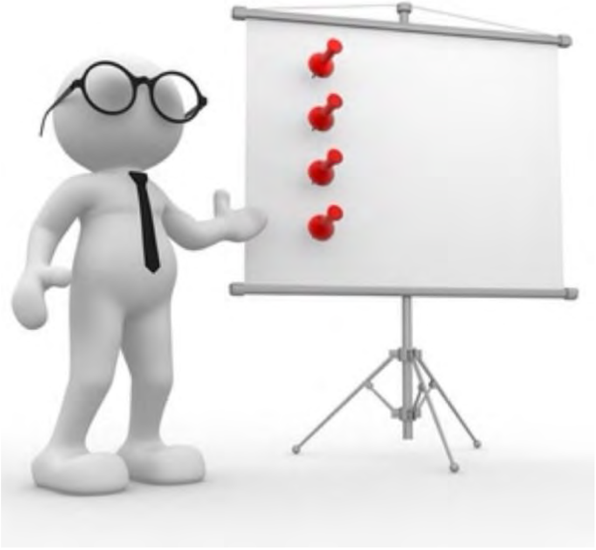
- **PhD:** “Analysis of recruitment of the superficial and deep scapular muscles in patients with chronic shoulder or neck pain, and implications for rehabilitation exercises”
- Professor at our department “Physiotherapy and Rehabilitation Sciences” : Rehabilitation of the Upper Limb



Overview

1. Analysis of recruitment of the superficial and deep scapular muscles in patients with chronic shoulder or neck pain, and implications for rehabilitation exercises
2. Shoulder impingement: can one label satisfy everything?
3. Central pain processing in shoulder pain
4. Progression in biceps load during rehabilitation exercises
5. The influence of induced shoulder muscle pain on rotator cuff and scapulothoracic muscle activity during elevation of the arm.



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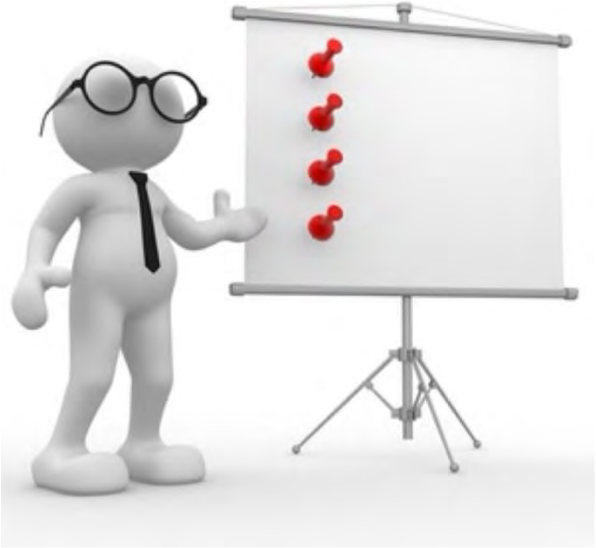

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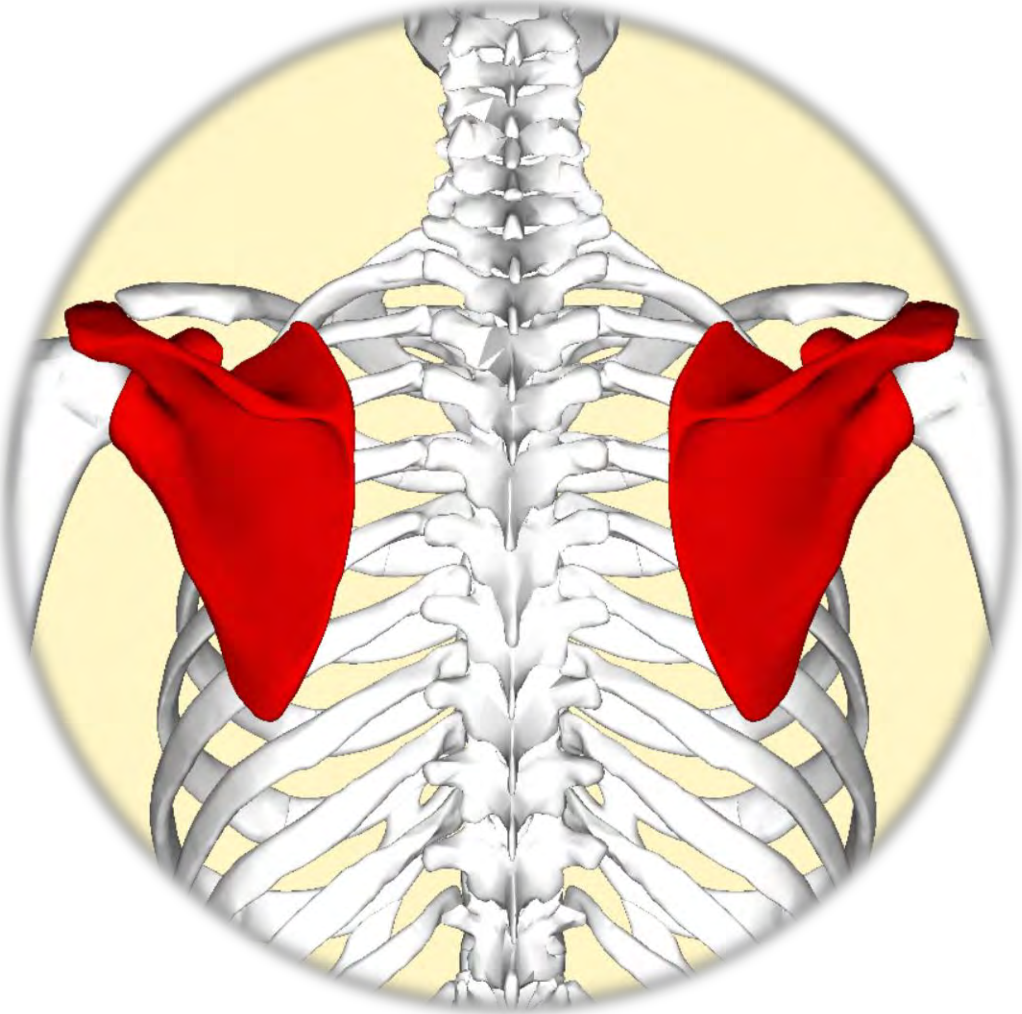
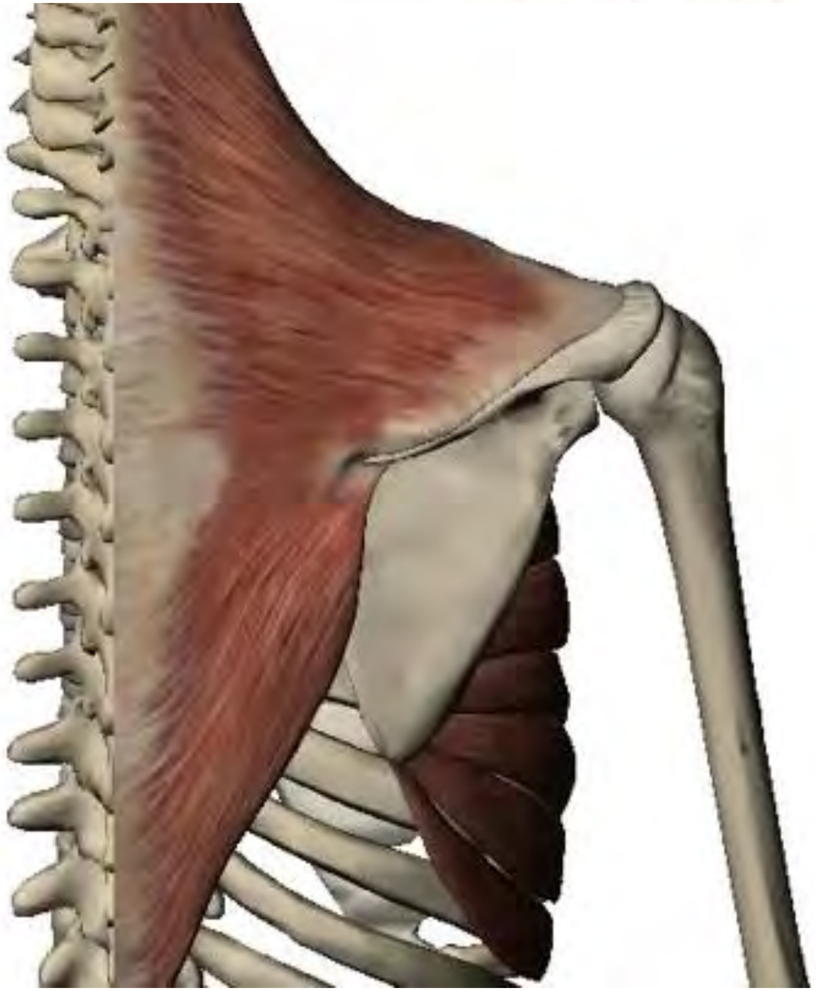
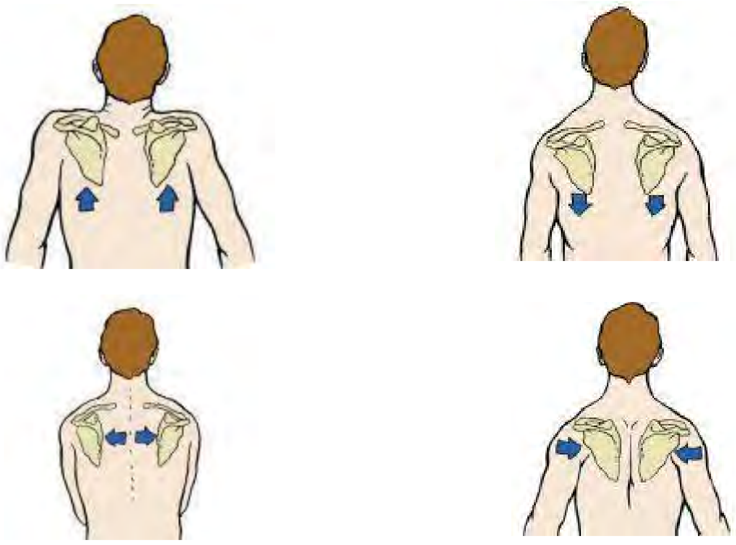




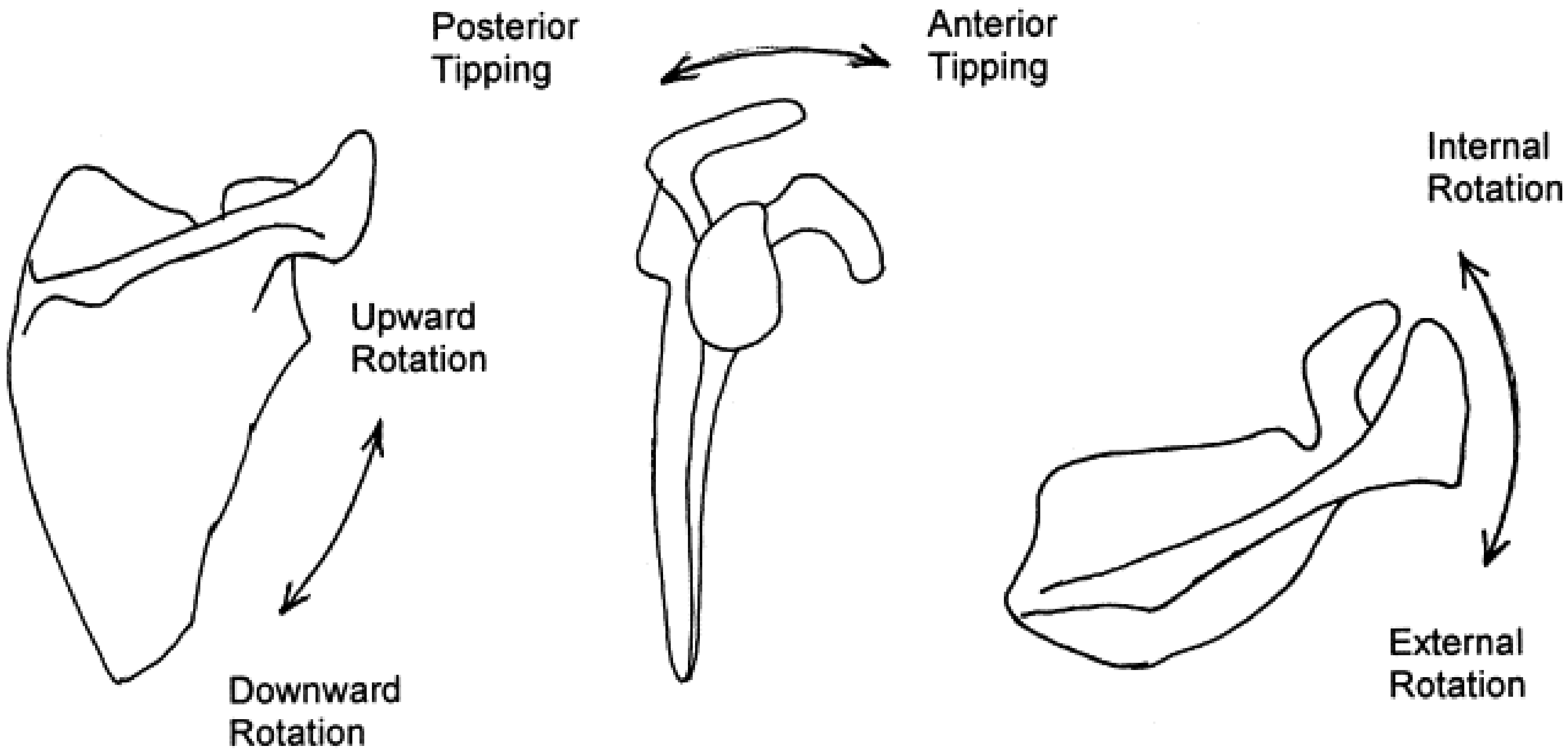
Movements of the scapula:



* TRANSLATION
  - Elevation – Depression
  - Protraction – Retraction

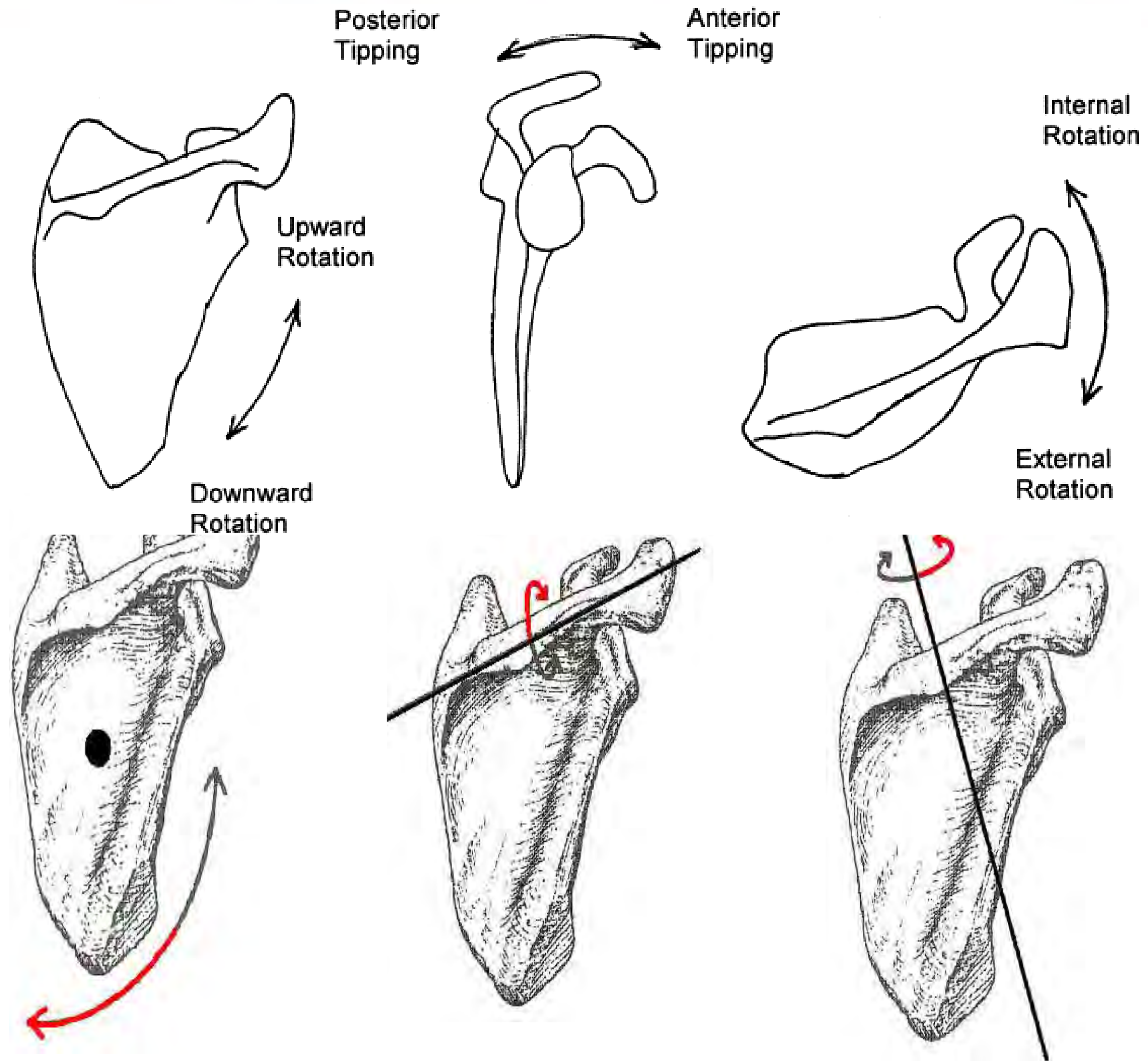
* ROTATION
  - Upward rotation – Downward rotation
  - Anterior tilt – Posterior tilt
  - Internal rotation – External rotation

ROTATION


Posterior
Tipping
Anterior
Tipping
Internal
Rotation
Upward
Rotation
Downward
Rotation
External
Rotation

UPWARD ROTATION

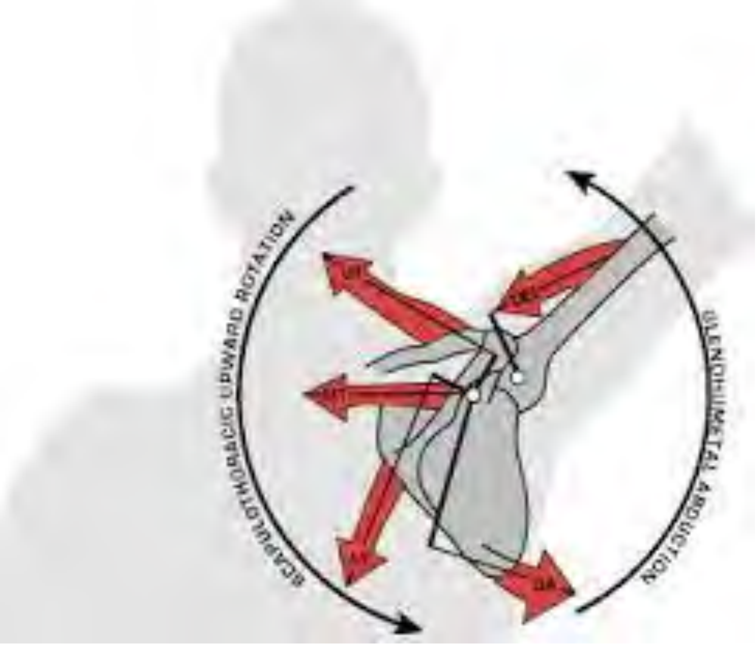
DOWNWARD ROTATION

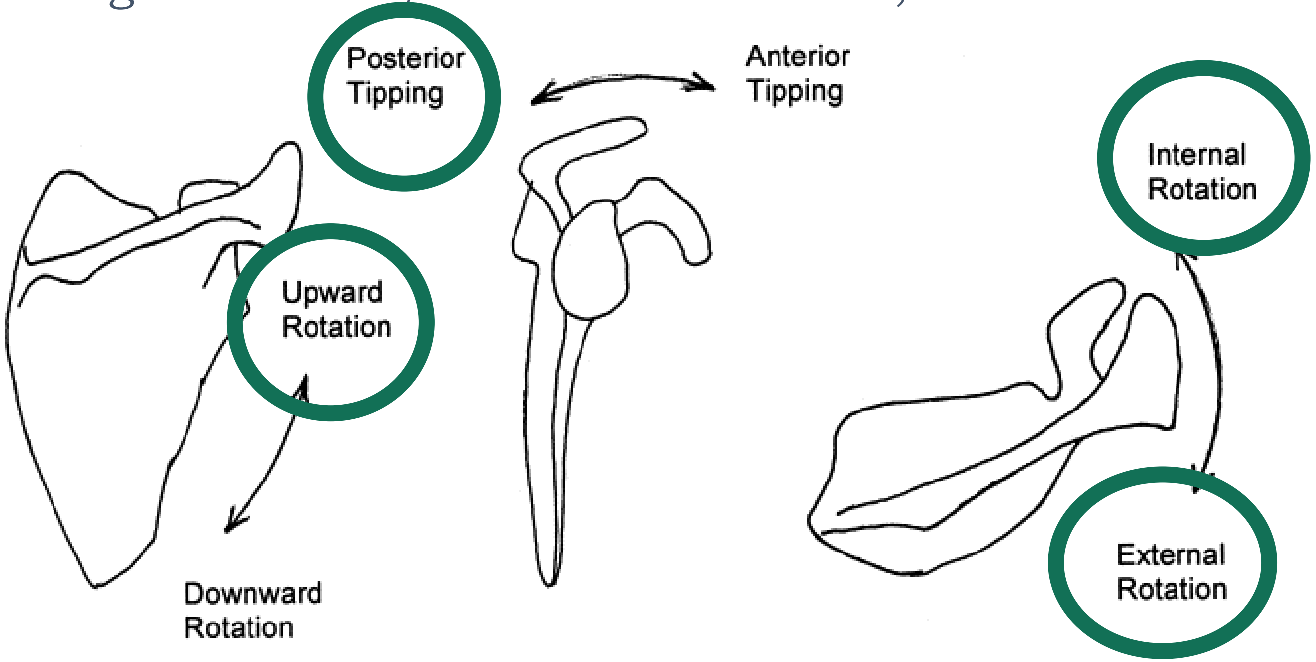

Posterior Tipping
Anterior Tipping
Internal Rotation
Upward Rotation
Downward Rotation
External Rotation

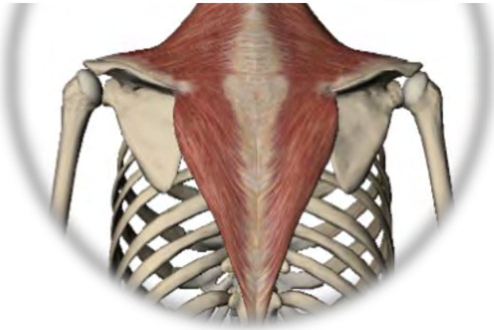
SCAPULAR MOVEMENT DURING ELEVATION OF THE ARM:

1) UPWARD ROTATION
2) POSTERIOR TILT
3) INTERNAL/EXTERNAL ROTATION

Braman et al. 2009, Ludewig et al. 2009, McClure et al. 2001, Kibler and McMullen, 2003

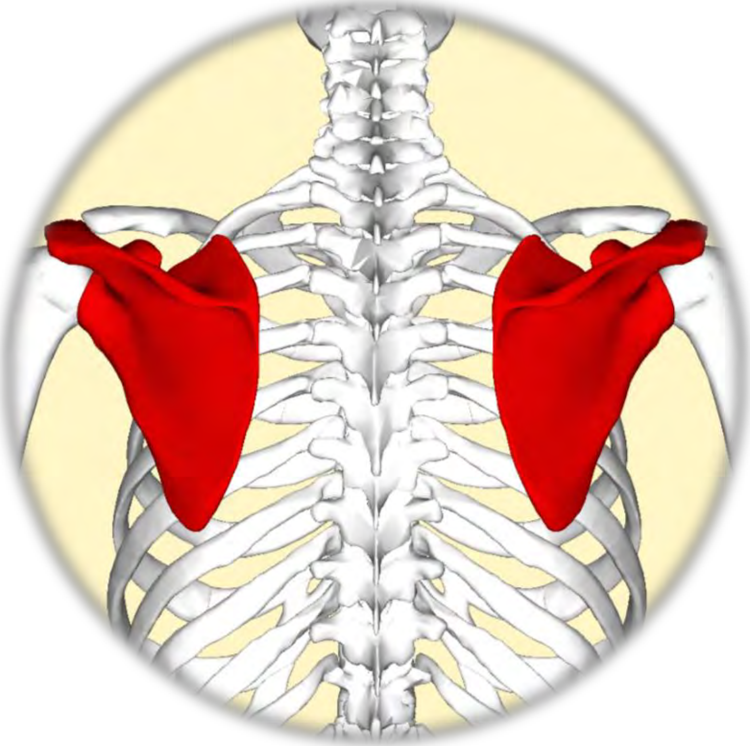




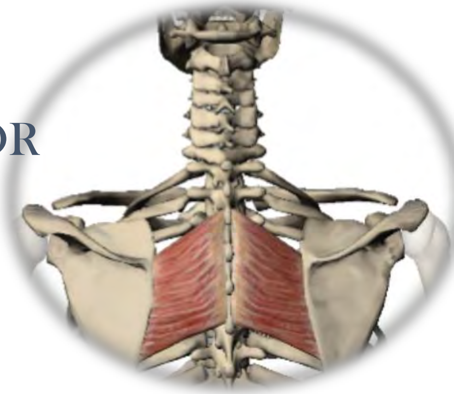


TRAPEZIUS

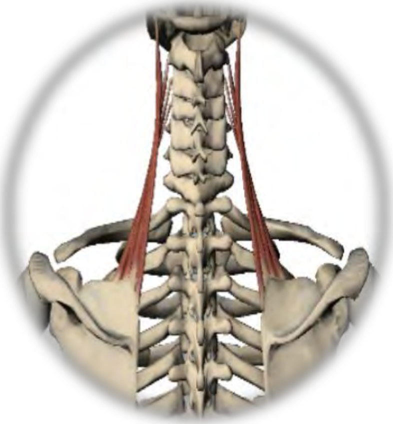
SERRATUS ANTERIOR



PECTORALIS MINOR

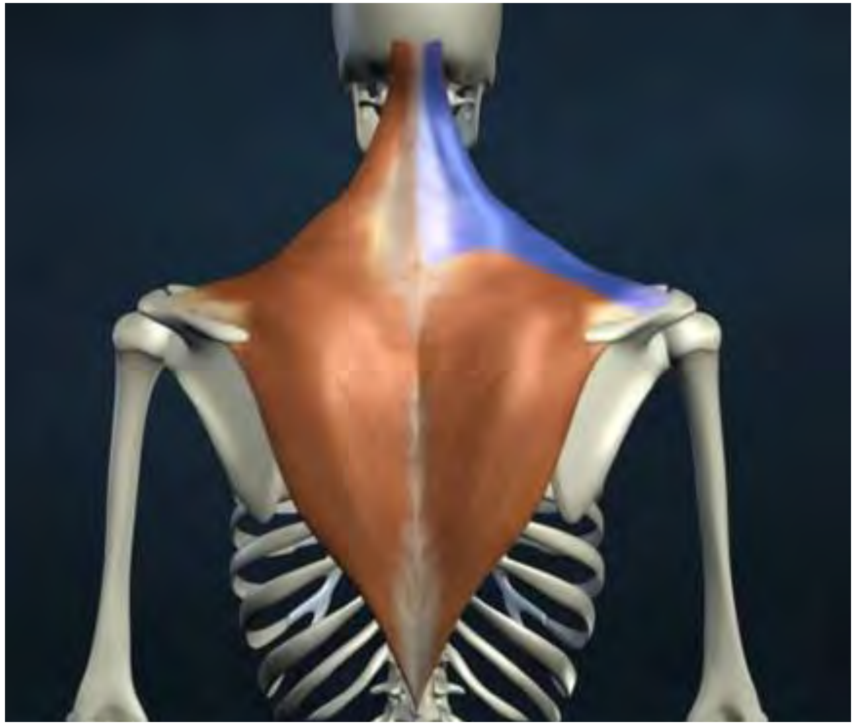


RHOMBOIDS

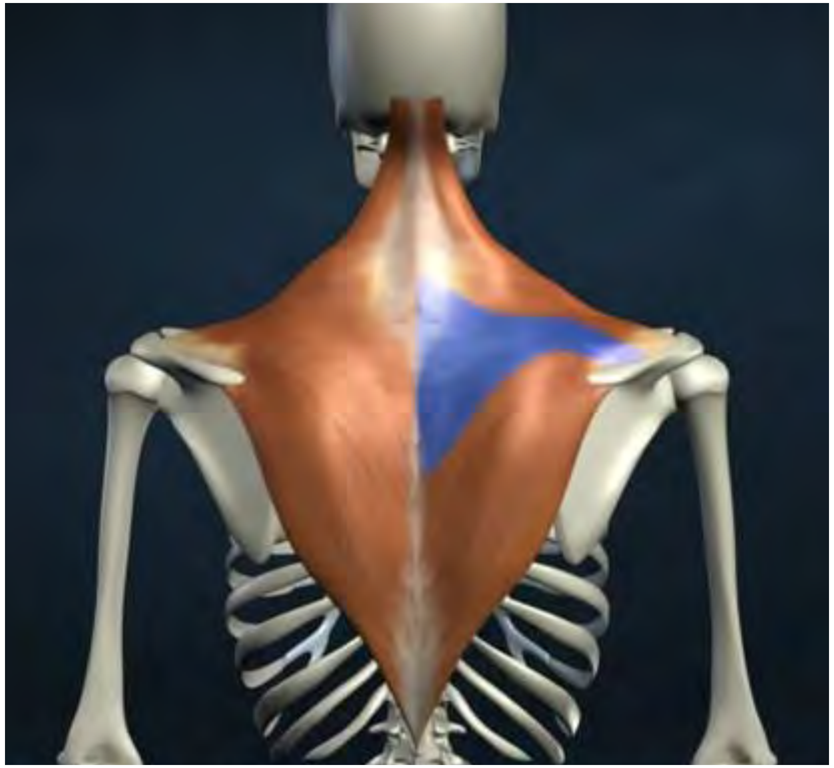


LEVATOR SCAPULAE

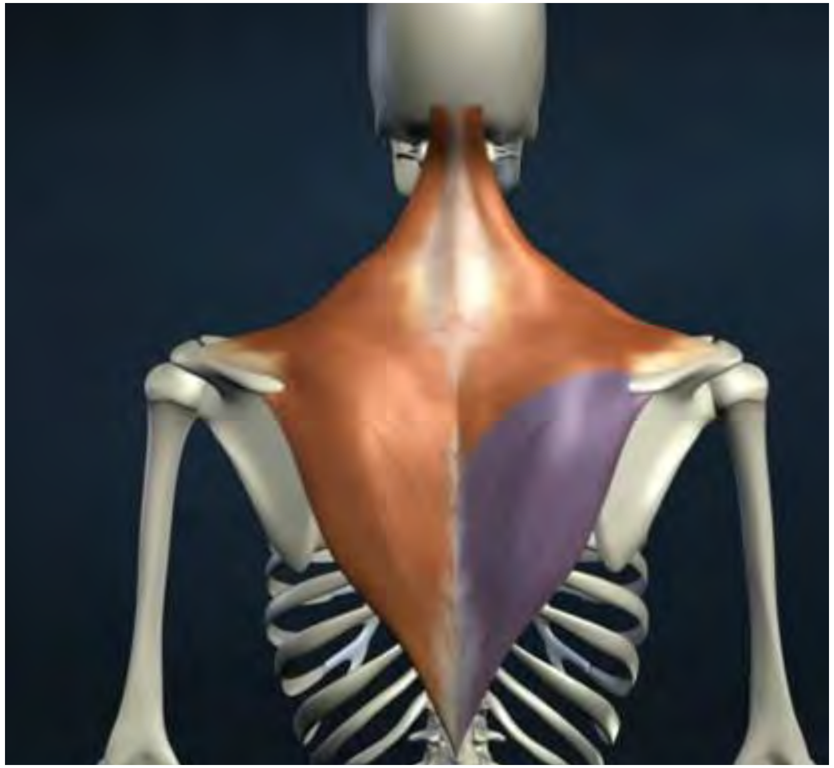
Upper Trapezius



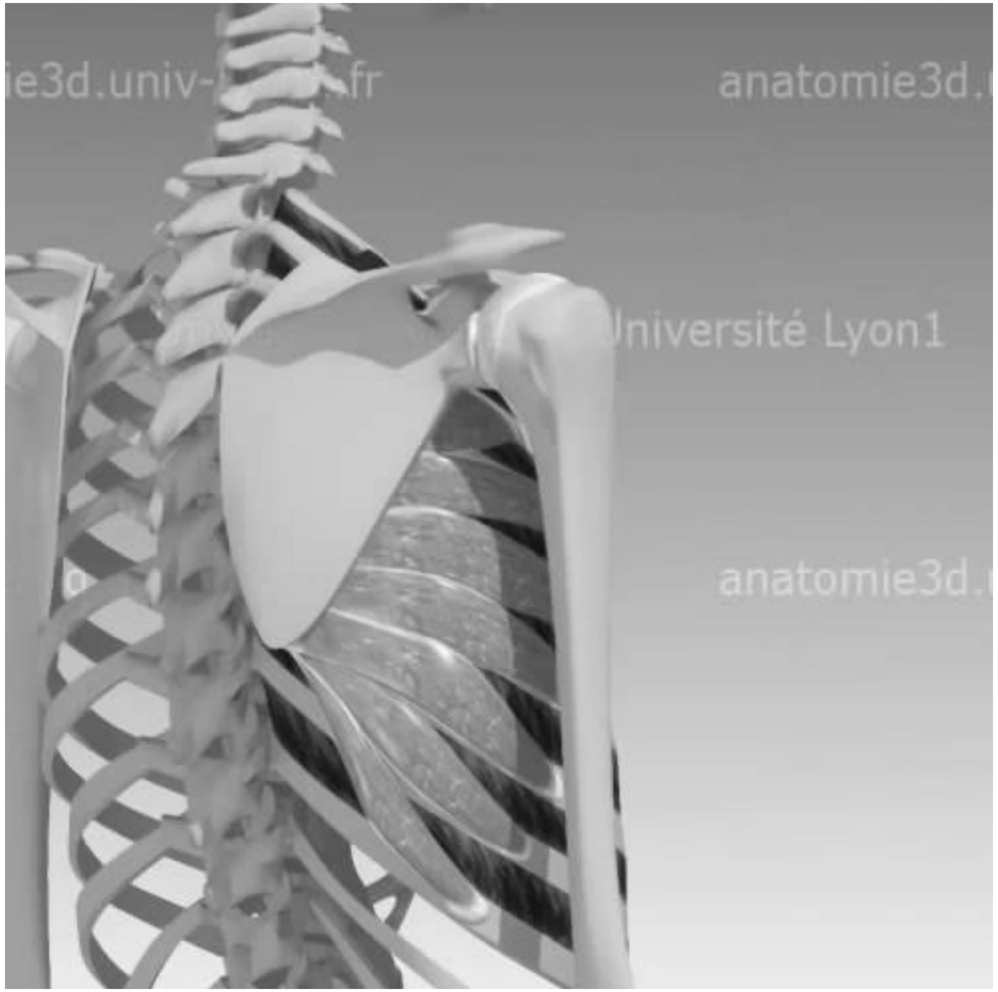
Middle Trapezius

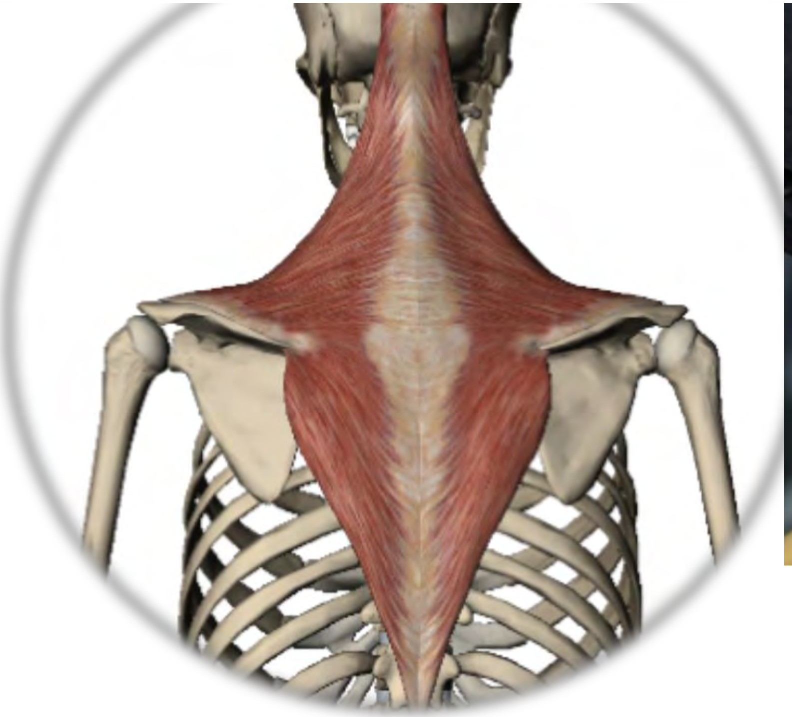


Lower Trapezius

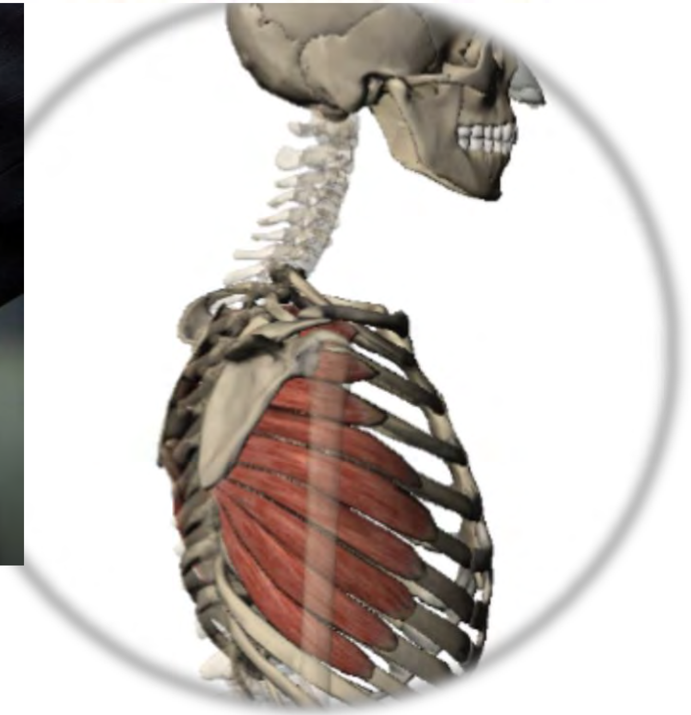


Serratus Anterior

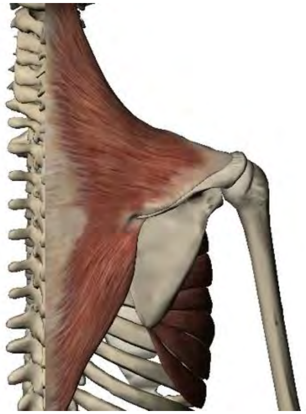




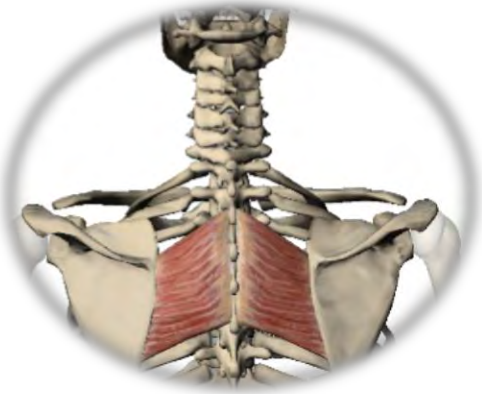
Trapezius

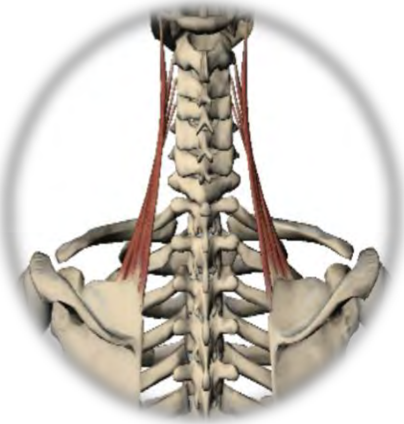


Serratus Anterior



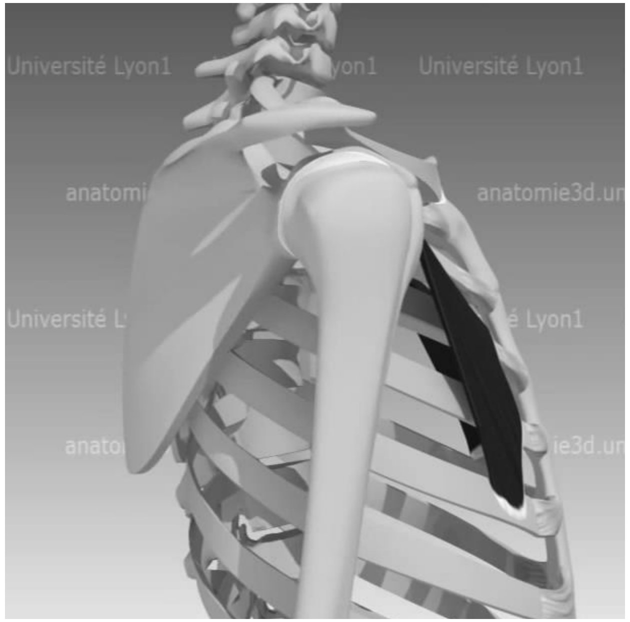

Pectoralis Minor

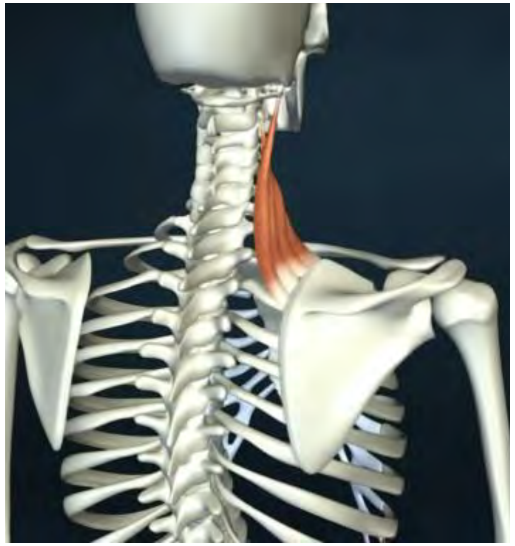

Rhomboid Major


Levator Scapulae

INFLUENCE THE POSITION AND MOVEMENT OF THE SCAPULA

Pectoralis Minor

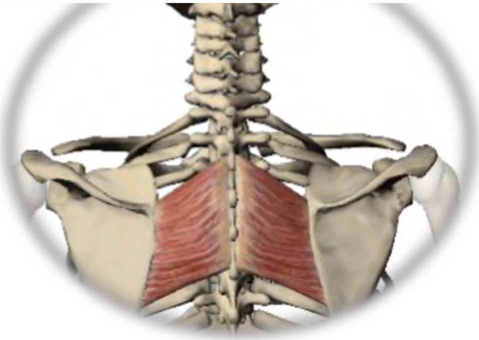




Levator Scapulae

Rhomboids

PECTORALIS MINOR



RHOMBOID MAJOR

LEVATOR SCAPULAE

- MAY INFLUENCE THE POSITION AND MOVEMENT OF THE SCAPULA

- MAY HINDER NORMAL SCAPULAR MOVEMENT IN CASE OF TIGHTNESS OR HYPERACTIIVTY

OPTIMAL FUNCTION SCAPULA:

is necessary for optimal function of the shoulder/neck region (central link between shoulder and neck)

- Disturbances in the function of the scapular muscles can induce mechanical load on the shoulder and on the neck region (Trapezius & Levator Scapulae)

DYSFUNCTION OF THE SCAPULA = SCAPULAR DYSKINESIS

Patients with shoulder pain (subacromial pain syndrome)

Patients with idiopathic neck pain

DYSFUNCTION OF THE SCAPULA = SCAPULAR DYSKINESIS

CHRONIC SHOULDER PAIN (impingement)

↓ UPWARD ROTATION
↓ POSTERIOR TILT
↑ INTERNAL ROTATION/ ↓ EXTERNAL ROTATION

* Ludewig & Reynolds 2009
* Struyf et al. 2011
* Timmons et al. 2012
* Ratcliffe et al. 2014
* Sousa et al. 2014

DYSFUNCTION OF THE SCAPULA =
SCAPULAR DYSKINESIS

CHRONIC IDIOPATHIC NECK PAIN

INITIAL EVIDENCE OF ALTERATIONS IN SCAPULAR POSITION/MOVEMENT (similar to alterations seen in patients with shoulder pain)

* Helgadottir et al. 2010
* Van Dillen et al. 2007
* Ha et al. 2011
* Lluch et al. 2014

DYSFUNCTION OF THE SCAPULA = SCAPULAR DYSKINESIS

- Pain
- Soft tissue tightness
- Muscle fatigue
- Cervical and thoracic posture
- Muscle activation/strength

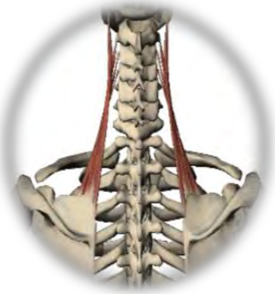
- <u>ALTERATIONS IN SCAPULOTHORACIC MUSCLE ACTIVITY:</u>

UPPER TRAPEZIUS ↓ or ↑
MIDDLE TRAPEZIUS ↓
LOWER TRAPEZIUS ↓
SERRATUS ANTERIOR ↓
Struyf et al. 2014, Sousa et al. 2014

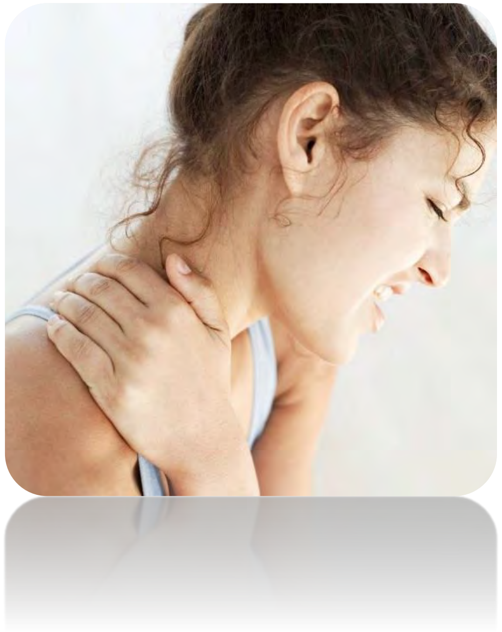
DEEPER LYING MUSCLES???

PECTORALIS MINOR

RHOMBOID MAJOR



LEVATOR SCAPULAE



- ALTERATIONS IN SCAPULOTHORACIC MUSCLE ACTIVITY:

UPPER TRAPEZIUS ↓ or ↑

Falla et al. 2004, Johnston et al. 2008a, Johnston et al. 2008b

MT, LT, SA ???

Deeper lying muscles???

PECTORALIS MINOR

RHOMBOID MAJOR

LEVATOR SCAPULAE

Training the scapulothoracic muscles :

↓ symptoms

(De Mey et al. 2012, Mulligan et al. 2016, Baskurt et al. 2011, Struyf et al. 2013, Moezy et al. 2014, Andersen et al. 2014)

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SHOULDER PAIN:

De Mey et al. 2012 :

6-week scapular training in overhead athletes with SIS:

- improved scapular muscle recruitment (decreased Trapezius muscle activation and decreased UT/SA ratio during a similar arm elevation task)
- significant functional improvement and less pain.

Baskurt et al. 2011:

compared (1) stretching and strengthening exercises and (2) scapular stabilization exercises in patients with SIS

- pain, ROM, muscle strength, joint position sense, scapular dysfunction and quality of life improved in both groups after treatment.
- improvements in muscle strength, joint position sense and scapular dysfunction: significantly larger with the scapular stabilization exercises.

Moezy et al. 2014:

compared (1) scapular stabilization exercise therapy and (2) physical therapy in patients with SIS

- Scapular stabilization exercise: superior in decreasing pain, improving scapular protraction, improving head and back posture and increasing shoulder mobility.

Mulligan et al. 2016:

4 weeks scapular stabilization exercises in patients with SIS

- decreased significantly the pain score & improved significantly the shoulder function

Struyf et al.2013:

compared (1) scapular-focused treatment (including stretching, scapular motor control training and passive manual mobilization) and (2) a control therapy (stretching, muscle friction and eccentric rotator cuff training) in patients with SIS

An important treatment effect in favor of scapular-focused treatment was found in self-reported disability, and also in pain during the Neer, Hawkins and Empty can test. In addition, the scapular focused treatment demonstrated an improvement in self-experienced pain at rest, whereas the control group did not change. *

NECK PAIN:

Andersen et al. 2014

compared (1) intensive scapular function training with exercises and (2) control therapy in patients with chronic non-specific neck/shoulder pain

- reducing pain and increasing shoulder elevation strength

Training the scapulothoracic muscles :

↓ symptoms

(De Mey et al. 2012, Mulligan et al. 2016, Baskurt et al. 2011, Struyf et al. 2013, Moezy et al. 2014, Andersen et al. 2014)

Choice of an exercise?

⇒Based upon the assumed effect of the exercise on the muscle activation

⇒Based upon the knowledge of the superficial lying scapulothoracic muscles

⇒Deeper lying muscle activity????

Deeper lying muscle activity

- in patient populations
- during different exercises

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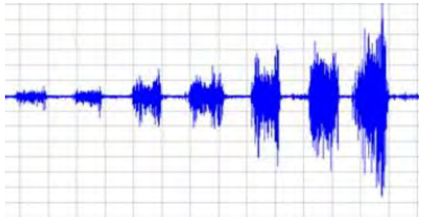
Part 1: SUPERFICIAL AND DEEPER LYING SCAPULOTHORACIC MUSCLE ACTIVITY IN PATIENTS WITH SHOULDER AND NECK PAIN

Part 2: SCAPULOTHORACIC MUSCLE ACTIVITY DURING DIFFERENT EXERCISES COMMONLY USED IN SCAPULR REHABILITATION PROGRAMS

- ELECTROMYOGRAPHY OF THE SCAPULOTHORACIC MUSCLES:
    - SURFACE EMG ELECTRODES:
      TRAPEZIUS & SERRATUS ANTERIOR
    - FINE-WIRE EMG ELECTRODES:
      PECTORALIS MINOR, LEVATOR SCAPULAE & RHOMBOID

- DOMINANT SIDE OF THE SUBJECT

  * PATIENTS WITH IMPINGEMENT SYMPTOMS
  * PATIENTS WITH IDIOPATHIC NECK PAIN
  * HEALTHY CONTROLS



<u>Part 1:</u> SUPERFICIAL AND DEEPER LYING SCAPULOTHORACIC MUSCLE ACTIVITY IN PATIENTS WITH SHOULDER PAIN

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Manual Therapy 23 (2016) 33–39

Contents lists available at ScienceDirect

Manual Therapy

journal homepage: www.elsevier.com/math

ELSEVIER

Original article

Scapulothoracic muscle activity during elevation exercises measured with surface and fine wire EMG: A comparative study between patients with subacromial impingement syndrome and healthy controls

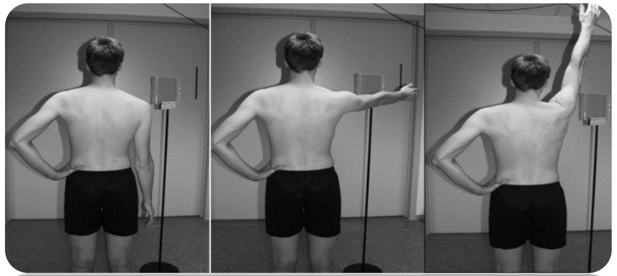
CrossMark

Birgit Castelein [a, *], Barbara Cagnie [a], Thierry Parlevliet [b], Ann Cools [a]

[a] *Department of Rehabilitation Sciences and Physiotherapy, Faculty of Medicine and Health Sciences, University Hospital, Ghent, Belgium*
[b] *Department of Physical Medicine and Orthopedic Surgery, University Hospital, Ghent, Belgium*

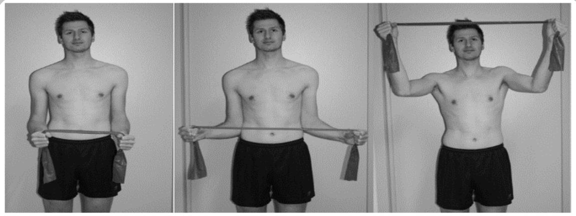
- 17 (♀) PATIENTS WITH SHOULDER IMPINGEMENT SYMPTOMS – 20 (♀) HEALTHY CONTROLS
  (matched for age, weight and height)
- 7 SCAPULOTHORACIC MUSCLES: UT – MT – LT – SA – LS – Pm – RM
- 3 ELEVATION TASKS IN THE SCAPULAR PLANE

SCAPTION



TOWEL WALL SLIDE

BILATERAL ELEVATION WITH EXTERNAL ROTATION



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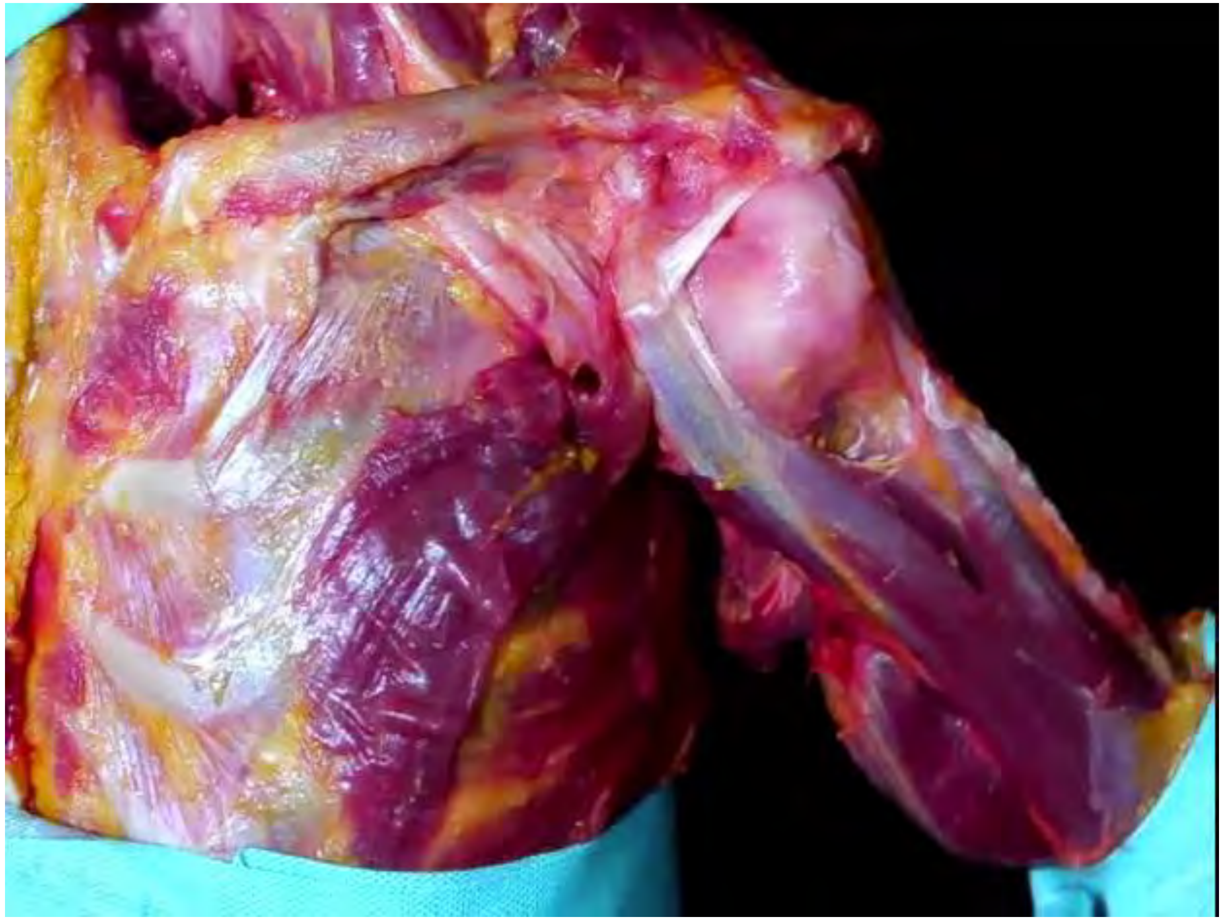
Muscle	Population	Scaption	Towel wall slide	Elevation with external rotation	P-value
UT	Healthy controls	17,7 ± 5,5	14,2 ± 4,6	12,3 ± 4,1	Exercise X Group NS
	SIS patients	18,7 ± 7,0	14,0 ± 6,5	12,0 ± 8,6	Group NS
	Mean Group Difference (SIS-healthy)	1,00 ± 2,00 (CI:-2,98 / 4,99)	-0,20 ±2,01 (CI:-4,18 / 3,78)	-0,23 ±2,04 (CI:-4,38 / 3,81)	
MT	Healthy controls	11,1 ± 4,5	7,4 ± 5,7	21,0 ± 11,9	Exercise X Group NS
	SIS patients	13,9 ± 8,9	7,5 ± 4,8	24,8 ± 11,5	Group NS
	Mean Group Difference (SIS-healthy)	2,86 ± 2,86 (CI:-2,82/ 8,55)	0,10 ± 2,81 (CI:-5,48 / 5,68)	3,81 ± 2,81 (CI:-1,78 / 9,39)	
LT	Healthy controls	15,7 ± 5,3	9,1 ± 4,4	29,3 ± 11,6	Exercise X Group NS
	SIS patients	15,6 ± 7,0	8,4 ± 4,7	27,0 ± 11,3	Group NS
	Mean Group Difference (SIS-healthy)	-0,11 ± 2,60 (CI: -5,26 / 5,05)	-0,61 ± 2,60 (CI: -5,77/ 4,55)	-2,29 ± 2,65 (CI: -7,54 / 2,96)	
SA	Healthy controls	28,7 ± 14,5	26,8 ± 11,9	20,8 ± 9,0	Exercise X Group NS
	SIS patients	25,7 ± 9,5	25,3 ± 11,0	19,2 ± 5,2	Group NS
	Mean Group Difference (SIS-healthy)	-2,99 ± 3,55 (CI:-10,0 / 4,04)	-1,52 ± 3,55 (CI: -8,55/ 5,51)	-1,62 ± 3,65 (CI: -8,86 / 5,61)	
Pm	Healthy controls	9,9 ± 7,6	12,3 ± 9,6	9,0 ± 7,6	Exercise X Group NS
	SIS patients	13,0 ± 8,4	17,5 ± 12,0	12,8 ± 7,5	Group P=0,023*
	Mean Group Difference (SIS-healthy)	3,09 ± 3,00 (CI: -2,86 / 9,04)	5,21 ± 2,95 (CI: -0,65/ 11,1)	3,8 ± 3,2 (CI: -2,35 / 10,0)	*Overall Mean Group difference: -4,04 ± 1,75 CI: 0,577 / 7,503
LS	Healthy controls	17,1 ± 11,0	13,7 ± 9,7	22,1 ± 17,4	Exercise X Group NS
	SIS patients	18,1 ± 12,0	13,3 ± 7,2	24,7 ± 17,4	Group NS
	Mean Group Difference (SIS-healthy)	0,99 ± 4,4 (CI: -7,70 / 9,57)	-0,40 ± 4,38 (CI: -9,09 / 8,27)	2,62 ± 4,38 (CI: -6,06 / 11,3)	
RM	Healthy controls	26,0 ± 17,8	10,9 ± 4,6	31,3 ± 14,0	Exercise X Group NS
	SIS patients	25,3 ± 14,6	11,0 ± 9,2	31,1 ± 18,4	Group NS
	Mean Group Difference (SIS-healthy)	-0,70 ± 4,67 (CI: -9,97 ± 8,6)	0,07 ± 4,81 (CI: -9,47 / 9,61)	-0,23 ± 4,75 (CI: -9,66 / 9,19)	

TABLE 2. EMG activity (%MVIC ± standard deviation) of each scapulothoracic muscle in each group

Muscle	Population	Scaption	Towel wall slide	Elevation with external rotation	P-value
Pm	Healthy controls SIS patients	9,9 ± 7,6 13,0 ± 8,4	12,3 ± 9,6 17,5 ± 12,0	9,0 ± 7,6 12,8 ± 7,5	Exercise X Group NS Group P=0,023*
	Mean Group Difference (SIS-healthy)	3,09 ± 3,00 (CI: -2,86 / 9,04)	5,21 ± 2,95 (CI: -0,65/ 11,1)	3,8 ± 3,2 (CI: -2,35 / 10,0)	* Overall Mean Group difference: -4,04 ± 1,75 CI: 0,577 / 7,503

PECTORALIS MINOR



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Journal of Electromyography and Kinesiology 31 (2016) 136–143

Contents lists available at ScienceDirect

Journal of Electromyography and Kinesiology

journal homepage: www.elsevier.com/locate/jelekin

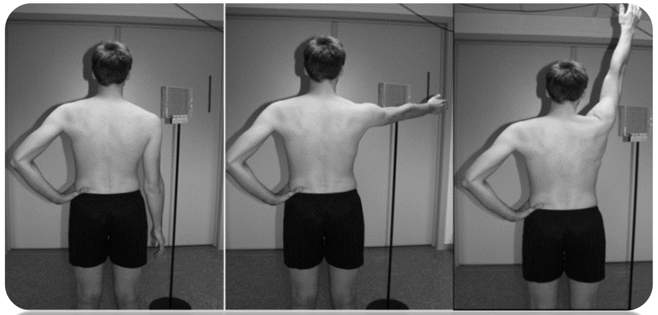
Are chronic neck pain, scapular dyskinesis and altered scapulothoracic muscle activity interrelated?: A case-control study with surface and fine-wire EMG

Birgit Castelein PhD, PT [a,*], Ann Cools PhD, PT [a], Thierry Parlevliet MD [b], Barbara Cagnie PhD, PT [a]

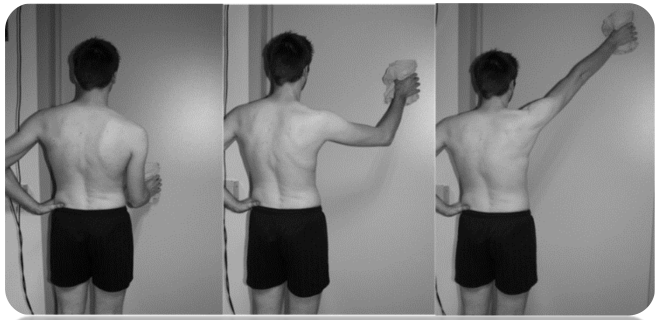
[a] Department of Rehabilitation Sciences and Physiotherapy, Faculty of Medicine and Health Sciences, Ghent University, Ghent, Belgium
[b] Department of Physical Medicine and Orthopedic Surgery, University Hospital, Ghent, Belgium

- 19 (♀) patients with idiopathic neck pain – 19 (♀) healthy controls (matched for gender, age, weight and height)
- Presence / absence of scapular dyskinesis

- 7 scapulothoracic muscles: UT – MT – LT – SA – LS – Pm – RM



Scaption



Towel Wall Slide

*Patients with idiopathic neck pain: ↑ Pm activity during the towel wall slide in comparison with healthy controls

*Patients with idiopathic neck pain and scapular dyskinesis:
↓ MT activity in comparison with healthy controls with scapular dyskinesis

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Part 2: SCAPULOTHORACIC MUSCLE ACTIVITY DURING DIFFERENT EXERCISES COMMONLY USED IN SCAPULAR REHABILITATION PROGRAMS

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Superficial and Deep Scapulothoracic Muscle Electromyographic Activity During Elevation Exercises in the Scapular Plane

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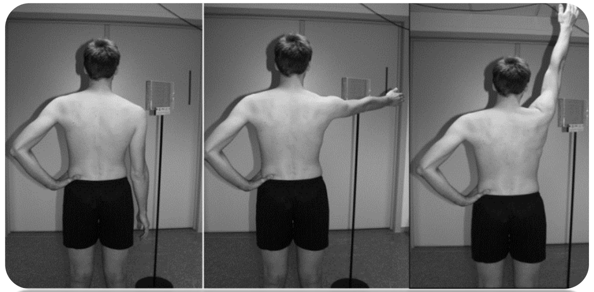
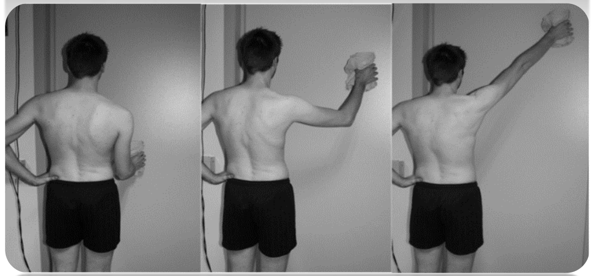
- 21 HEALTHY SUBJECTS (10♀, 11♂)
- MUSCLES: UT, MT, LT, SA, Pm, LS & RM
- 3 ELEVATION EXERCISES, with and without load

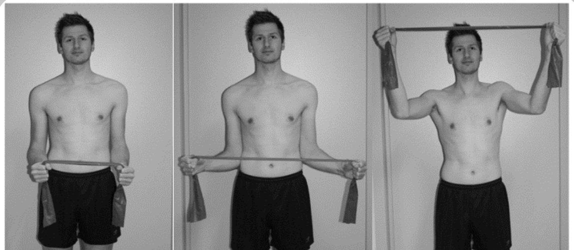
SCAPTION



TOWEL WALL SLIDE



ELEVATION WITH EXTERNAL ROTATION



	No Additional Load			Additional Load		
	Scaption	Wall Slide	Elevation Plus External Rotation	Scaption	Wall Slide	Elevation Plus External Rotation
Upper trapezius	15.9 ± 4.0†	13.6 ± 4.7	12.0 ± 4.0	39.5 ± 10.2†	33.0 ± 10.0	30.9 ± 9.7
Middle trapezius	9.1 ± 4.0	7.3 ± 7.6	19.1 ± 12.2†	26.6 ± 12.9‡	14.6 ± 9.9	25.1 ± 13.7‡
Lower trapezius	12.0 ± 5.6	7.4 ± 4.5	22.5 ± 7.5†	29.2 ± 10.7‡	17.0 ± 7.6	31.0 ± 10.2‡
Serratus anterior	25.1 ± 12.2	26.8 ± 10.3	22.5 ± 11.4	55.2 ± 16.0	53.2 ± 11.9	48.6 ± 15.9
Levator scapulae	17.7 ± 10.5	13.9 ± 13.6	24.7 ± 17.1†	37.1 ± 17.6‡	22.4 ± 15.6	31.2 ± 16.2‡
Pectoralis minor	13.4 ± 6.7	15.7 ± 9.0†	13.7 ± 9.0	28.3 ± 13.5	41.3 ± 27.1†	26.2 ± 15.2
Rhomboid major	21.7 ± 12.9‡	11.6 ± 6.3	33.9 ± 25.0‡	41.1 ± 16.1‡	24.7 ± 9.2	41.2 ± 25.8‡

TABLE 2. Electromyographic Activity of Each Scapulothoracic Muscle During the Different Exercises for Each Load Condition*

	No Additional Load			Additional Load		
	Scaption	Wall Slide	Elevation Plus External Rotation	Scaption	Wall Slide	Elevation Plus External Rotation
Upper trapezius	15.9 ± 4.0†	13.6 ± 4.7	12.0 ± 4.0	39.5 ± 10.2†	33.0 ± 10.0	30.9 ± 9.7
Middle trapezius	9.1 ± 4.0	7.3 ± 7.6	19.1 ± 12.2†	26.6 ± 12.9‡	14.6 ± 9.9	25.1 ± 13.7‡
Lower trapezius	12.0 ± 5.6	7.4 ± 4.5	22.5 ± 7.5†	29.2 ± 10.7‡	17.0 ± 7.6	31.0 ± 10.2‡
Serratus anterior	25.1 ± 12.2	26.8 ± 10.3	22.5 ± 11.4	55.2 ± 16.0	53.2 ± 11.9	48.6 ± 15.9
Levator scapulae	17.7 ± 10.5	13.9 ± 13.6	24.7 ± 17.1†	37.1 ± 17.6‡	22.4 ± 15.6	31.2 ± 16.2‡
Pectoralis minor	13.4 ± 6.7	15.7 ± 9.0†	13.7 ± 9.0	28.3 ± 13.5	41.3 ± 27.1†	26.2 ± 15.2
Rhomboid major	21.7 ± 12.9‡	11.6 ± 6.3	33.9 ± 25.0‡	41.1 ± 16.1‡	24.7 ± 9.2	41.2 ± 25.8‡

TABLE 2. Electromyographic Activity of Each Scapulothoracic Muscle During the Different Exercises for Each Load Condition*

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ELSEVIER

Manual Therapy

journal homepage: www.elsevier.com/math

Original article

Serratus anterior or pectoralis minor: Which muscle has the upper hand during protraction exercises?

Birgit Castelein [a,*], Barbara Cagnie [a], Thierry Parlevliet [b], Ann Cools [a]

- The SA has a critical role in stabilizing the scapula against the thorax + contributes to the movement of the scapula during elevation
- Research has linked shoulder disorders to impairments of the SA activation

=> Exercises that target SA in the rehabilitation:

Protraction Exercises

- Pm: synergist during protraction exercises

  BUT: also downward rotation & depression
- Overuse of Pm: malaligned scapula

TO WHAT EXTENT IS THE Pm ACTIVATED DURING SA EXERCISES?

- 26 HEALTHY SUBJECTS(15♀, 11♂)
- MUSCLES: SERRATUS ANTERIOR & PECTORALIS MINOR
- 3 PROTRACTION EXERCISES

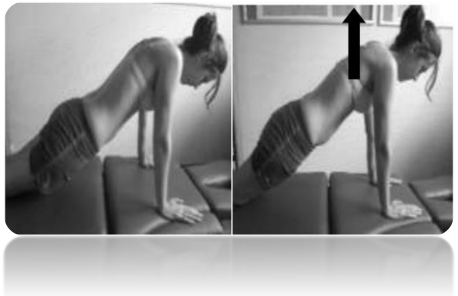
Serratus Punch

Modified Push-Up Plus Wall Version

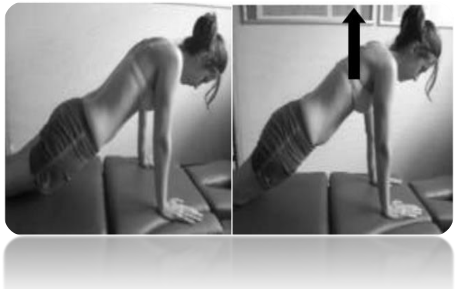
Modified Push-Up Plus Floor Version

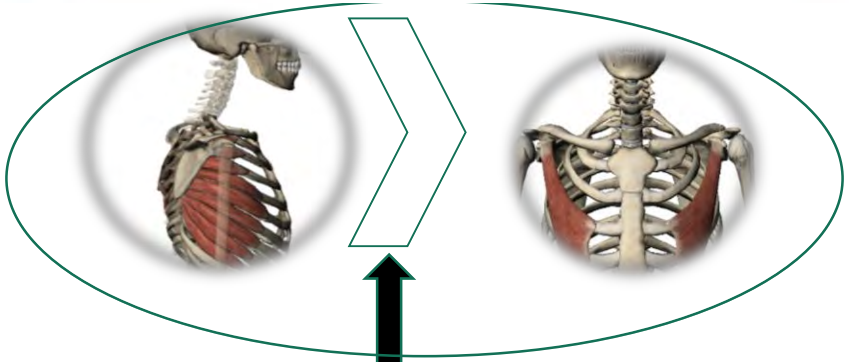
<u>* During the Serratus Punch:</u>
SA activity significantly higher than Pm activity

- <u>Pectoralis Minor:</u>



* <u>Serratus Anterior:</u>





CONCENTRIC PHASE OF THE PROTRACTION EXERCISES

CONCENTRIC

ECCENTRIC

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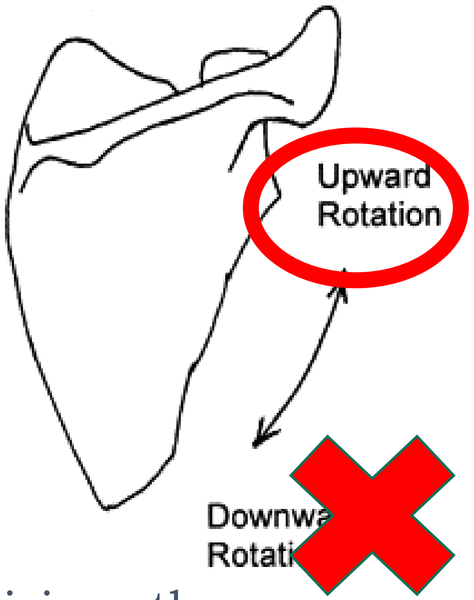
Manual Therapy

Original article

Modifying the shoulder joint position during shrugging and retraction exercises alters the activation of the medial scapular muscles

Birgit Castelein [a,*], Ann Cools [a], Thierry Parlevliet [b], Barbara Cagnie [a]



- In patients with scapular dysfunction:
  often imbalance between upward rotators & downward rotators
  => can cause abnormalities in coordinated scapular rotation

- Exercises with focus on activation of upward rotators while minimizing the activation of the downward rotators

- Shrug exercises are often recommended to activate muscles that produce upward rotation, but little information is available on the activity of the downward rotators during shrugging exercises

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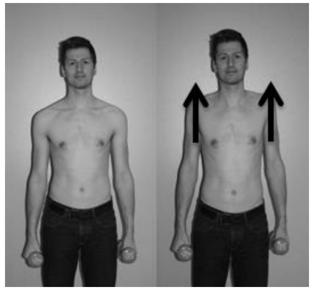
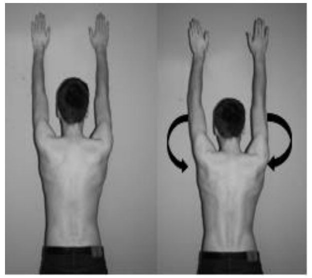
- 26 HEALTHY SUBJECTS(15♀, 11♂)
- MEDIAL SCAPULAR MUSCLES: UT, LS, MT, RM & LT
- 3 EXERCISES:

SHRUG



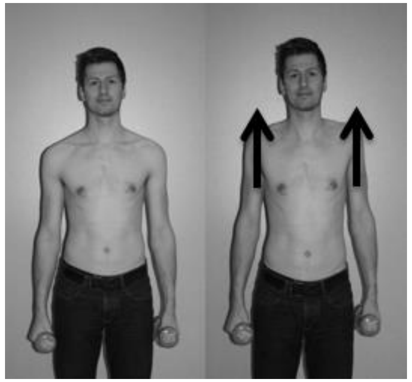
SHRUG OVERHEAD

RETRACTION OVERHEAD

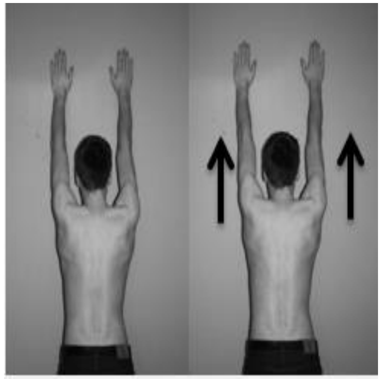


	Shrug	ShrugOverhead	RetractionOverhead
Upper Trapezius	33.8 ± 12.9	25.8 ± 11.9	28.4 ± 12.5
Middle Trapezius	8.1 ± 5.3	6.9 ± 4.6	16.1 ± 11.6
Lower Trapezius	3.4 ± 1.9	7.2 ± 4.5	22.4 ± 8.2
Levator Scapulae	44.0 ± 25.8	19.1 ± 14.1	25.9 ± 22.7
Rhomboid Major	18.8 ± 15.0	10.3 ± 7.3	29.9 ± 15.7

TABLE 1. EMG Activity (%MVIC) of each scapular muscle during the different exercises.



Similar UT



Similar UT
↓ LS & RM

Similar UT
↑ MT, LT & RM

Alterations in scapulothoracic muscle activity can be present in patients with shoulder or neck pain:

REHABILITATION

RESEARCH & CLINICAL PRACTICE:

- MIDDLE TRAPEZIUS, LOWER TRAPEZIUS, SERRATUS ANTERIOR: **ACTIVATION**
- PECTORALIS MINOR: **AVOID ACTIVATION**
- LEVATOR SCAPULAE, RHOMBOID MAJOR & UPPER TRAPEZIUS: **????**
    - LEVATOR SCAPULAE: clinical experience: overactive & shortened
    - RHOMBOID MAJOR
    - UPPER TRAPEZIUS

⇒ **SPECIFIC NEEDS AND MUSCLE DYSFUNCTIONS MAY VARY BETWEEN INDIVIDUALS**

⇒ **CLINICAL EXAMINATION: CRUCIAL TO FIND POSSIBLE MUSCLE DYSFUNCTION AND INDIVIDU-SPECIFIC REHABILITATION PROGRAM**

SCAPULA properly positioned?




- **Clinical tools?**

  Struyf et al. 2014:

  “Clinical assessment of the scapula: a review of the literature”

Br J Sports Med. 2014 Jun;48(11):883-90. doi: 10.1136/bjsports-2012-091059. Epub 2012 Jul 21.

Clinical assessment of the scapula: a review of the literature.

Struyf F[1], Nijs J, Mottram S, Roussel NA, Cools AM, Meeusen R.

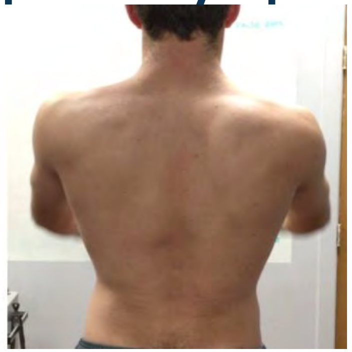
Author information

Abstract

Scientific evidence supporting a role for faulty scapular positioning in patients with various shoulder disorders is cumulating. Clinicians who manage patients with shoulder pain and athletes at risk of developing shoulder pain need to have the skills to assess static and dynamic scapular positioning and dynamic control. Several methods for the assessment of scapular positioning are described in scientific literature. However, the majority uses expensive and specialised equipment (laboratory methods), making their use in clinical practice nearly impossible. On the basis of biometric and kinematic studies, guidelines for interpreting the observation of static and dynamic scapular positioning pattern in patients with shoulder pain are provided. At this point, clinicians can use reliable clinical tests for the assessment of both static and dynamic scapular positioning in patients with shoulder pain. However, this review also provides clinicians several possible pitfalls when performing clinical scapular evaluation. On the basis of its clinical relevance, its proven reliability, its relation to body length and its applicability in a clinical setting, this review recommends to assess the scapula both static (visual observation and acromial distance or Baylor/double square method for shoulder protraction) and semidynamic (visual observation and inclinometry for scapular upward rotation). In addition, when the patient demonstrates with shoulder impingement symptoms, the scapular repositioning test and scapular assistant test are recommended for relating the patients' symptoms to the position or movement of the scapula.

SCAPULA properly positioned?






- **CLINICAL TOOLS?**

  Struyf et al. 2014:

  “Clinical assessment of the scapula: a review of the literature”

  ⇒ Overview of different reliable clinical tools for both static and dynamic positioning of the scapula, **but no real cut-off value**

  NO CONSENSUS -> it is up to the clinician to decide when scapular dysfunction or scapular muscle dysfunction is present

- Current recommendation?
  - => SCAPULAR DYSKINESIS TEST

"clinical observation of the medial and inferior scapular borders for winging or medial border prominence, lack a smooth coordinated movement as exemplified by early scapular elevation or shrugging during ascending arm forward flexion, and rapid downward rotation during arm lowering from full flexion."

YES or NO

Role of scapular dyskinesis?

- Scapular dyskinesis can be present in overhead athletes too
- 3 prospective studies (Clarsen et al. 2014, Kawasaki et al. 2012, McKenna et al. 2012):
  - Association between scapular dysfunction and development shoulder pain
- 2 prospective studies (Myers et al. 2013, Struyf et al. 2014)
  - No association between scapular dysfunction and development of shoulder pain

Prospective studies

- 1) Kawasaki et al. (2012) showed that scapular dyskinesis, based on visual observation, **is a risk factor** for shoulder pain during the season in professional rugby players.
- 2) Myers et al. (2013) reported that scapular dysfunction, identified during preseason screening, could **not be established as a prospective risk factor** for throwing-related upper extremity injuries in high school baseball players.
- 3) Shitara et al. (2015) did also **not identify scapular dyskinesis as a risk factor** for shoulder and elbow injuries in high school baseball pitchers.
- 4) Clarsen et al. (2014) showed that obvious scapular dyskinesis **is a risk factor** for shoulder injuries among elite male handball players.
- 5) A prospective study of Struyf et al. (2014) investigated possible scapular related risk factors for developing shoulder pain. It was found that scapular characteristics **could not predict** the development of shoulder pain in the overhead athlete population.

Presence of scapular dyskinesis: contributing factor to the symptoms of the patient?

⇒SYMPTOM ALTERATION TESTS:

= identify if scapular dyskinesis is driving symptoms by manually correcting the scapula during provocation testing

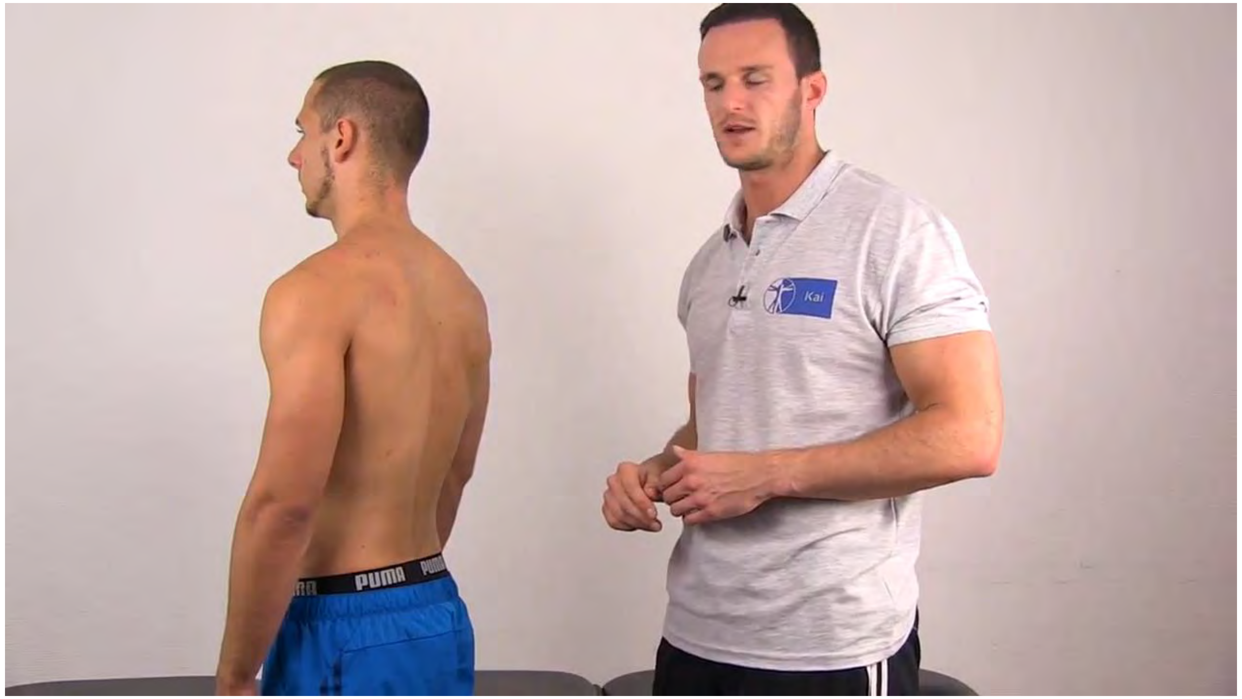
*Scapular Assistance Test (SAT)

*Scapular Retraction Test (SRT)

*(Shoulder symptom modification procedure (SSMP))

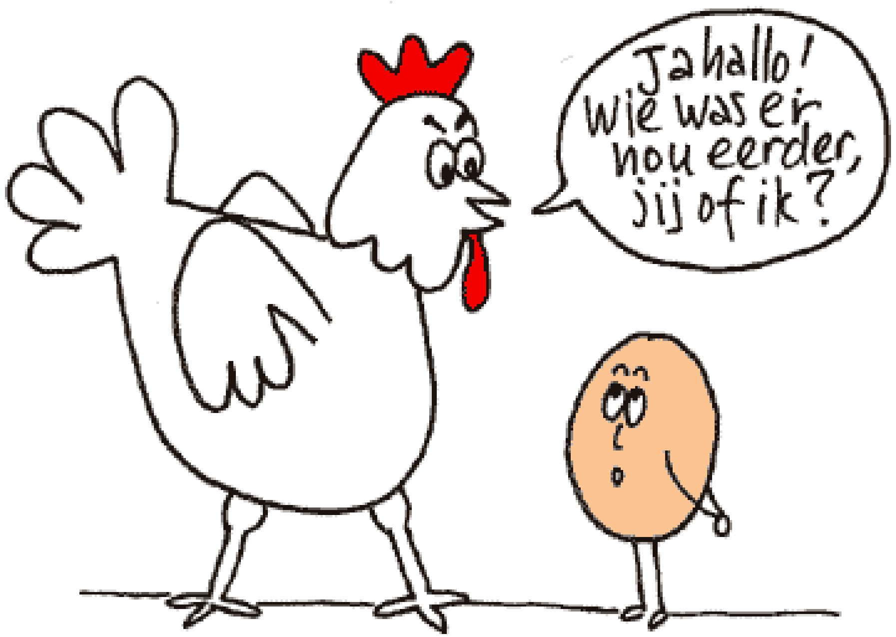
SCAPULAR ASSISTANCE TEST

SCAPULAR RETRACTION TEST



If there is a relation between scapula and symptoms

⇒Inclusion in the rehabilitation



SCAPULAR REHABILITATION PROGRAM

SCAPULOTHORACIC MUSCLE DYSFUNCTION	TREATMENT
LACK OF SOFT TISSUE FLEXIBILITY	**STRETCHING AND MOBILISATION**
PECTORALIS MINOR LEVATOR SCAPULAE	*MANUAL SOFT TISSUE TECHNIQUES AND MOBILISATION *MANUAL STRETCHING AND MOBILISATION WITH MOVEMENT *HOME STRETCHING *TRIGGER POINT THERAPY
UPPER TRAPEZIUS RHOMBOIDEI	
MIDDLE TRAPEZIUS LOWER TRAPEZIUS SERRATUS ANTERIOR	**STRENGTH TRAINING**
LACK OF MUSCLE PERFORMANCE (control or strength)	**NEUROMUSCULAR COORDINATION TRAINING**

FUNCTIONAL TRAINING

STRENGTH/ENDURANCE TRAINING

BALANCE-RATIO TRAINING

CONSCIOUS MUSCLE CONTROL

SCAPULAR REHABILITATION PROGRAM

SCAPULOTHORACIC MUSCLE DYSFUNCTION	TREATMENT
LACK OF SOFT TISSUE FLEXIBILITY	**STRETCHING AND MOBILISATION**
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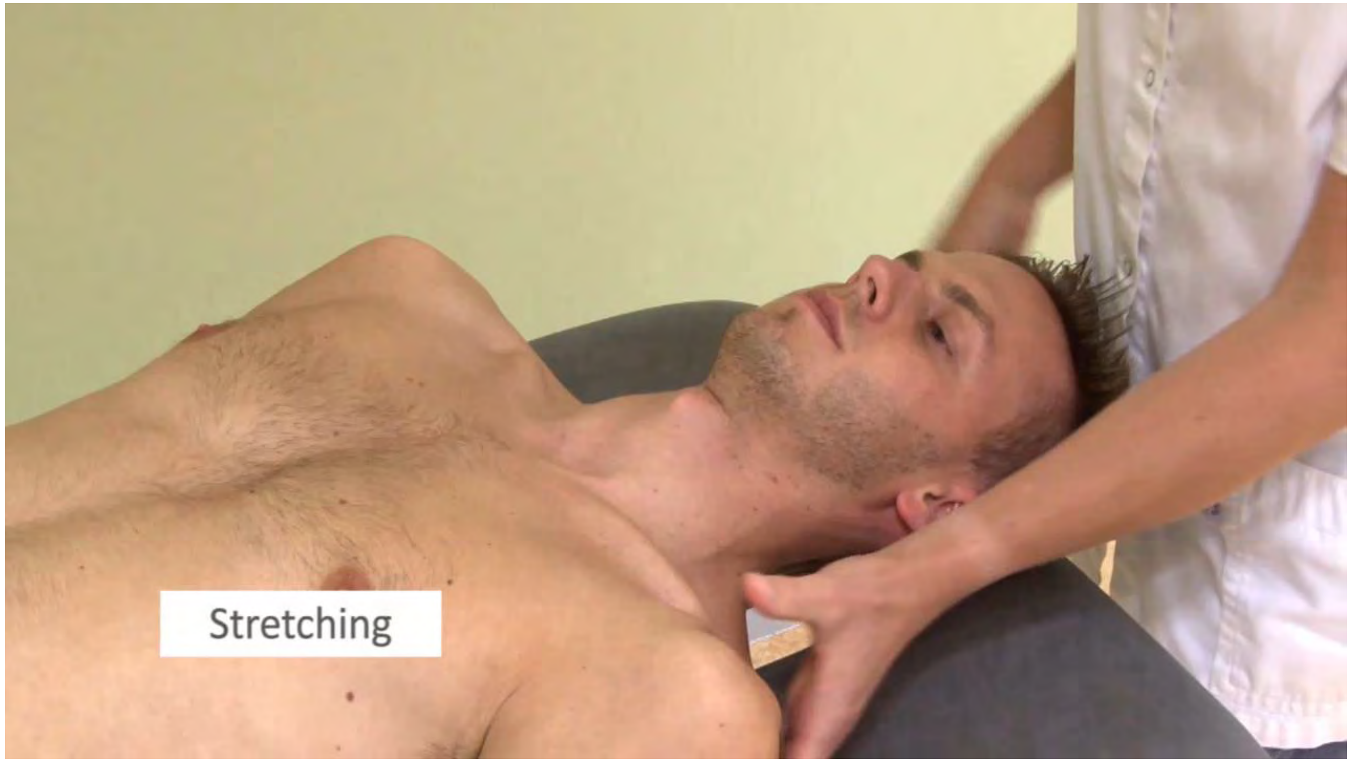
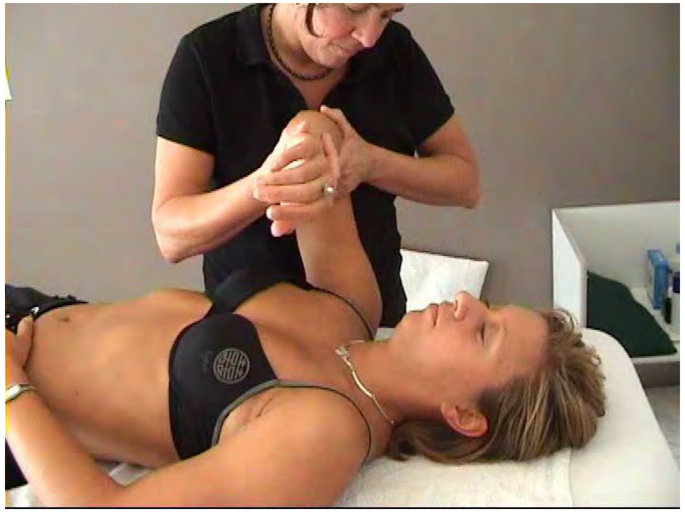
Stretching Pectoralis Minor

Stretching Levator Scapulae



Stretching Trapezius pars descendens

Stretching Posterior Capsule



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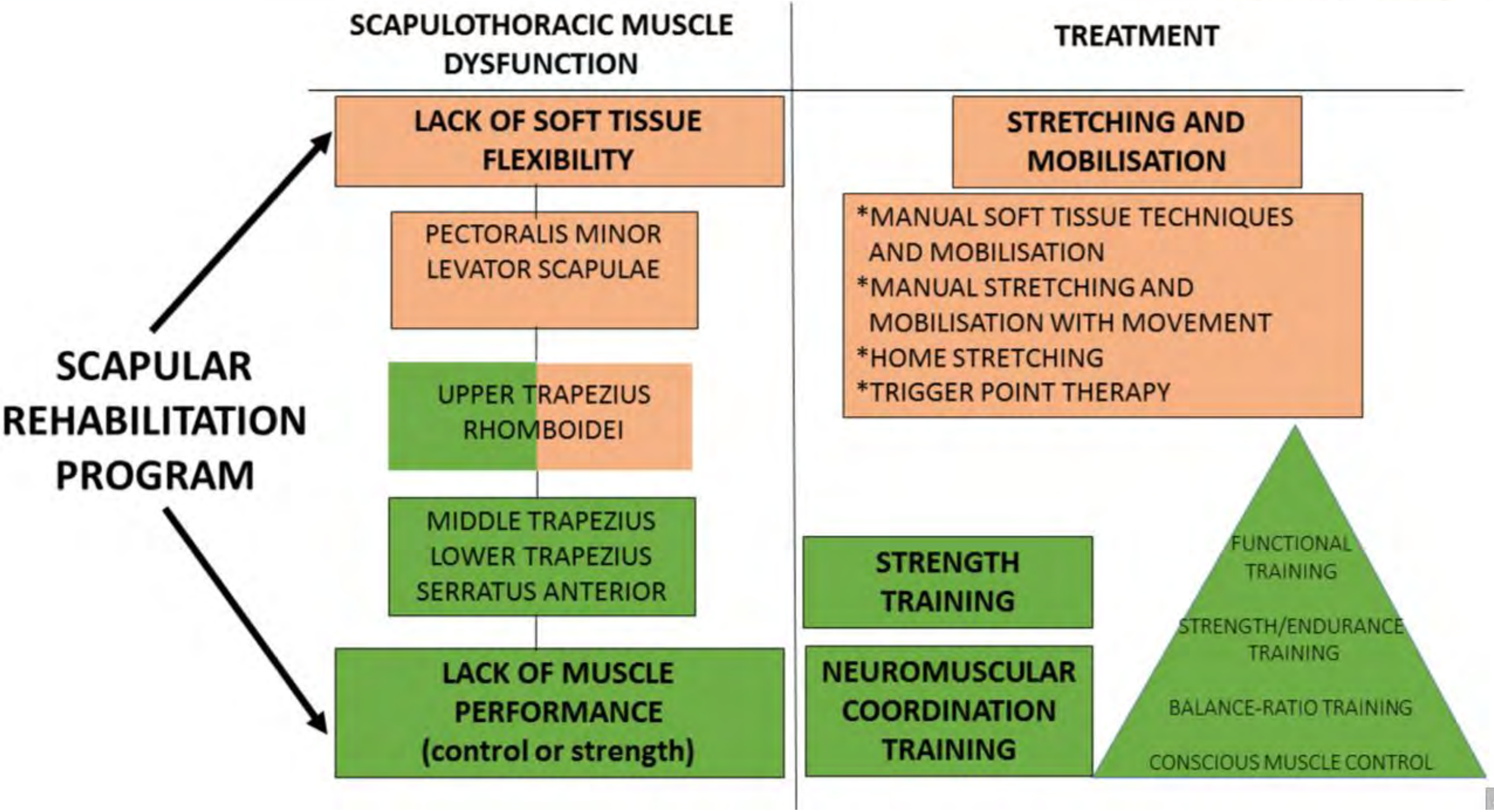
SCAPULOTHORACIC MUSCLE DYSFUNCTION
TREATMENT
SCAPULAR REHABILITATION PROGRAM
LACK OF SOFT TISSUE FLEXIBILITY
PECTORALIS MINOR
LEVATOR SCAPULAE
UPPER TRAPEZIUS
RHOMBOIDEI
MIDDLE TRAPEZIUS
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*HOME STRETCHING
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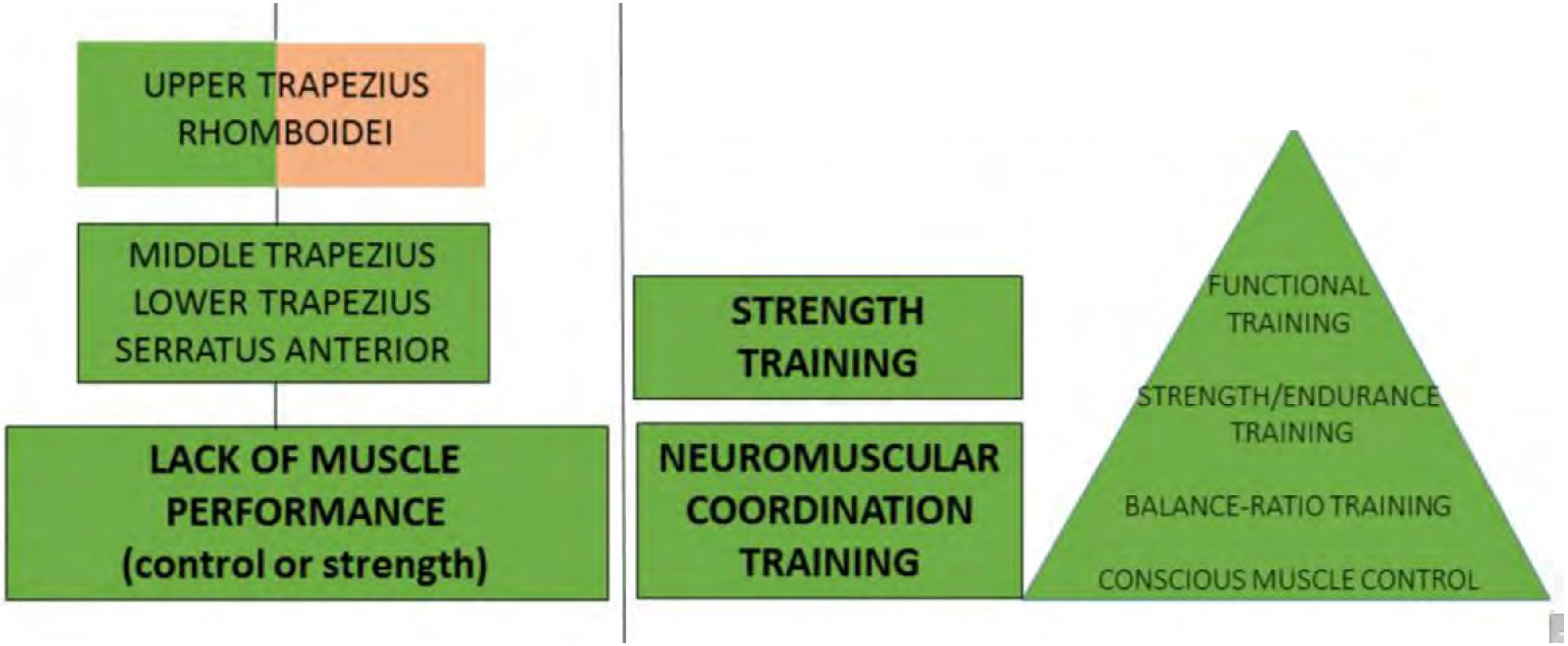
SCAPULAR REHABILITATION PROGRAM



TRAINING

=> CRUCIAL TO SELECT THE MOST APPROPRIATE EXERCISE ACCORDING TO THE INDIVIDUAL PRESENTATION OF THE PATIENT

=> RECOMMENDATIONS FOR EXERCISES

<u>Clinical Examination</u>
Inspection
Palpation
Manual Muscle Testing
Symptom alteration tests
Etc.

- In the past:

    Choice for exercises based upon knowledge from Trapezius and Serratus Anterior

- Now:

    Take into account the activity of the deeper lying muscles also!!

Focus Upper Trapezius:

- Promote activation of UT (upward rotation)

- Avoid activation of UT (muscle is too active)

Focus Upper Trapezius:

- Promote activation of UT (upward rotation)
  - Clinically: downward rotation of the scapula

Focus Upper Trapezius:

- **Promote activation UT (upward rotation)**
  - Clinically: downward rotation of the scapula
    - => exercises with focus on upward rotation with minimal activation of downward rotators

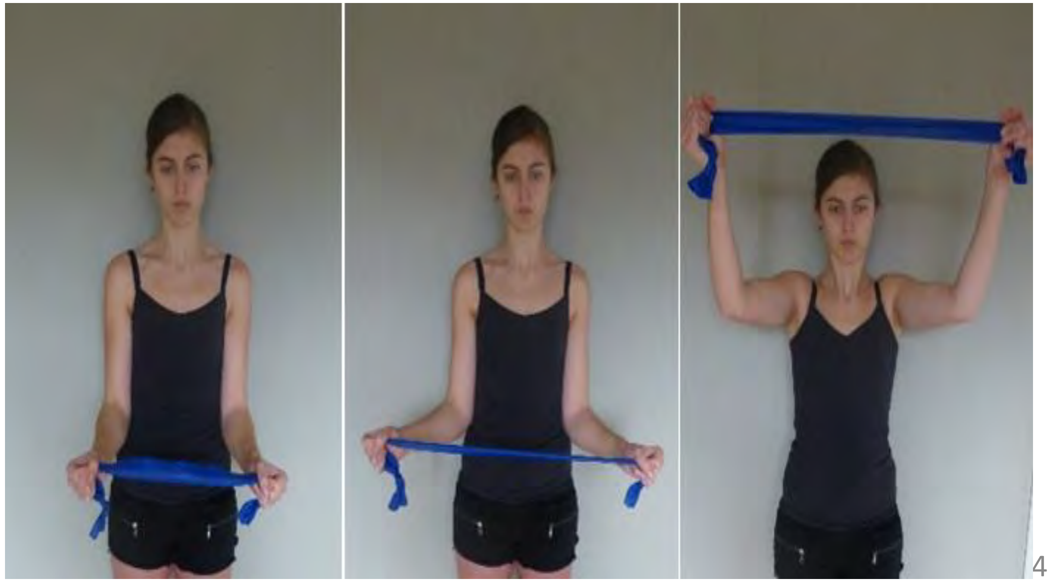
    = SHRUGOVERHEAD

Focus Upper Trapezius:

- **Avoid activation UT (muscle is already too active)**
  - Clinically: shrugging sign

    * TOWEL WALL SLIDE

    *ELEVATION WITH EXTERNAL ROTATION



Ratio's:

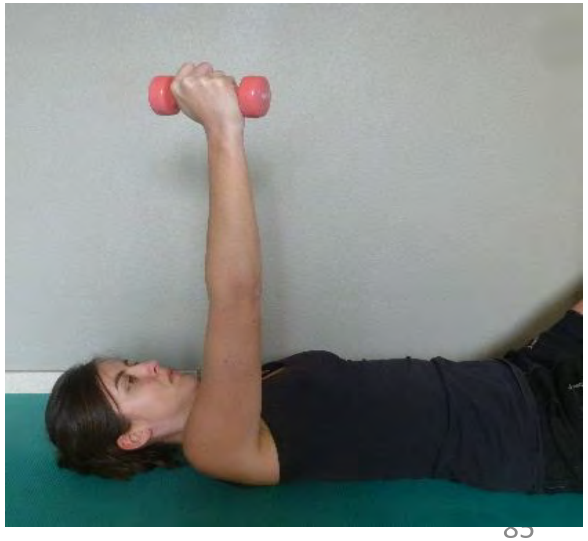
- **Between Trapezius en Serratus Anterior:**

  *** low UT/SA:**

  elbow push-up/prone bridging

  serratus punch supine

  serratus punch in GKK (bench slide).



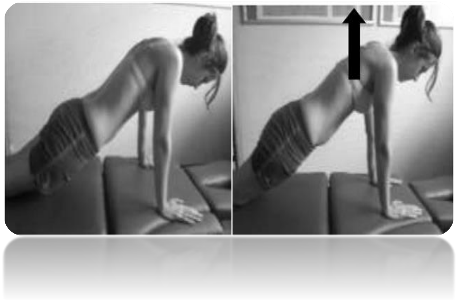
Focus Serratus Anterior:

- **Promote activation SA**
  - Clinically: internal rotation of the scapula, prominence medial borderr (scapula alata of winging) or prominent angulus inferior or excessive anterior tilting



⇒Exercises with focus on SA:

⇒Serratus punch > push-up floor > push-up wall


Focus Serratus Anterior:

- Promote activation SA
  - Clinically: internal rotation of the scapula, prominence medial borderr (scapula alata of winging) or prominent angulus inferior or excessive anterior tilting

⇒ Exercises with focus on SA:

⇒ Serratus punch > push-up floor > push-up wall

⇒ Exercises with low Pm/SA ratio:

⇒ SERRATUS PUNCH

Ratio's:

- **Between different parts of Trapezius:**
    - Low UT/MT & UT/LT

Sidelying forward flexion

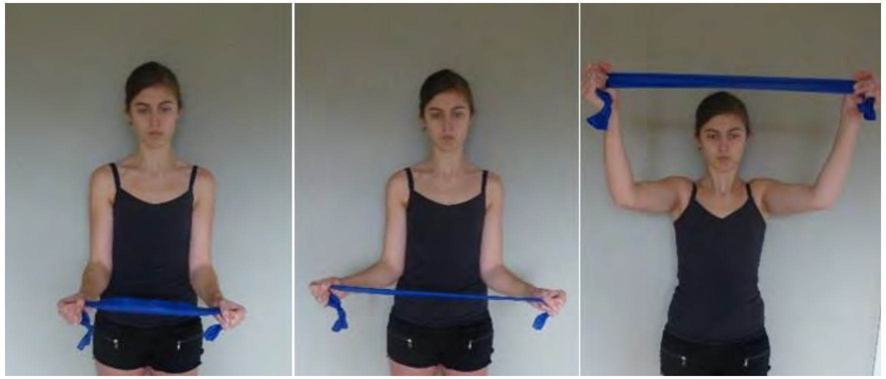
Prone horizontal abduction with external rotation

Sidelying External Rotation

Prone Extension

Focus Rhomboid:

- **Promote activation RM:**
  - elevation with external rotation



- **Avoid activation RM:**
  - towel wall slide

- High UT
- Low LS

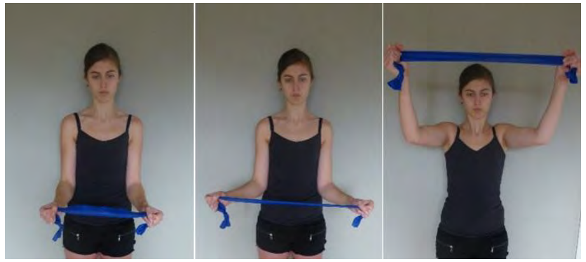
ShrugOverhead

- High SA
- Low UT

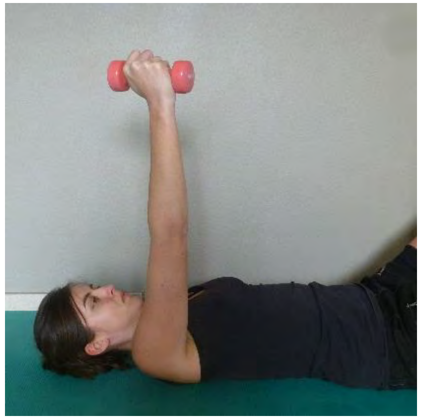
Towel Wall Slide

Prone bridging/
Elbow Push-Up

Bilateral Elevation with External Rotation

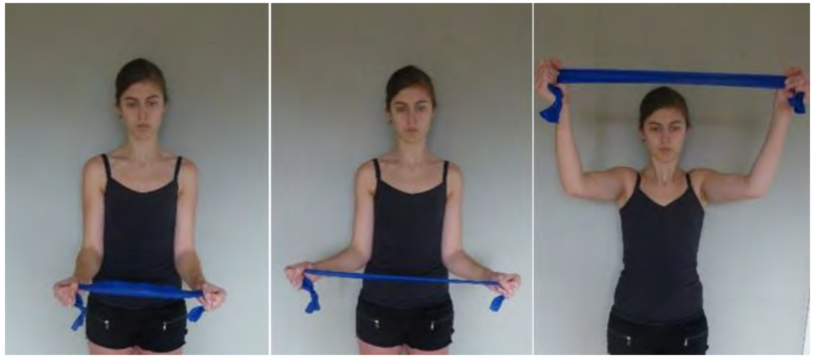


Serratus Punch Supine



- High LT
- Low Pm

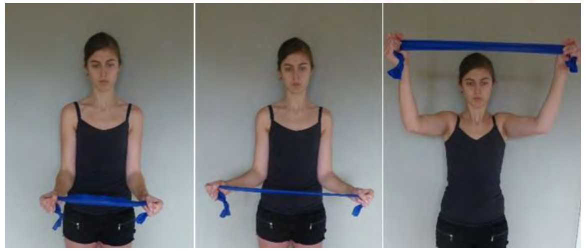
Bilateral Elevation with External Rotation

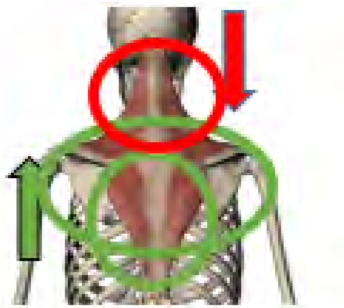


- High SA
- Low Pm

Serratus Punch

Bilateral Elevation with External Rotation





- High MT
  High LT
- Low UT

Sidelying forward flexion

Prone horizontal abduction with external rotation

Sidelying External Rotation

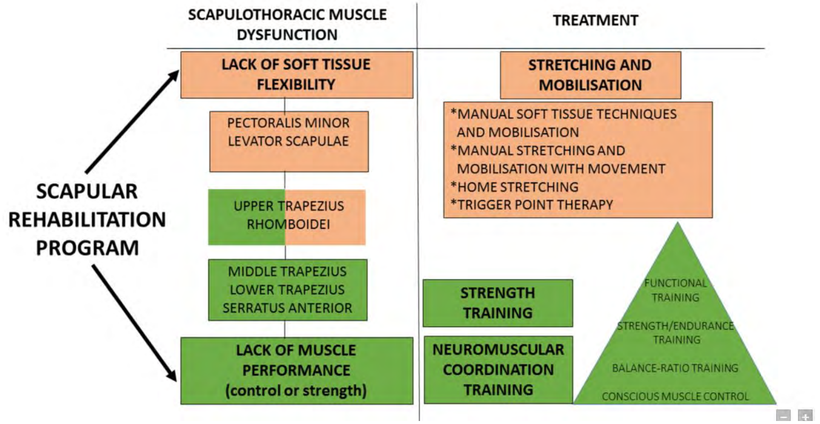
Prone Extension

CONCLUSION

- ALTERATIONS IN SCAPULOTHORACIC MUSCLE ACTIVITY CAN BE PRESENT IN PATIENTS WITH SHOULDER AND NECK PAIN

  + POSSIBLE ROLE PECTORALIS MINOR

- CRUCIAL TO SELECT THE MOST APPROPRIATE EXERCISE ACCORDING TO THE SPECIFIC NEEDS/INDIVIDUAL PRESENTATION OF THE PATIENT



Overview

1. Analysis of recruitment of the superficial and deep scapular muscles in patients with chronic shoulder or neck pain, and implications for rehabilitation exercises
2. Shoulder impingement: can one label satisfy everything?
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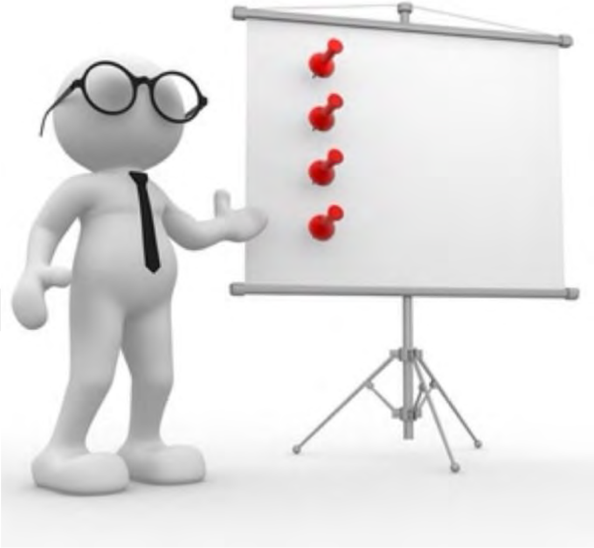

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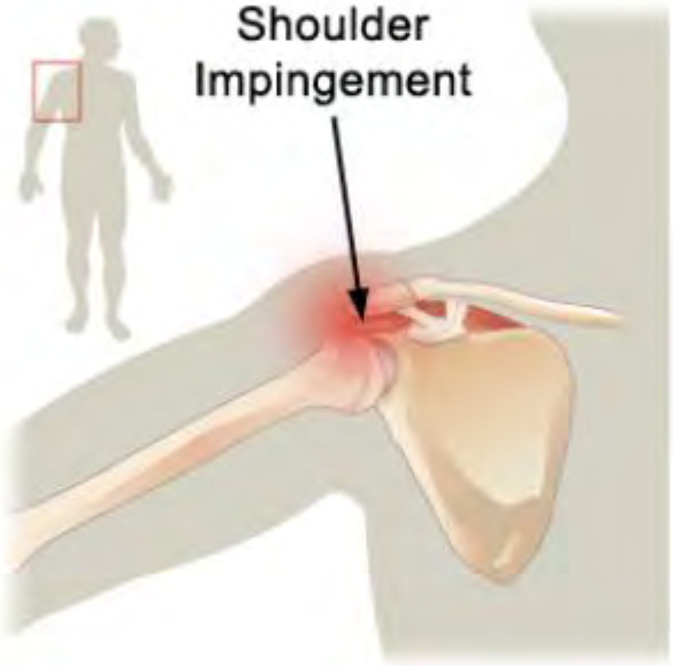
Shoulder impingement: can one label satisfy everything?



Br J Sports Med. 2017 Mar;51(5):416-417. doi: 10.1136/bjsports-2016-096772. Epub 2016 Nov 2.

Shoulder pain: can one label satisfy everyone and everything?

Cools AM[1], Michener LA[2].

"Subacromial Impingement *Syndrome*" (Neer)

⇒ diagnostic: structural impingement of the structures in the subacromial space

⇒ controversial: does not fully explain the mechanism

"Impingement related shoulder pain"

= Impingement = cluster of symptoms and possible mechanism for pain, rather than pathoanatomic diagnose itself

SURGERY VERSUS PHYSIOTHERAPY

Structural anatomy,
pathoanatomical diagnostic labels

Movement-related impairments
(motor control, soft tissue strength, flexibility, functional osteokinematics and arthrokinematics)

~~SIS as diagnostic label~~

Diagnostic labels based on tissue-specific pathology fail to accurately classify the patient into subgroups for clinical decision making

~~SIS as subacromial conflict~~

Subacromial Pain Syndrome

- Discussion on terminoloy:
  - Subacromial pain syndrome
  - Rotator cuff disease
  - Anterolateral shoulder pain
    or shoulder pain of unknown aetiology

=> no single label to satisfy everyone and everything

- Abandon “perfect name” for the problem & “umbrella” terminology

- Shoulder pain can be caused by several mechanisms:
  - Bursa, rotator cuff, tendon failure, central sensitisation, muscle imbalances etc.
  - No single label to cover all the mechanisms and pathologies associated with pain of the subacromial region

Non-traumatic shoulder pain is multifactoral

> “We should not try to put all patients under the same umbrella – the umbrella will never be big enough to keep every-one out of the rain”
>
> “Better to create several umbrellas to put our patients under and keep them dry”

- Classifying patients into subcategories like:
  - flexibility deficits versus muscle dysfunction,
  - high versus low irritability
  - glenohumeral versus scapulothoracic impairment,
  - strength deficits versus motor control impairment
  - Etc.
- Labelling of patients, but also individually based approach

Overview

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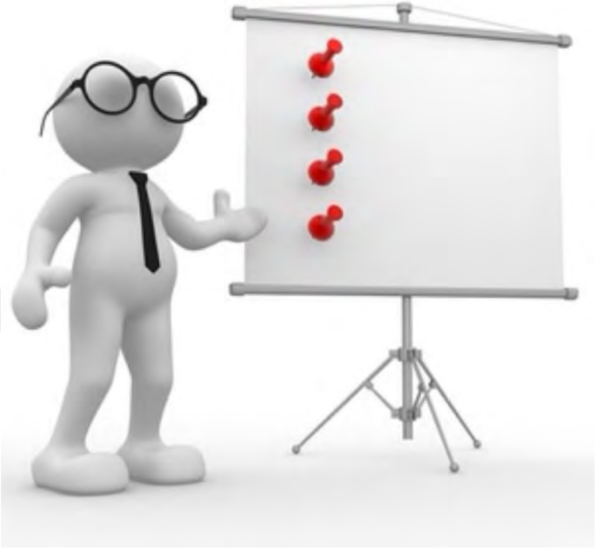
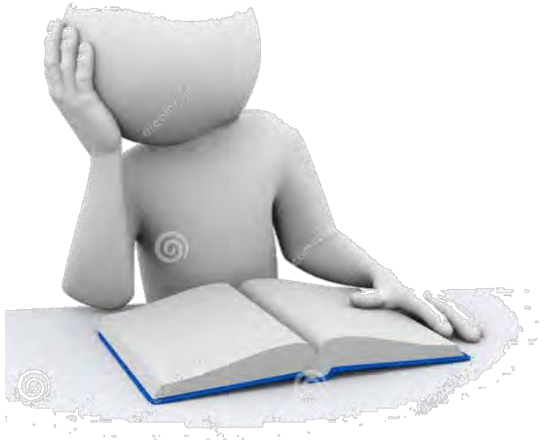


Central pain processing in shoulder pain?

“Despite the large group of individuals seeking for primary-care services, about 50% of patients with shoulder pain still report persistent pain after 12 months.”

“Chronic shoulder pain often cannot be explained by an obvious anatomic defect or tissue damage”



- **Central sensitization:**
  = An amplification of neural signaling within the central nervous system that elicits pain hypersensitivity
    - => minimal tissue damage or sensory input without tissue damage can be sufficient to trigger pain

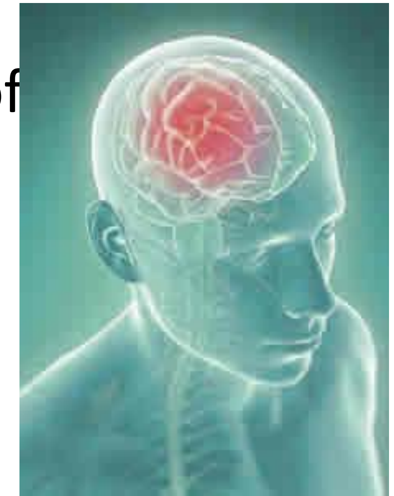
- Sensitivity of the tissues can be altered
  - within the injured area (primary hyperalgesia)
  - but also in the adjacent, uninjured tissue (secondary hyperalgesia)

- Central sensitisation has already been found in various chronic pain populations including:
  - Chronic Whiplash, Fibromyalgia, Carpal Tunnel Syndrome, Osteoarthritis, Tension-type headache, temporomandibular joint pain

Central Pain Processing in Patients with Shoulder Pain: A Review of the Literature

Suzie Noten, MSc[*,†]; Filip Struyf, PhD[*]; Enrique Lluch, PhD, MSc[†,‡]; Marika D'Hoore, PT, MSc[*]; Eveline Van Looveren, PT, MSc[*]; Mira Meeus, PhD[*,†,§]

- Central sensitization might play a role in a subgroup of these shoulder patients.
- Conclusion:
  - In patients with musculoskeletal shoulder pain, there is involvement of central nervous system



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The role of central sensitization in shoulder pain: A systematic literature review

Marc N. Sanchis, PT[a], Enrique Lluch, PT[b,c,d,e,*], Jo Nijs, PT, PhD[c,d,e], Filip Struyf, PT, PhD[c,f], Maija Kangasperko, PT[a]

Conclusion: Although peripheral mechanisms are involved, hypersensitivity of the central nervous system plays a role in a subgroup within the shoulder pain population.

Evaluation of CS?

- No golden standard!
- *Quantitative sensory testing*
  - *Pain pressure tresholds*
- *Conditioned pain modulation*
- *Exercise-induced endogenous analgesia*

Central sensitisation manifests itself at different degrees over a continuum from none at all to severe

Some evidence that psychological factors could be associated with prognosis of CSP

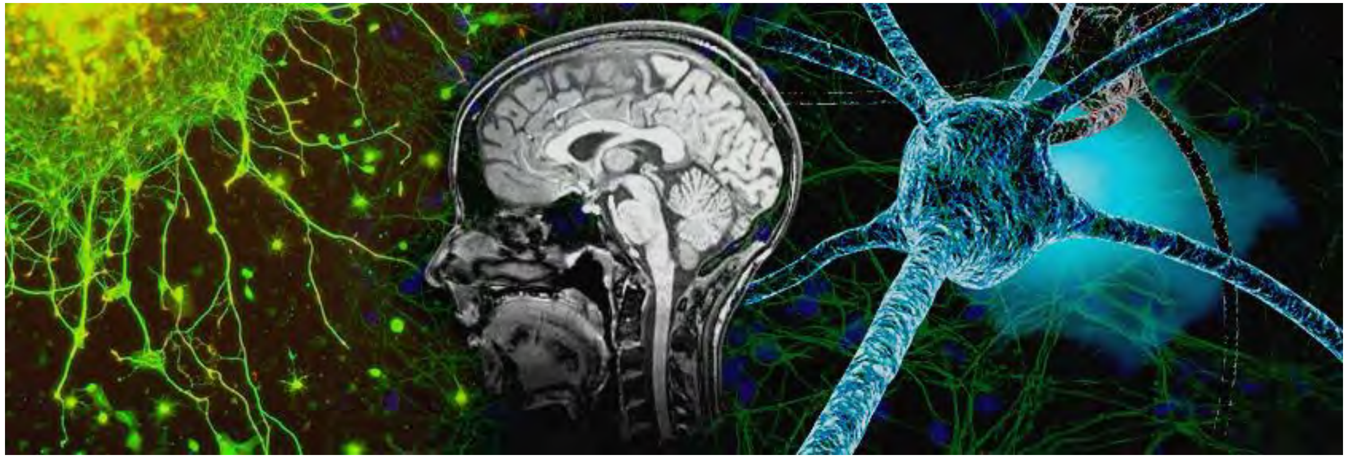
- **Reilingh et al. (2008) Rheumatology** investigated the course and prognosis of shoulder pain in the 6 first months after presentation to the GP. Predictors of a better outcome for CSP were *lower scores on pain catastrophising and higher baseline pain intensity*.
- **Gill et al. (2013) ACR** examined which factors are predictive of incident, recurrent or resolved shoulder pain in a community-based sample from the general population. Findings showed how recurrent shoulder pain was associated with *depressive symptoms*.
- **Chester et al. (2016) BJSM** aimed to identify which baseline patient and clinical characteristics are associated with a better outcome, 6 weeks and 6 months after starting a course of physiotherapy for shoulder pain. In this study, *higher patient expectation* of complete recovery compared to slight improvement because of physiotherapy and *higher pain self-efficacy* were associated with patient-rated outcomes.
- **=> psychological factors could play a role in people with shoulder pain and favour the perpetuation of chronic shoulder pain**

Overview **different questionnaires:**

- Kinesiophobia and pain-related fear
  - FACS: Fear – Avoidance Components Scale
- Pain Catastrophizing
  - PCS: Pain Catastrophising Scale
- Anxiety and Depression
  - HADS: Hospital Anxiety and Depression Scale
- Patient expectations of recovery
  - scale: “How likely is it that within the next 3 months you will have resumed some form of recovery?”

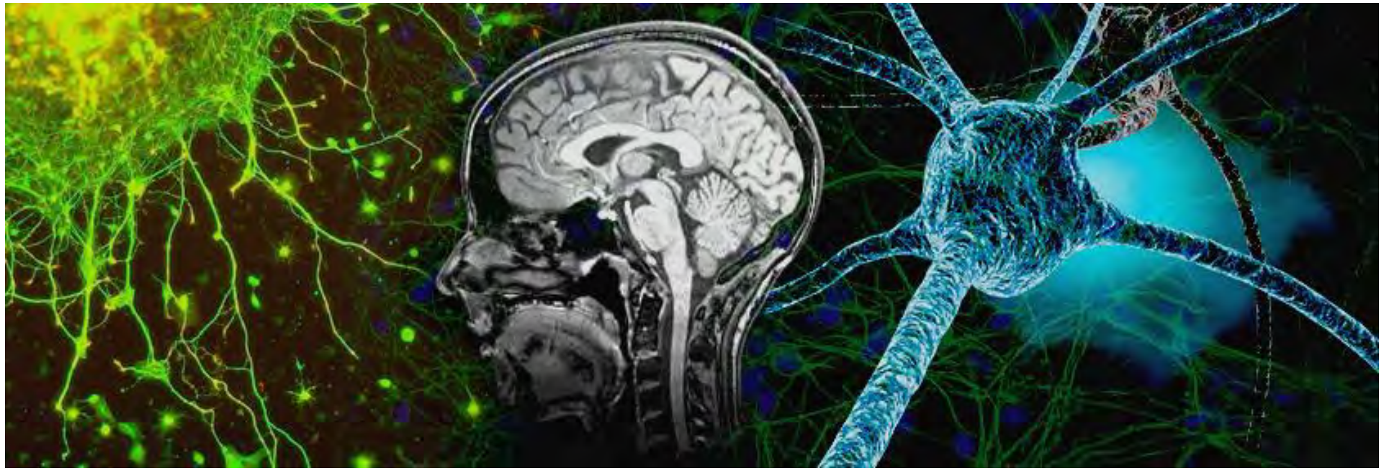
similar clinical presentation ≠ equal pain processing mechanisms underlying their symptoms

=> could explain why some patients fail to recover after standard treatment directed at peripheral targets.



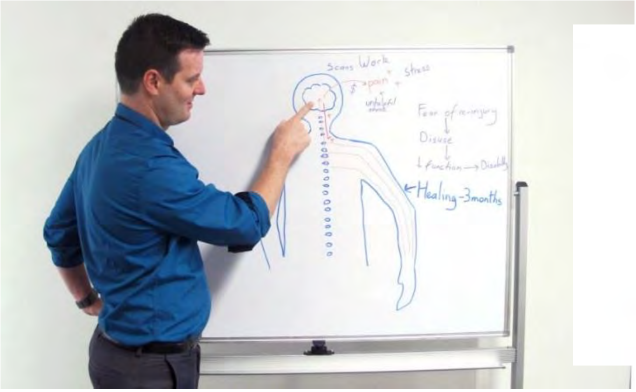
“Clinicians should be encouraged to identify patients with chronic shoulder pain who show psychological symptoms (beliefs, attitudes, expectations) in the preliminary assessment”

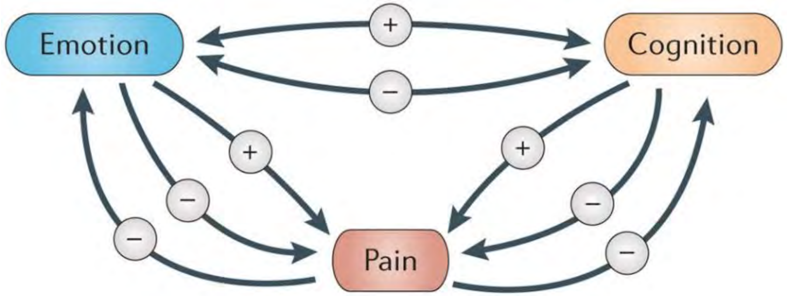
⇒possibility to consider **other therapeutic interventions** rather than physical therapies for chronic shoulder pain



Pain neuroscience education

=> decreasing hyperexcitability of the central nervous system





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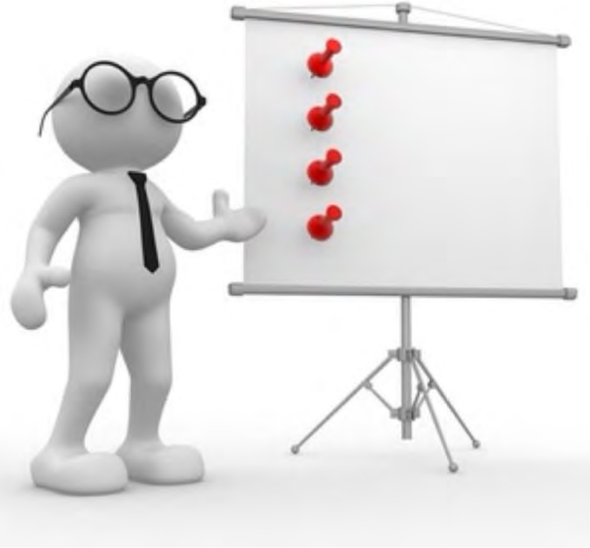

Progression in biceps load during rehabilitation exercises

=> Help for the clinician for the nonoperative and postoperative treatment of biceps-related disorders and superior labrum anterior-posterior (SLAP) lesions in overhead athletes

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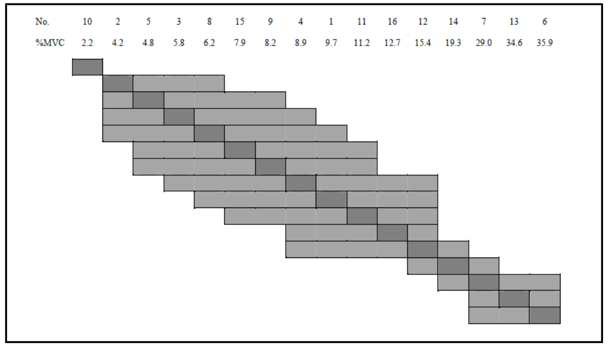
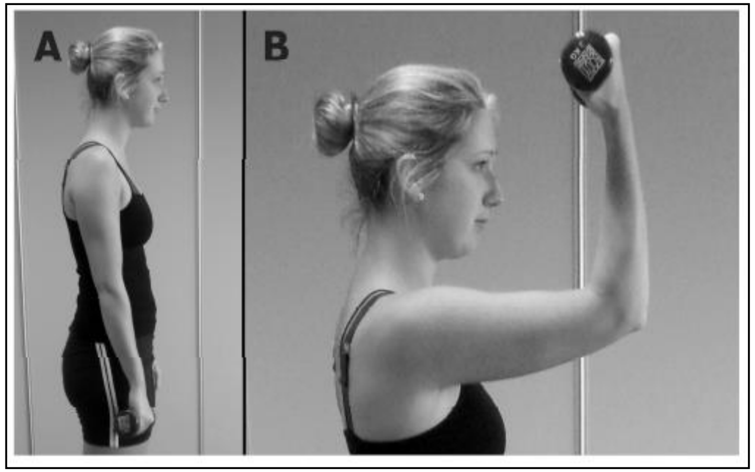
Rehabilitation Exercises for Athletes With Biceps Disorders and SLAP Lesions

A Continuum of Exercises With Increasing Loads on the Biceps

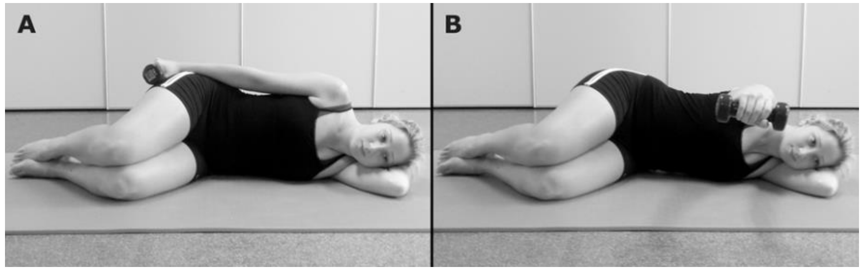
Ann M. Cools,*[†] PT, PhD, Dorien Borms,[†] PT, MSc, Simon Cottens,[†] PT, MSc, Marcia Himpe,[†] PT, MSc, Stijn Meersdom,[†] PT, MSc, and Barbara Cagnie,[†] PT, PhD
Investigation performed at the Department of Rehabilitation Sciences and Physiotherapy, Faculty of Medicine and Health Sciences, Ghent University, Ghent, Belgium

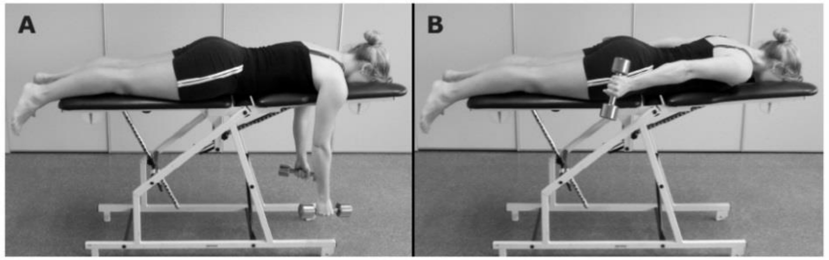


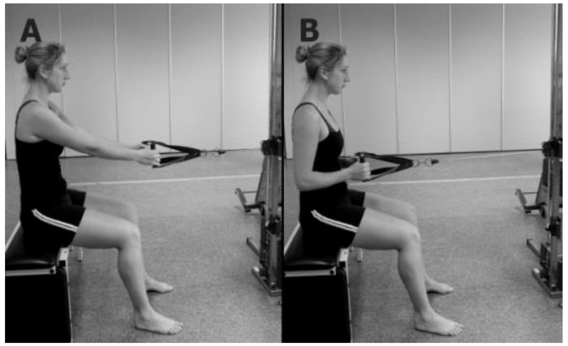


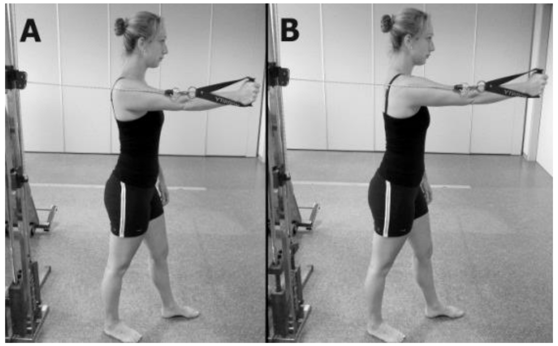
	UT		MT		LT		SA		DA		DP		BB		TB	
No.	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	32,7	11,09	78,3	45,37	76,6	38,66	10,3	9,41	43,4	22,21	125,6	66,40	9,7	6,18	33,8	17,49
2	17,1	11,54	36,1	15,32	28,6	34,56	10,3	6,44	7,8	4,14	64,6	21,69	4,2	2,05	50,1	16,85
3	14,2	11,20	23,1	12,50	14,8	19,66	4,1	3,12	7,3	4,56	31,0	14,84	5,8	4,61	8,9	6,02
4	8,9	6,81	6,0	3,35	5,9	4,00	42,7	15,49	53,2	25,09	12,2	10,60	8,9	7,49	16,3	7,69
5	11,5	5,17	10,2	5,71	8,5	5,60	37,0	18,12	41,2	20,12	8,3	5,83	4,8	3,15	30,5	12,72
6	48,2	22,42	31,3	15,68	41,0	24,04	68,9	16,85	107,9	44,97	17,8	10,50	35,9	18,82	15,7	8,05
7	55,2	22,74	45,4	17,09	45,2	27,31	58,1	14,88	106,4	39,32	27,5	18,61	29,0	16,69	16,0	10,76
8	2,7	1,99	3,2	1,99	4,2	2,17	9,4	5,49	15,7	12,36	2,0	1,55	6,2	3,51	5,9	4,43
9	22,3	12,09	57,5	25,05	75,1	48,97	13,3	8,97	11,4	7,27	49,5	22,48	8,2	5,10	21,7	10,79
10	3,2	2,26	3,3	1,74	3,0	1,82	4,6	3,18	4,3	3,90	3,4	2,60	2,2	1,24	10,7	5,26
11	23,7	9,93	44,6	40,07	74,9	56,26	43,6	14,36	13,7	18,04	38,6	23,85	11,2	6,04	17,5	12,20
12	4,7	3,39	11,8	11,08	20,6	18,88	5,8	4,10	4,1	2,45	19,4	14,34	15,4	7,19	18,7	12,67
13	2,9	2,00	7,2	6,44	21,7	17,78	8,1	5,07	10,8	9,23	5,6	3,31	34,6	15,91	10,3	5,72
14	33,0	19,20	20,2	10,99	32,5	19,65	47,9	14,01	80,5	32,36	11,1	6,20	19,3	10,06	9,7	5,90
15	7,9	5,29	6,4	4,69	6,0	4,86	15,0	8,93	14,0	11,56	5,8	3,61	7,9	4,63	14,7	6,73
16	43,6	21,14	48,7	16,48	55,8	30,34	48,0	17,09	53,2	23,16	41,3	23,35	12,7	5,40	16,4	9,97

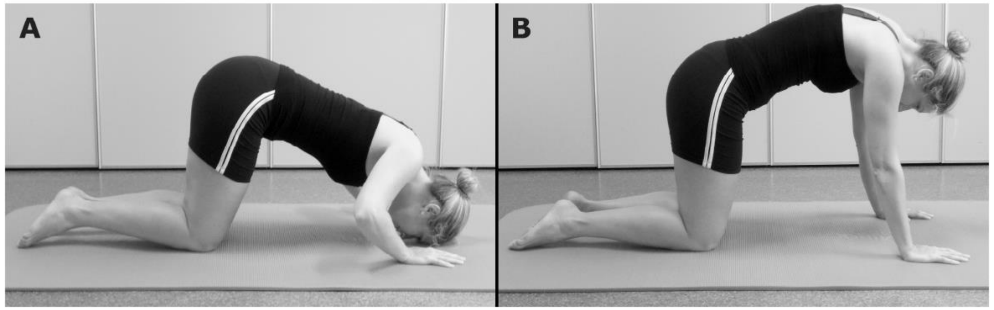
SCAPULOTHORACIC MUSCLE GROUP











	1	Forward flexion in side-lying position[9]
	2	Prone extension[9, 42]
	3	Seated rowing[9, 13, 20, 31-32]
	4	Serratus punch[15]
	5	Knee push-up plus[15, 27-28, 42]

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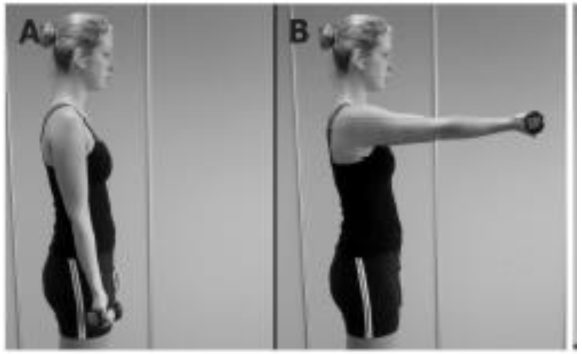
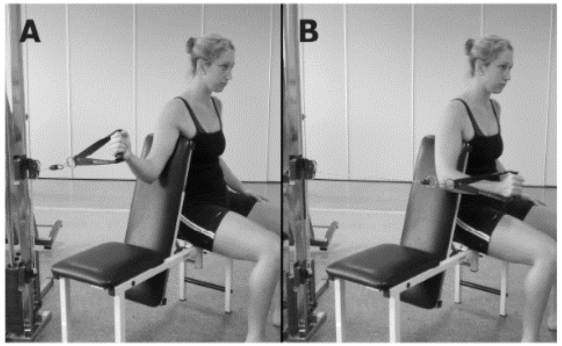
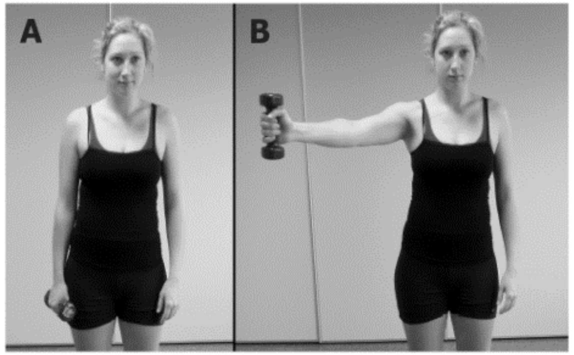
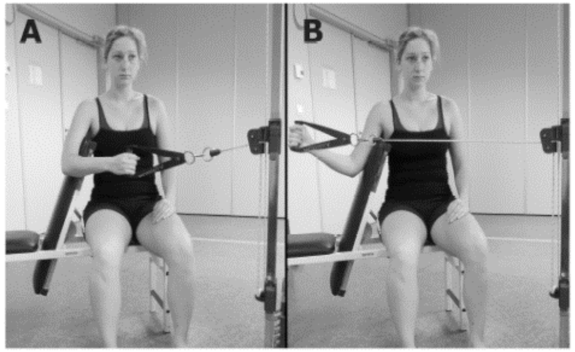
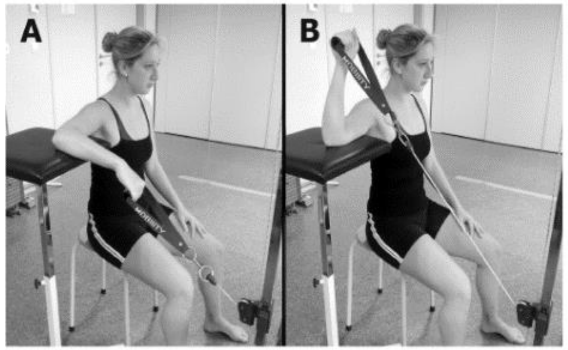
GLENOHUMERAL MUSCLE GROUP





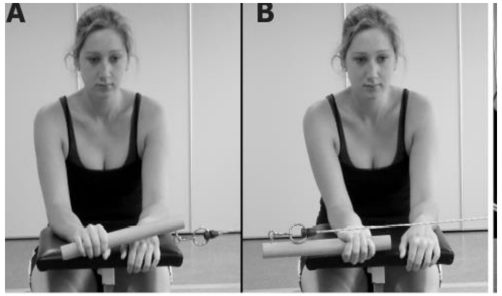


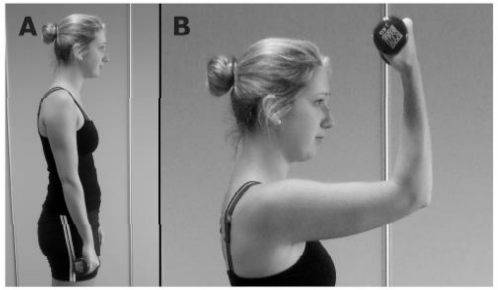




6	forward flexion in external rotation and forearm supination[30-32, 38]
7	Full can[9, 31-32, 38,]
8	Internal rotation in 20° abduction[30, 32, 38, 42]
9	External rotation in 20° abduction[30, 32, 33, 38, 42]
10	Internal rotation in 90° abduction[32, 42]
11	External rotation in 90° abduction[32, 33, 42]

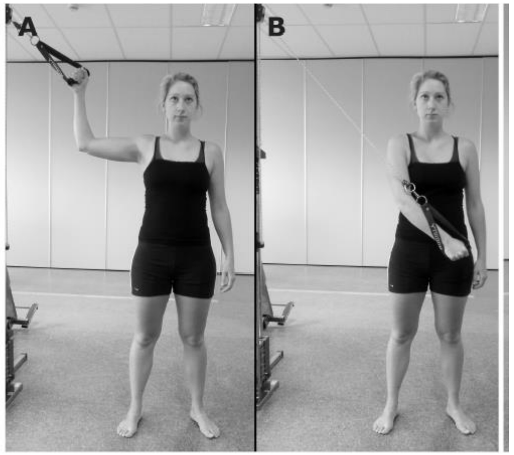
BICEPS BRACHII

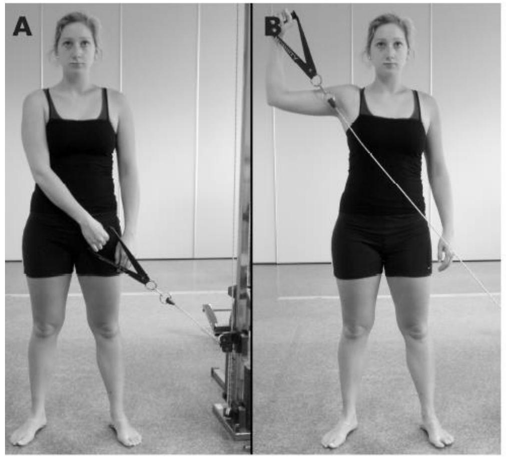




12	Forearm supination[42]
13	Elbow flexion in forearm supination[42]
14	Uppercut[42]

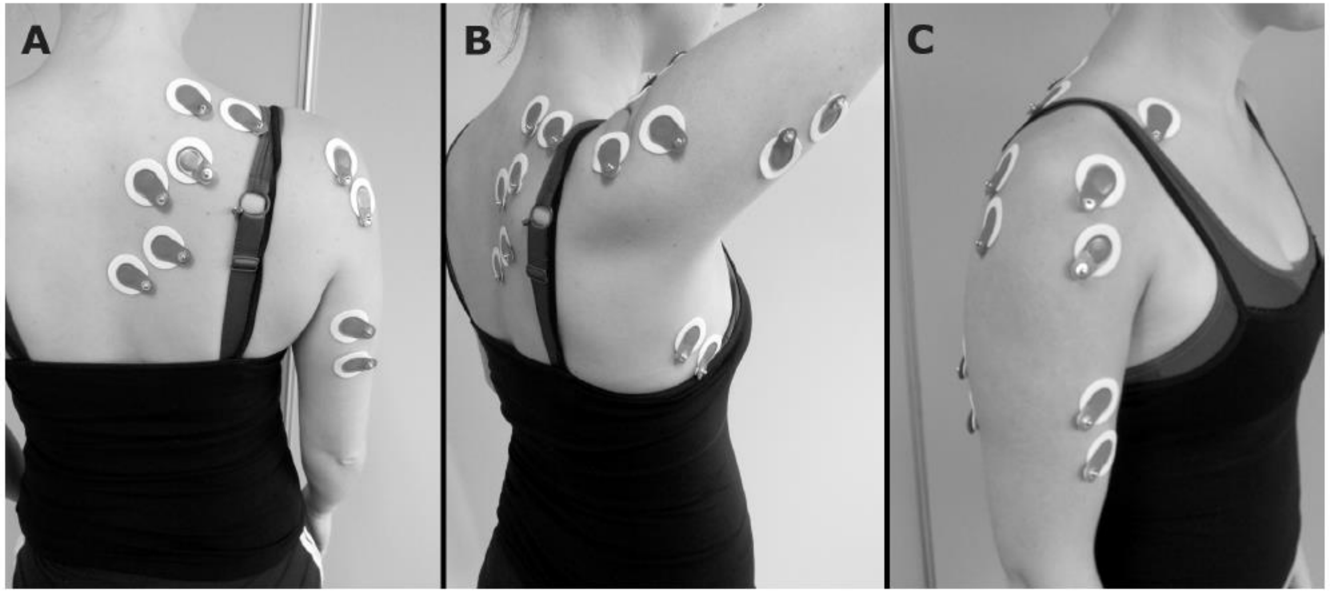
FUNCTIONAL DIAGONALS





15	Internal rotation diagonal[32, 42]
16	External rotation diagonal[32, 42]

EMG-measurements



1. UT
2. MT
3. LT
4. SA
5. AD
6. PD
7. BB
8. TB

	UT		MT		LT		SA		DA		DP		BB		TB	
No.	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
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2	17,1	11,54	36,1	15,32	28,6	34,56	10,3	6,44	7,8	4,14	64,6	21,69	4,2	2,05	50,1	16,85
3	14,2	11,20	23,1	12,50	14,8	19,66	4,1	3,12	7,3	4,56	31,0	14,84	5,8	4,61	8,9	6,02
4	8,9	6,81	6,0	3,35	5,9	4,00	42,7	15,49	53,2	25,09	12,2	10,60	8,9	7,49	16,3	7,69
5	11,5	5,17	10,2	5,71	8,5	5,60	37,0	18,12	41,2	20,12	8,3	5,83	4,8	3,15	30,5	12,72
6	48,2	22,42	31,3	15,68	41,0	24,04	68,9	16,85	107,9	44,97	17,8	10,50	35,9	18,82	15,7	8,05
7	55,2	22,74	45,4	17,09	45,2	27,31	58,1	14,88	106,4	39,32	27,5	18,61	29,0	16,69	16,0	10,76
8	2,7	1,99	3,2	1,99	4,2	2,17	9,4	5,49	15,7	12,36	2,0	1,55	6,2	3,51	5,9	4,43
9	22,3	12,09	57,5	25,05	75,1	48,97	13,3	8,97	11,4	7,27	49,5	22,48	8,2	5,10	21,7	10,79
10	3,2	2,26	3,3	1,74	3,0	1,82	4,6	3,18	4,3	3,90	3,4	2,60	2,2	1,24	10,7	5,26
11	23,7	9,93	44,6	40,07	74,9	56,26	43,6	14,36	13,7	18,04	38,6	23,85	11,2	6,04	17,5	12,20
12	4,7	3,39	11,8	11,08	20,6	18,88	5,8	4,10	4,1	2,45	19,4	14,34	15,4	7,19	18,7	12,67
13	2,9	2,00	7,2	6,44	21,7	17,78	8,1	5,07	10,8	9,23	5,6	3,31	34,6	15,91	10,3	5,72
14	33,0	19,20	20,2	10,99	32,5	19,65	47,9	14,01	80,5	32,36	11,1	6,20	19,3	10,06	9,7	5,90
15	7,9	5,29	6,4	4,69	6,0	4,86	15,0	8,93	14,0	11,56	5,8	3,61	7,9	4,63	14,7	6,73
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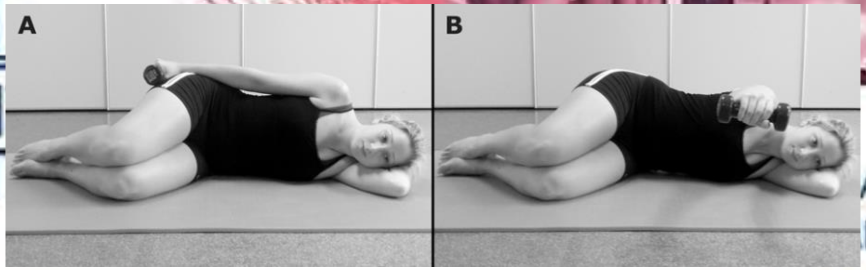
(Cools et al. AJSM 2014)

No.	UT		MT		LT		SA		DA		DP		BB		TB	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	32,7	11,09	78,3	45,37	76,6	38,66	10,3	9,41	43,4	22,21	125,6	66,40	9,7	6,18	33,8	17,49
2	17,1	11,54	36,1	15,32	28,6	34,56	10,3	6,44	7,8	4,14	64,6	21,69	4,2	2,05	50,1	16,85
3	14,2	11,20	23,1	12,50	14,8	19,66	4,1	3,12	7,3	4,56	31,0	14,84	5,8	4,61	8,9	6,02
4	8,9	6,81	6,0	3,35	5,9	4,00	42,7	15,49	53,2	25,09	12,2	10,60	8,9	7,49	16,3	7,69
5	11,5	5,17	10,2	5,71	8,5	5,60	37,0	18,12	41,2	20,12	8,3	5,83	4,8	3,15	30,5	12,72
6	48,2	22,42	31,3	15,68	41,0	24,04	68,9	16,85	107,9	44,97	17,8	10,50	35,9	18,82	15,7	8,05
7	55,2	22,74	45,4	17,09	45,2	27,31	58,1	14,88	106,4	39,32	27,5	18,61	29,0	16,69	16,0	10,76
8	2,7	1,99	3,2	1,99	4,2	2,17	9,4	5,49	15,7	12,36	2,0	1,55	6,2	3,51	5,9	4,43
9	22,3	12,09	57,5	25,05	75,1	48,97	13,3	8,97	11,4	7,27	49,5	22,48	8,2	5,10	21,7	10,79
10	3,2	2,26	3,3	1,74	3,0	1,82	4,6	3,18	4,3	3,90	3,4	2,60	2,2	1,24	10,7	5,26
11	23,7	9,93	44,6	40,07	74,9	56,26	43,6	14,36	13,7	18,04	38,6	23,85	11,2	6,04	17,5	12,20
12	4,7	3,39	11,8	11,08	20,6	18,88	5,8	4,10	4,1	2,45	19,4	14,34	15,4	7,19	18,7	12,67
13	2,9	2,00	7,2	6,44	21,7	17,78	8,1	5,07	10,8	9,23	5,6	3,31	34,6	15,91	10,3	5,72
14	33,0	19,20	20,2	10,99	32,5	19,65	47,9	14,01	80,5	32,36	11,1	6,20	19,3	10,06	9,7	5,90
15	7,9	5,29	6,4	4,69	6,0	4,86	15,0	8,93	14,0	11,56	5,8	3,61	7,9	4,63	14,7	6,73
16	43,6	21,14	48,7	16,48	55,8	30,34	48,0	17,09	53,2	23,16	41,3	23,35	12,7	5,40	16,4	9,97

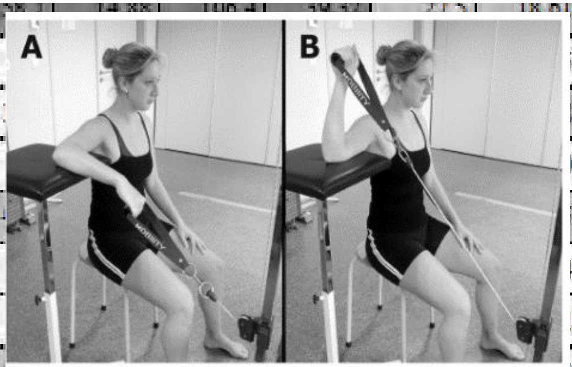
(Cools et al. AJSM 2014)

<20% MVC: low activity
20-50%MVC: moderate
>50%MVC: high activity

Moderate:
forward flexion in supination
full can
elbow flexion in forearm supi



No.	UT		MT		LT		SA		DA		DP		BB		TB	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	32,7	11,09	78,3	45,3[illegible]	76,6	38,66	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9,7	6,18	33,8	17,49
2	17,1	11,54	36,1	15,32	28,6	34,56	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4,2	2,05	50,1	16,85
3	14,2	11,20	23,1	12,50	14,8	19,66	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5,8	4,61	8,9	6,02
4	8,9	6,81	6,0	3,35	5,9	4,00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8,9	7,49	16,3	7,69
5	11,5	5,17	10,2	5,71	8,5	5,60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4,8	3,15	30,5	12,72
6	48,2	22,42	31,3	15,68	41,0	24,04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	35,9	18,82	15,7	8,05
7	55,2	22,74	45,4	17,09	45,2	27,31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29,0	16,69	16,0	10,76
8	2,7	1,99	3,2	1,90	4,2	2,17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6,2	3,51	5,9	4,43
9	22,3	12,09	57,5	25,0[illegible]	75,1	48,97	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8,2	5,10	21,7	10,79
10	3,2	2,26	3,3	1,74	3,0	1,82	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2,2	1,24	10,7	5,26
11	23,7	9,93	44,6	40,0[illegible]	74,9	56,26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,2	6,04	17,5	12,20
12	4,7	3,39	11,8	11,08	20,6	18,88	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15,4	7,19	18,7	12,67
13	2,9	2,00	7,2	6,44	21,7	17,78	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	34,6	15,91	10,3	5,72
14	33,0	19,20	20,2	10,99	32,5	19,65	47,9	14,01	[illegible]	[illegible]	[illegible]	[illegible]	19,3	10,06	9,7	5,90
15	7,9	5,29	6,4	4,69	6,0	4,86	15,0	8,93	[illegible]	[illegible]	[illegible]	3,61	7,9	4,63	14,7	6,73
16	43,6	21,14	48,7	16,4[illegible]	55,8	30,34	48,0	17,09	[illegible]	[illegible]	[illegible]	3,35	12,7	5,40	16,4	9,97



(Cools et al. AJSM 2014)

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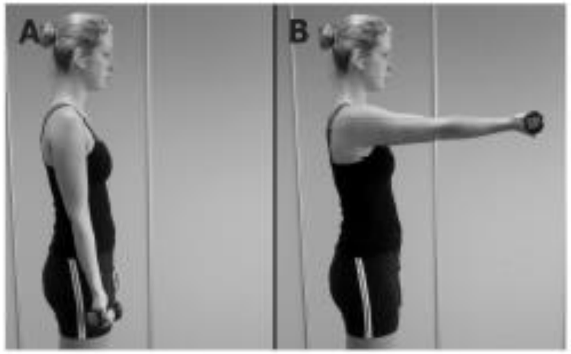
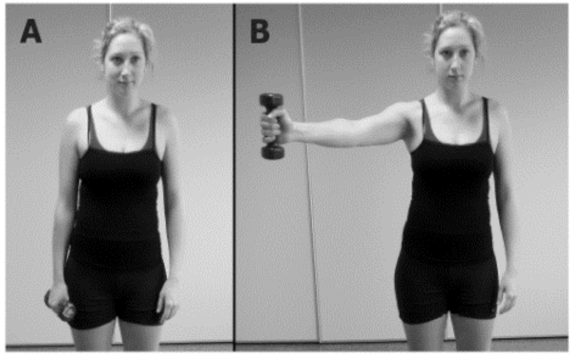




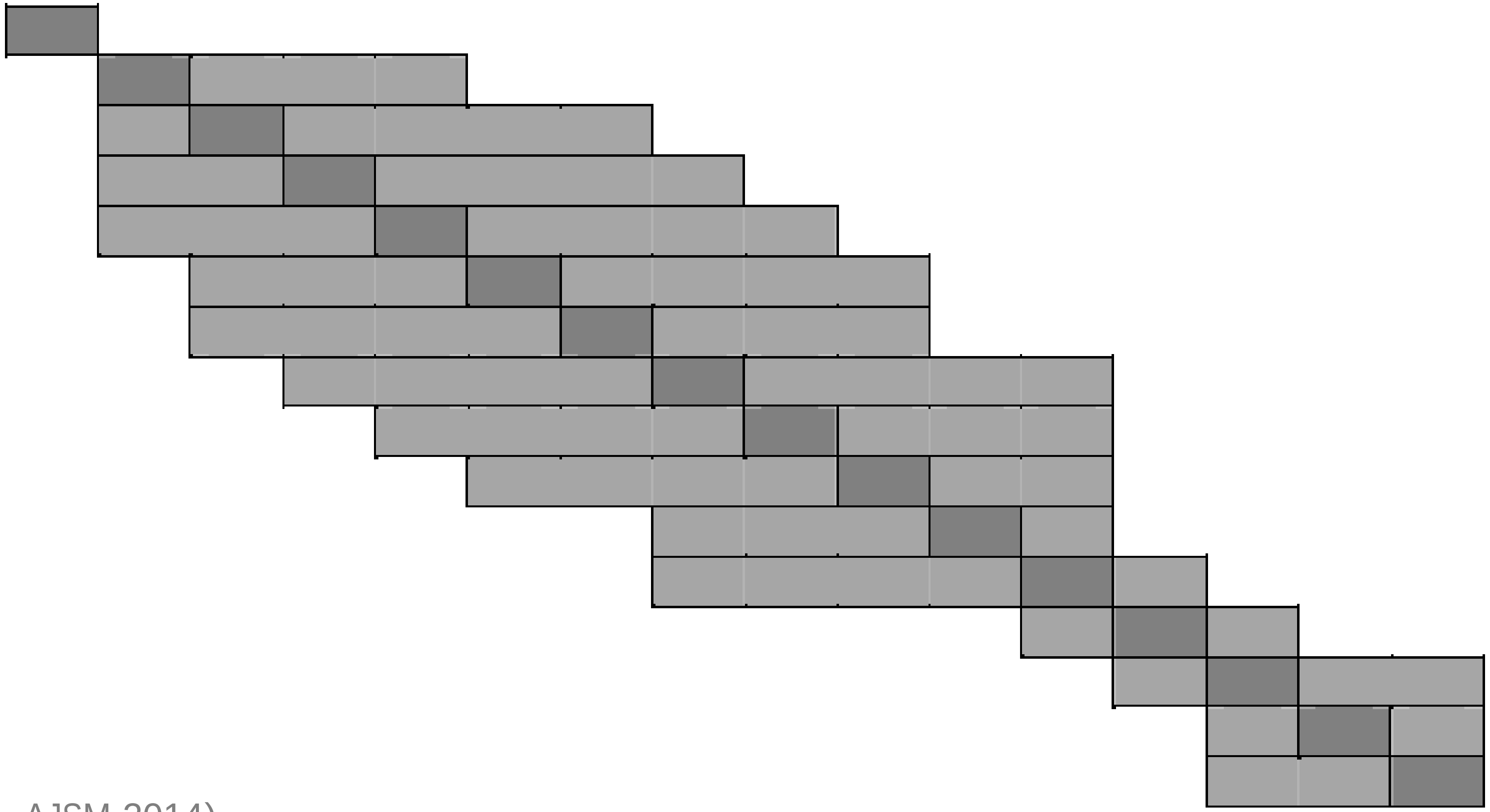
	UT		MT		LT		SA		DA		DP		BB		TB	
No.	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
			78,3	45,37	76,6	38,66	10,3	9,41	43,4	22,21	125,6	66,40	9,7	6,18	33,8	17,49
			36,1	15,32	28,6	34,56	10,3	6,44	7,8	4,14	64,6	21,69	4,2	2,05	50,1	16,85
			23,1	12,50	14,8	19,66	4,1	3,12	7,3	4,56	31,0	14,84	5,8	4,61	8,9	6,02
			6,0	3,35	5,9	4,00	42,7	15,49	53,2	25,09	12,2	10,60	8,9	7,49	16,3	7,69
			10,2	5,71	8,5	5,60	[illegible]	[illegible]	41,2	20,12	8,3	5,83	4,8	3,15	30,5	12,72
			31,3	15,68	41,0	24,04	68,9	16,85	107,9	44,97	17,8	10,50	35,9	18,82	15,7	8,05
			45,4	17,09	45,2	27,31	58,1	14,88	106,4	39,32	27,5	18,61	29,0	16,69	16,0	10,76
	2,7	1,99	3,2	1,99	4,2	2,17	9,4	5,49	15,7	12,36	2,0	1,55	6,2	3,51	5,9	4,43
9	22,3	12,09	57,5	25,05	75,1	48,97	13,3	8,97	11,4	7,27	49,5	22,48	8,2	5,10	21,7	10,79
10	3,2	2,26	3,3	1,74	3,0	1,82	4,6	3,18	4,3	3,90	3,4	2,60	2,2	1,24	10,7	5,26
			44,6	40,07	74,9	56,26	43,6	14,36	13,7	18,04	38,6	23,85	11,2	6,04	17,5	12,20
			11,8	11,08	20,6	18,88	5,8	4,10	4,1	2,45	19,4	14,34	15,4	7,19	18,7	12,67
			7,2	6,44	21,7	17,78	8,1	5,07	10,8	9,23	5,6	3,31	34,6	15,91	10,3	5,72
			20,2	10,99	32,5	19,65	47,9	14,01	80,5	32,36	11,1	6,20	19,3	10,06	9,7	5,90
			6,4	4,69	6,0	4,86	15,0	8,93	14,0	11,56	5,8	3,61	7,9	4,63	14,7	6,73
			48,7	16,48	55,8	30,34	48,0	17,09	53,2	23,16	41,3	23,35	12,7	5,40	16,4	9,97

(Cools et al. AJSM 2014)

Exercises targeting the Trapezius result in less loads on the biceps muscle compared with exercises for the SA

=> might be preferred before SA training in patients with biceps-related pathological lesions.

No.	10	2	5	3	8	15	9	4	1	11	16	12	14	7	13	6
%MVC	2.2	4.2	4.8	5.8	6.2	7.9	8.2	8.9	9.7	11.2	12.7	15.4	19.3	29.0	34.6	35.9



(Cools et al. AJSM 2014)

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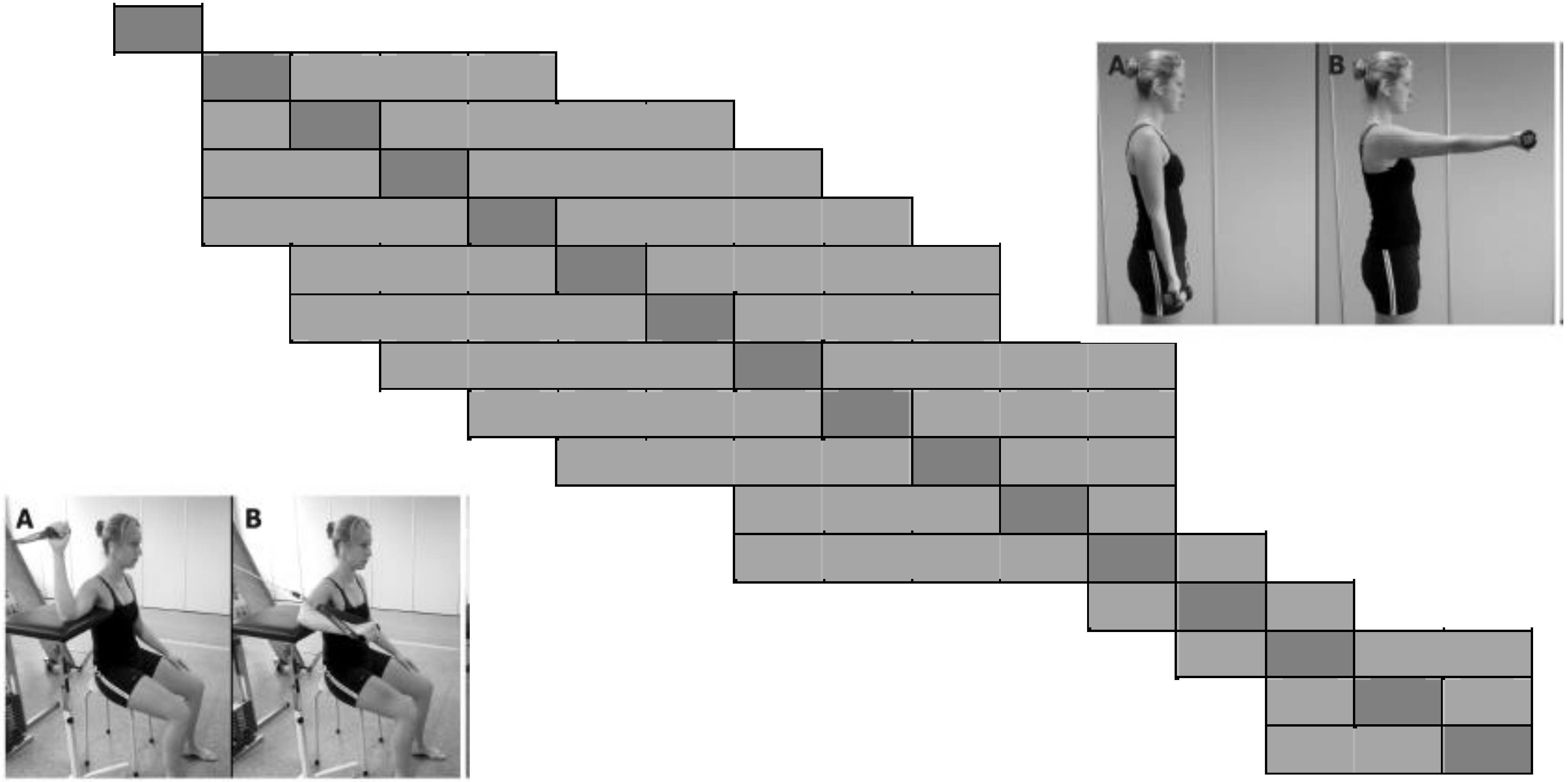
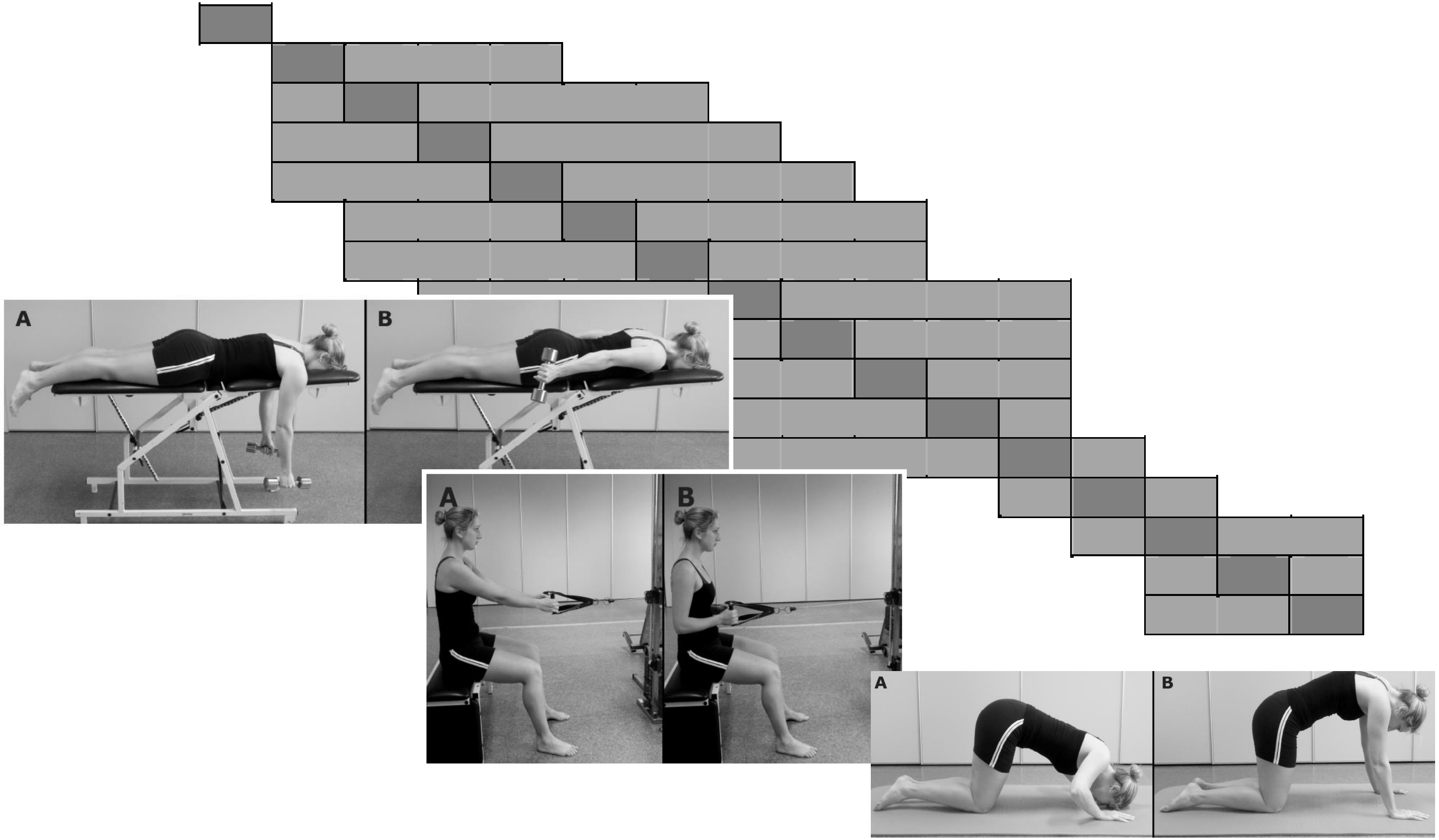
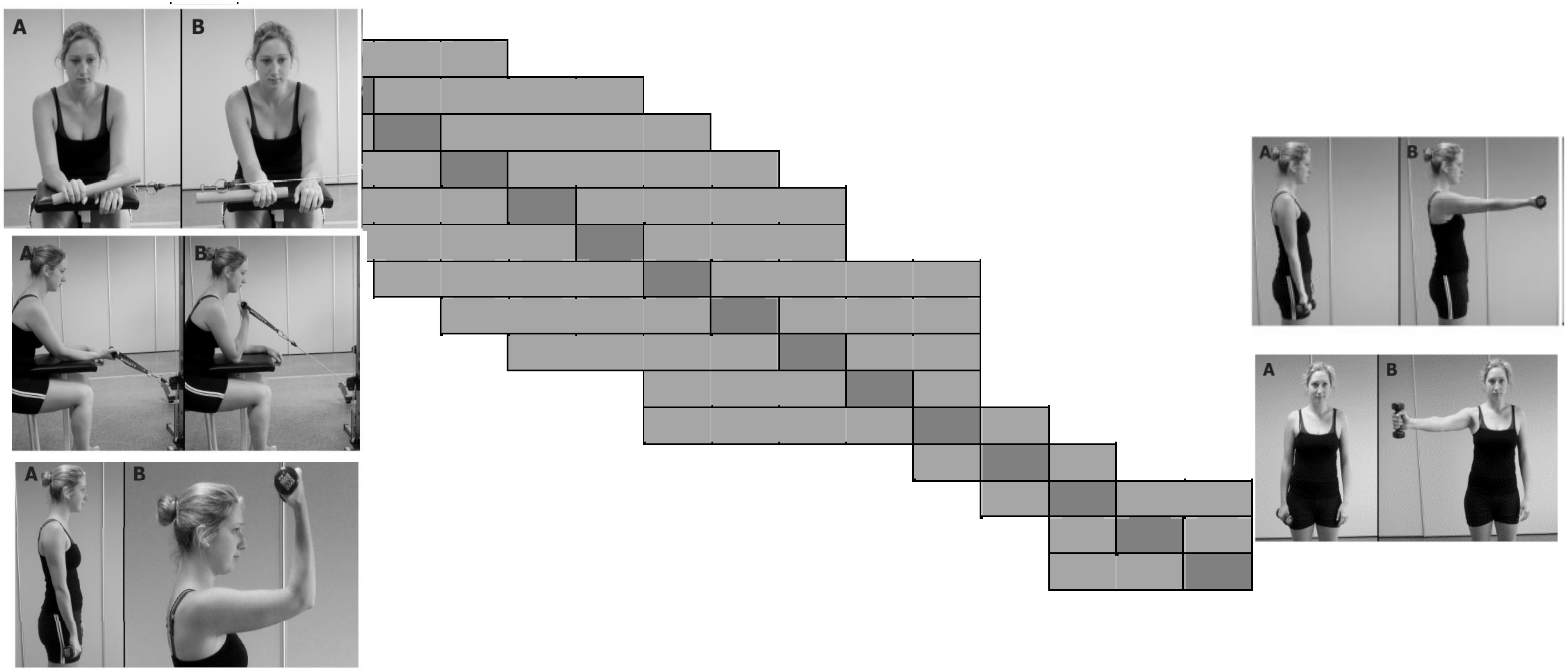
No.	10	2	5	3	8	15	9	4	1	11	16	12	14	7	13	6
%MVC	2.2	4.2	4.8	5.8	6.2	7.9	8.2	8.9	9.7	11.2	12.7	15.4	19.3	29.0	34.6	35.9



No.	10	2	5	3	8	15	9	4	1	11	16	12	14	7	13	6
%MVC	2.2	4.2	4.8	5.8	6.2	7.9	8.2	8.9	9.7	11.2	12.7	15.4	19.3	29.0	34.6	35.9



No.	10	2	5	3	8	15	9	4	1	11	16	12	14	7	13	6
%MVC	2.2	4.2	4.8	5.8	6.2	7.9	8.2	8.9	9.7	11.2	12.7	15.4	19.3	29.0	34.6	35.9



(Cools et al. AJSM 2014)

Results?

- Effects of these exercises in patients with biceps related pathology?
- High level activity in biceps during exercises?

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Follow up study 2016

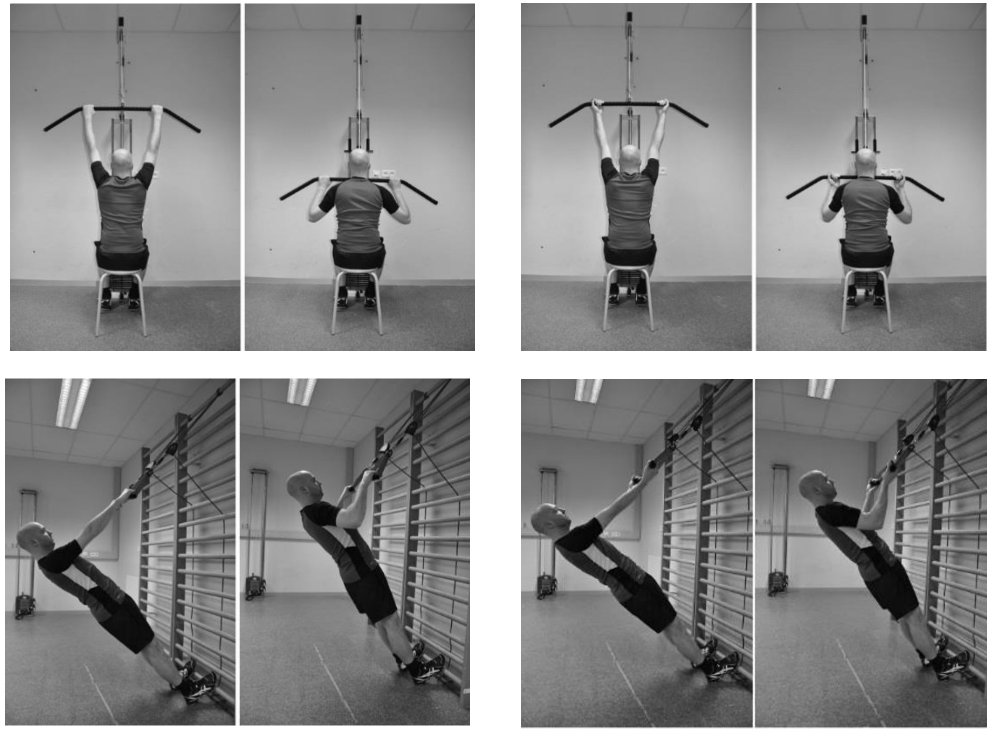
Biceps Disorder Rehabilitation for the Athlete

A Continuum of Moderate- to High-Load Exercises

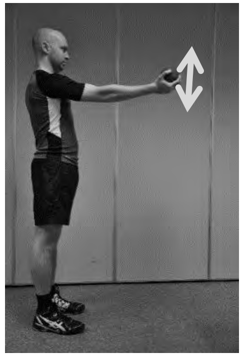
Dorien Borms,*† PT, Inge Ackerman,† PT, Pieter Smets,† PT, Glen Van den Berge,† PT, and Ann M. Cools,† PT, PhD
Investigation performed at Ghent University, Ghent, Belgium

Exercise	UT		MT		LT		SA		BB		TB	
No.	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	7.90	9.13	24.30	16.18	37.45	53.50	61.35	40.59	16.86	8.93	17.43	8.87
2	7.10	6.71	24.62	19.54	35.82	51.71	58.72	42.66	18.92	9.35	17.19	9.31
3	30.25	13.75	57.11	31.20	52.28	40.67	61.12	56.54	24.06	17.26	22.73	16.49
4	22.24	15.61	43.94	28.48	50.81	55.73	68.88	75.92	41.96	28.20	23.37	15.28
5	16.88	11.00	17.01	15.23	17.11	12.71	38.31	23.33	43.99	19.85	11.26	6.71
6	46.72	16.55	30.80	22.82	36.53	40.18	94.26	46.73	35.56	24.85	21.69	14.75
7	57.52	18.03	29.89	17.17	37.06	40.09	122.48	46.53	56.96	41.63	33.40	16.31
8	28.96	10.53	39.52	27.34	38.86	24.71	42.59	23.14	14.97	10.83	21.13	9.21
9	15.48	6.50	15.84	10.78	26.41	28.83	40.13	23.11	17.26	9.01	16.43	6.63
10	25.39	9.76	23.96	26.46	28.50	32.44	68.92	60.25	27.58	19.55	20.65	10.35
11	30.45	10.99	46.83	41.01	54.41	54.02	65.77	33.88	67.37	25.46	22.28	10.48

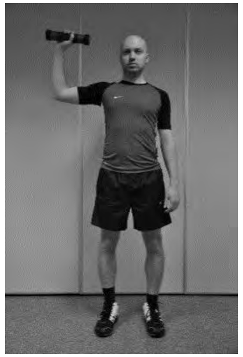
1	Lateral pull-down in pronation[16,45]
2	Lateral pull-down in supination[44]
3	Pull-up in pronation with Redcord[14]
4	Pull-up in supination with Redcord

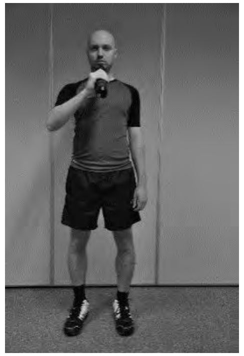


5	Inclined biceps curl with dumbbell[39]
6	Forward flexion in external rotation and forearm supination with dumbbell[9]
7	Throwing forward flexion in 90° with soft weight ball



8	Arm shake with Xco-trainer[22]
9	Chest shake with Xco-trainer[22]
10	Air punch[27,28]
11	Reverse punch with elastic tubing





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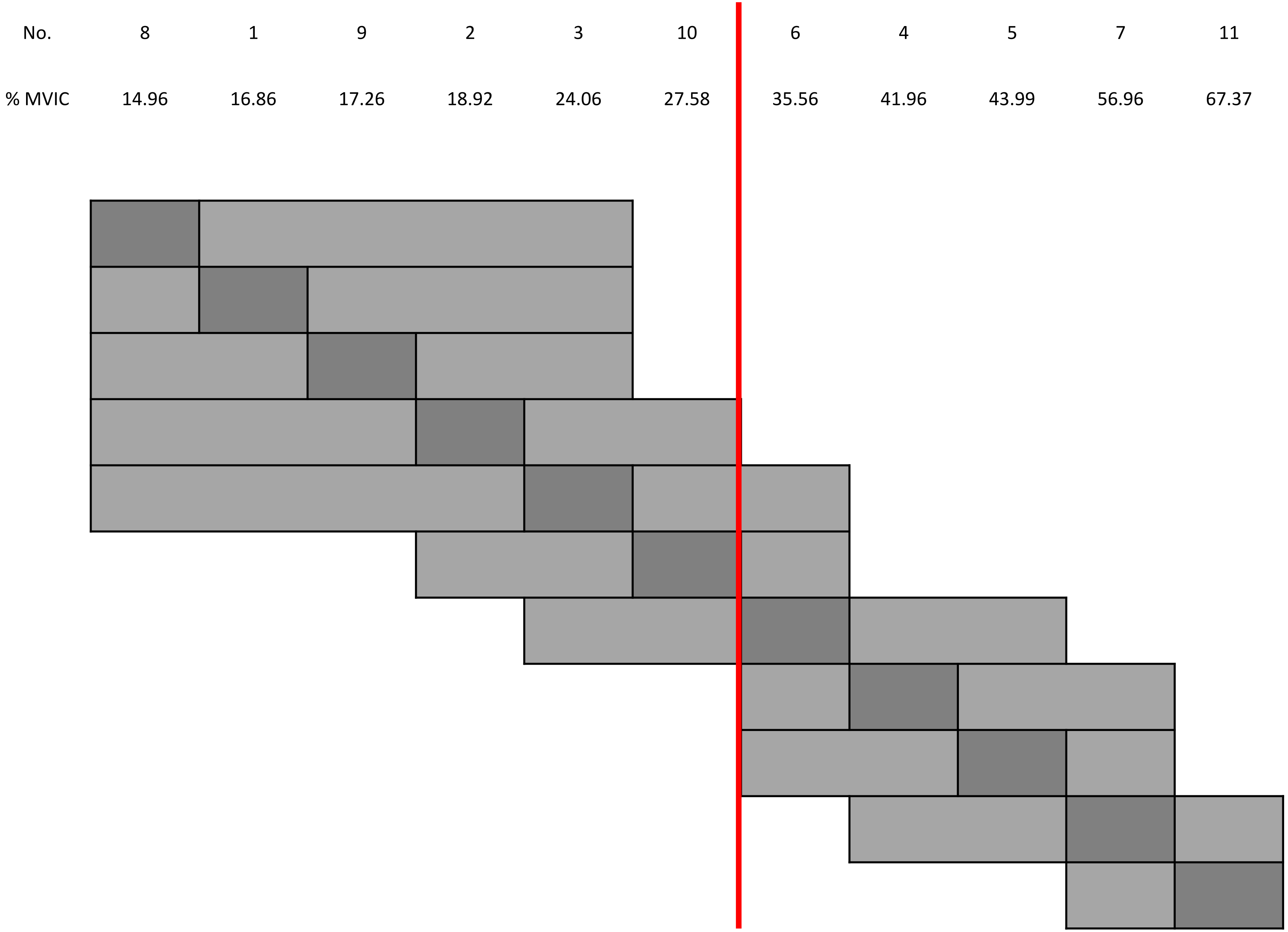
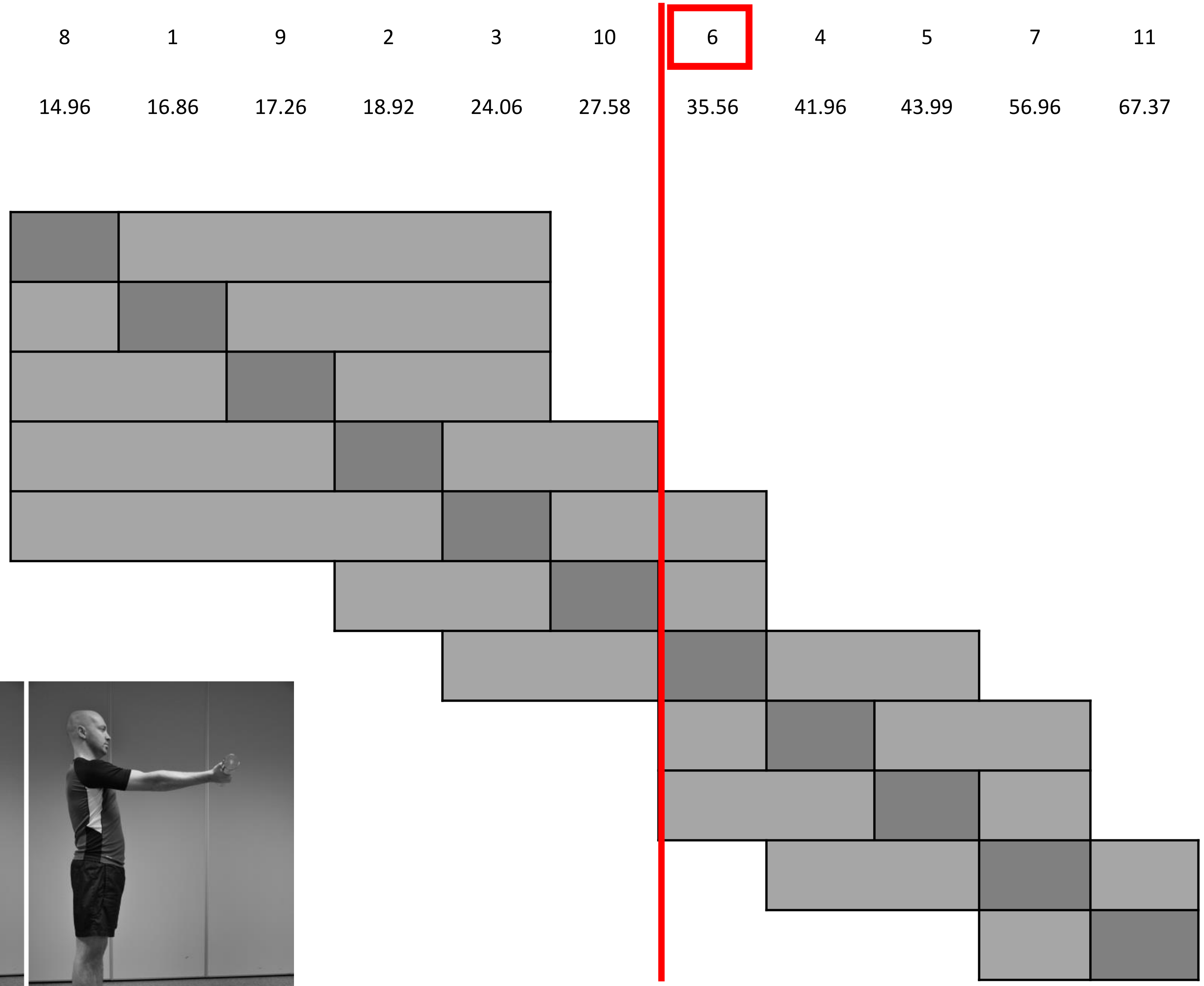
Exercise	UT		MT		LT		SA		BB		TB	
No.	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	7.90	9.13	24.30	16.18	37.45	53.50	61.35	40.59	16.86	8.93	17.43	8.87
2	7.10	6.71	24.62	19.54	35.82	51.71	58.72	42.66	18.92	9.35	17.19	9.31
3	30.25	13.75	57.11	31.20	52.28	40.67	61.12	56.54	24.06	17.26	22.73	16.49
4	22.24	15.61	43.94	28.48	50.81	55.73	68.88	75.92	41.96	28.20	23.37	15.28
5	16.88	11.00	17.01	15.23	17.11	12.71	38.31	23.33	43.99	19.85	11.26	6.71
6	46.72	16.55	30.80	22.82	36.53	40.18	94.26	46.73	35.56	24.85	21.69	14.75
7	57.52	18.03	29.89	17.17	37.06	40.09	122.48	46.53	56.96	41.63	33.40	16.31
8	28.96	10.53	39.52	27.34	38.86	24.71	42.59	23.14	14.97	10.83	21.13	9.21
9	15.48	6.50	15.84	10.78	26.41	28.83	40.13	23.11	17.26	9.01	16.43	6.63
10	25.39	9.76	23.96	26.46	28.50	32.44	68.92	60.25	27.58	19.55	20.65	10.35
11	30.45	10.99	46.83	41.01	54.41	54.02	65.77	33.88	67.37	25.46	22.28	10.48

<20% MVC: low activity
20-50%MVC: moderate
>50%MVC: high activity

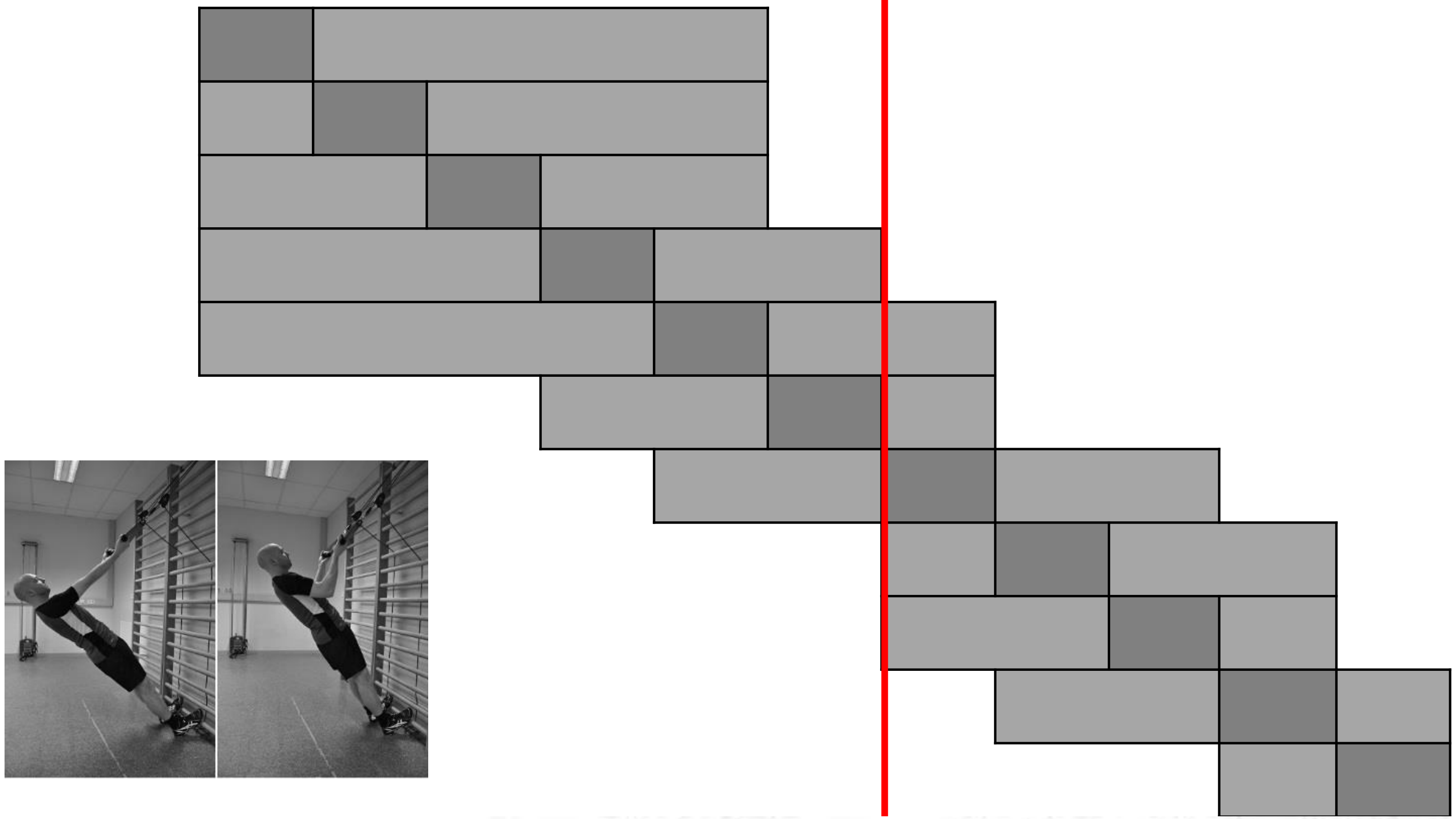

No. 8 1 9 2 3 10 6 4 5 7 11
% MVIC 14.96 16.86 17.26 18.92 24.06 27.58 35.56 41.96 43.99 56.96 67.37

No.	8	1	9	2	3	10	6	4	5	7	11
% MVIC	14.96	16.86	17.26	18.92	24.06	27.58	35.56	41.96	43.99	56.96	67.37



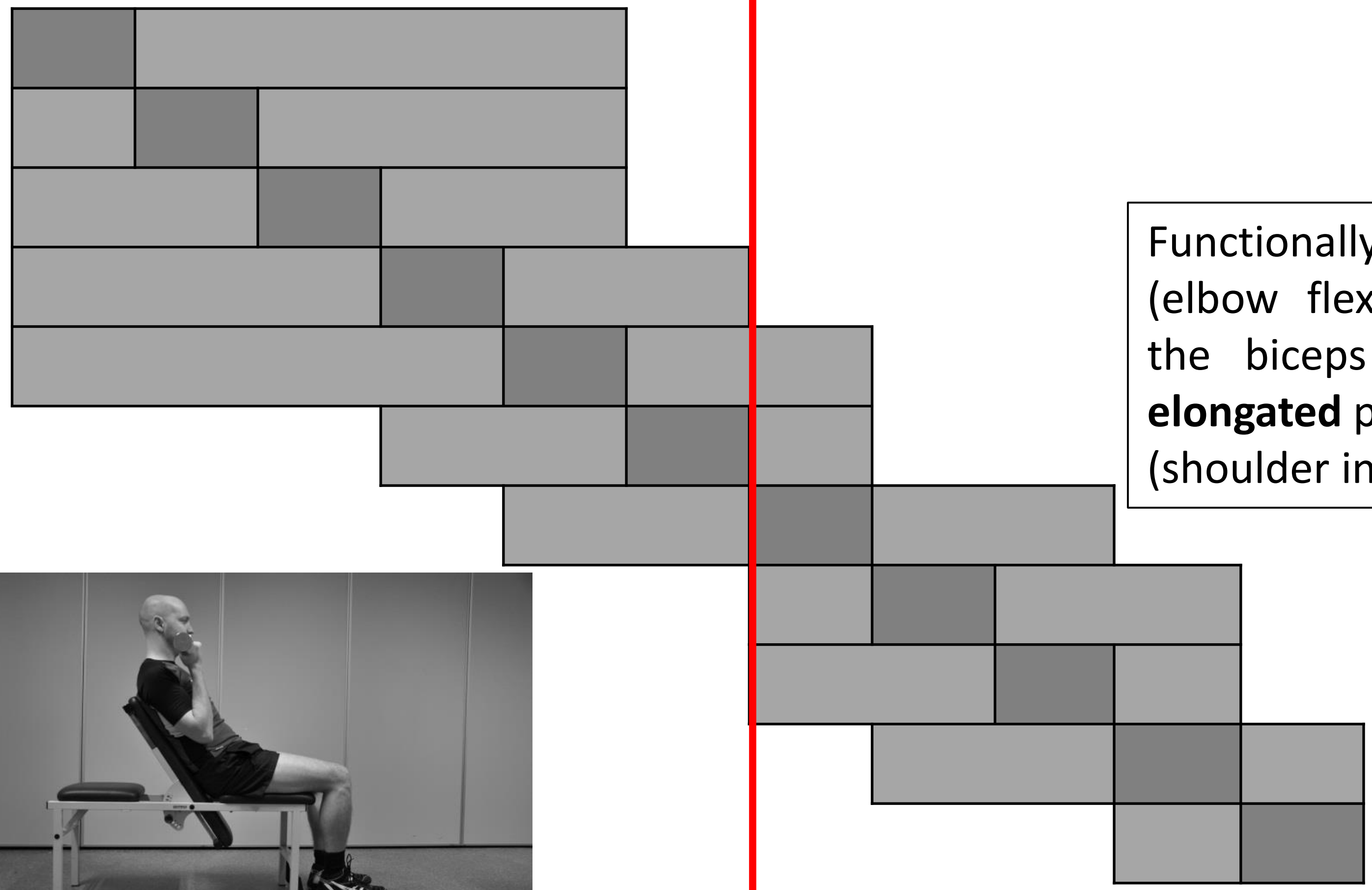
6	Forward flexion in external rotation and forearm supination with dumbbell[9]	Subject stands with the dominant arm at the side in external rotation and forearm supination. Subject performs forward flexion in a sagittal plane to 90°.

No.	8	1	9	2	3	10	6	4	5	7	11
% MVIC	14.96	16.86	17.26	18.92	24.06	27.58	35.56	41.96	43.99	56.96	67.37



4	Pull-up in supination with Redcord	Subject is in supine plank position with shoulders in 90° forward flexion and only heels touching the ground with metatarsophalangeal joint supported by the lowest rung of a climbing track. Hands grasp the Redcord handles in supination. Subject performs a pull-up until 90° elbow flexion while maintaining neutral spine alignment and keeping heel contact with the floor.

No.	8	1	9	2	3	10	6	4	$\boxed{5}$	7	11
% MVIC	14.96	16.86	17.26	18.92	24.06	27.58	35.56	41.96	43.99	56.96	67.37

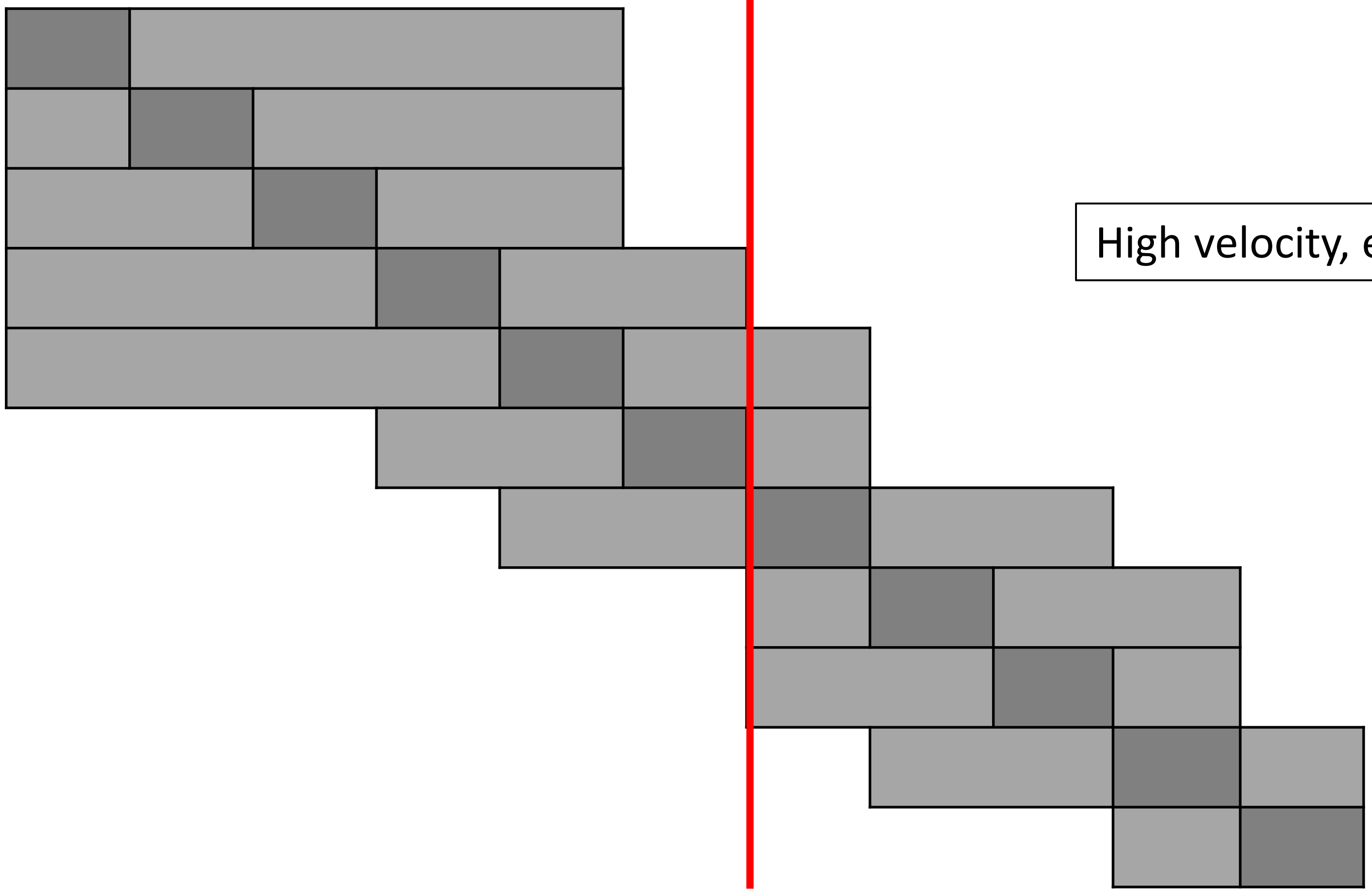


Functionally contracting (elbow flexion in supination) the biceps muscle from **an elongated** position (shoulder in extension)

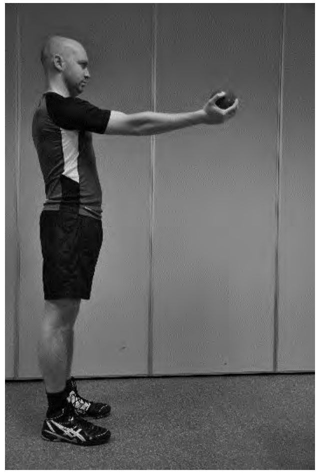
5 Inclined biceps curl with dumbbell[39]

Subject sits in 50° trunk extension, and dominant arm hangs vertically along the body with elbow supination. Subject performs a full elbow flexion in supination while maintaining vertical alignment in the upper arm.

No.	8	1	9	2	3	10	6	4	5	7	11
% MVIC	14.96	16.86	17.26	18.92	24.06	27.58	35.56	41.96	43.99	56.96	67.37

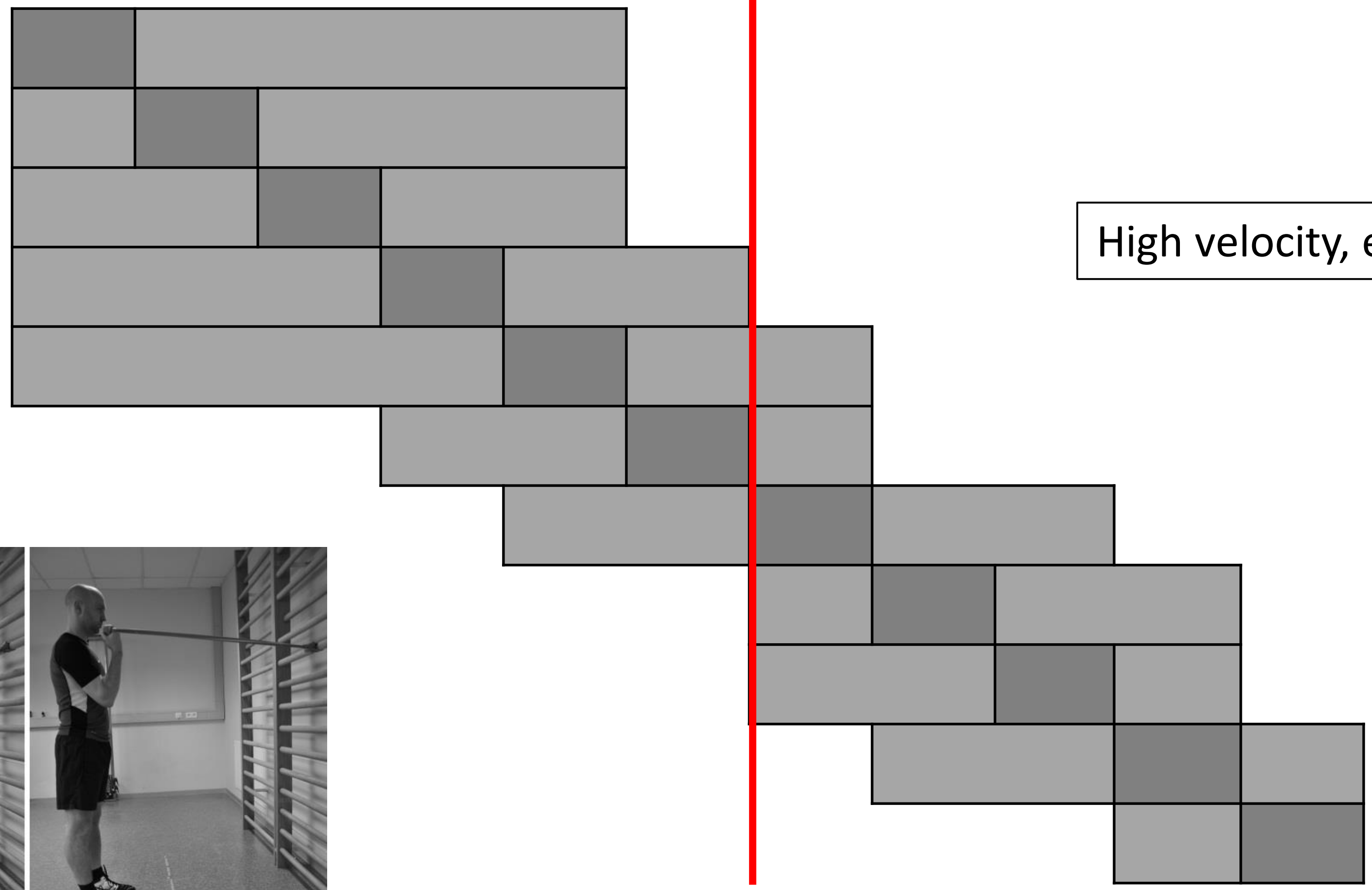


High velocity, explosive exercise



7	Throwing forward flexion in 90° with soft weight ball	Subject stands with dominant arm in 90° forward flexion and supination in a sagittal plane. Subject performs a forward flexion to throw the ball in the air, followed by a delayed catch of the ball in 90° forward flexion.

No.	8	1	9	2	3	10	6	4	5	7	$\boxed{11}$
% MVIC	14.96	16.86	17.26	18.92	24.06	27.58	35.56	41.96	43.99	56.96	67.37



High velocity, explosive exercise

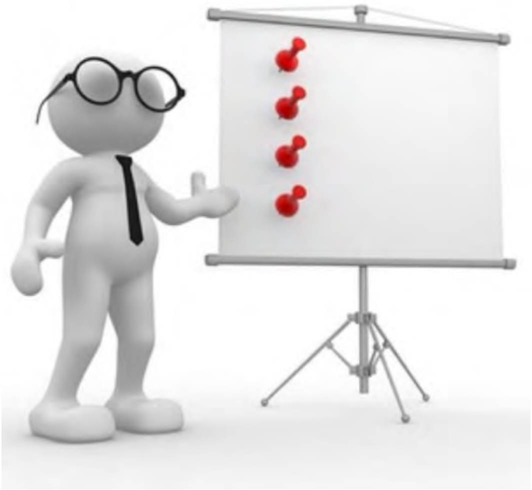
11	Reverse punch with elastic tubing	Subject stands with dominant upper arm in 90° forward flexion and full elbow extension with pronation. Subject performs a reverse punch in a sagittal plane by fully flexing the elbow in supination against elastic tubing resistance and with the upper arm vertically aligned along the body.

CONCLUSION

- Study describes a continuum of exercises with an increasing level of EMG activity in the BB
- Exercises targeting the Trapezius resulted in less loads on the biceps compared with exercises for the SA

Overview

1. Analysis of recruitment of the superficial and deep scapular muscles in patients with chronic shoulder or neck pain, and implications for rehabilitation exercises
2. Shoulder impingement: can one label satisfy everything?
3. Central pain processing in shoulder pain
4. Progression in biceps load during rehabilitation exercises
5. **The influence of induced shoulder muscle pain on rotator cuff and scapulothoracic muscle activity during elevation of the arm.**



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The influence of induced shoulder muscle pain on rotator cuff and scapulothoracic muscle activity during elevation of the arm

CrossMark

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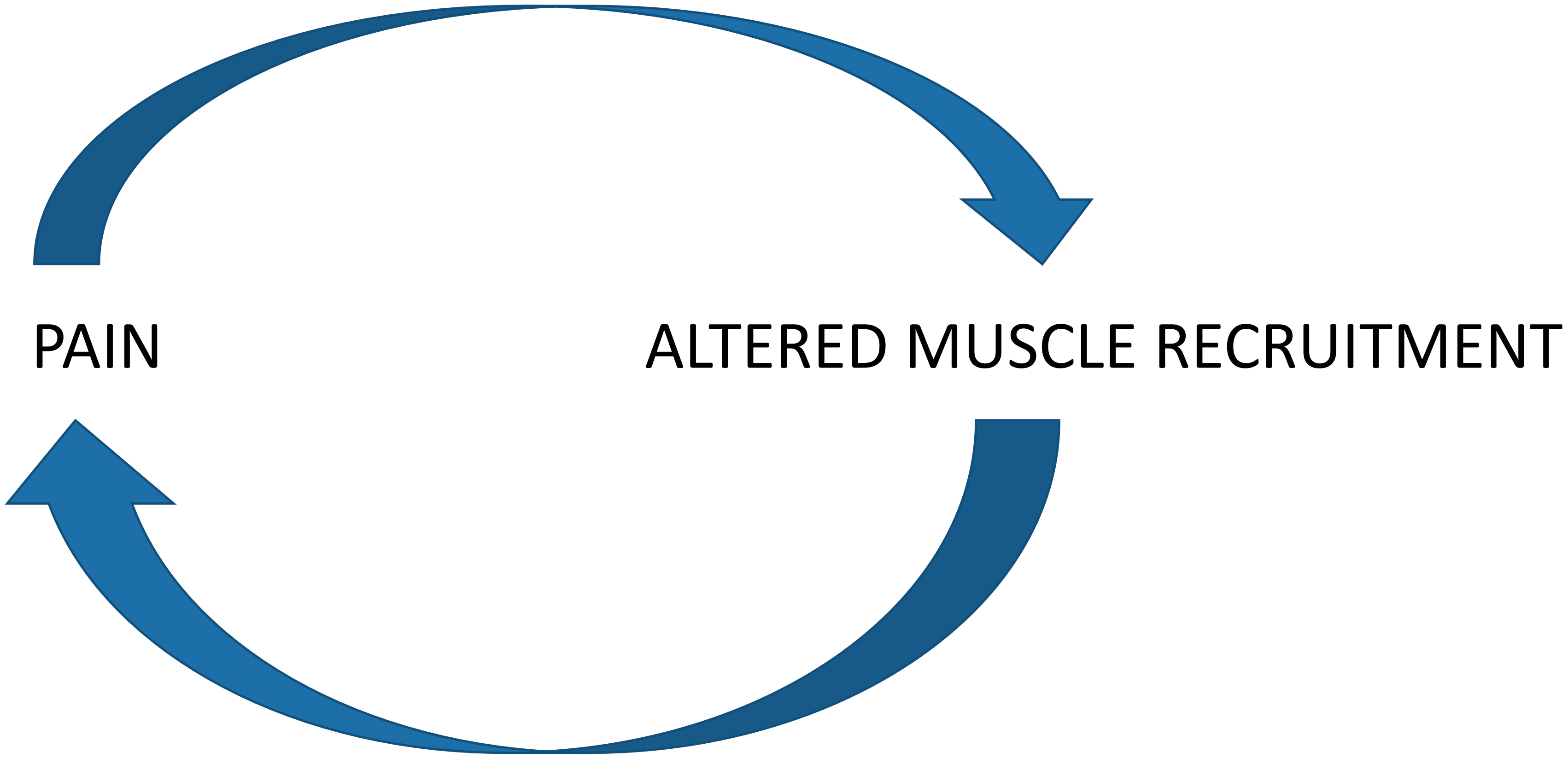
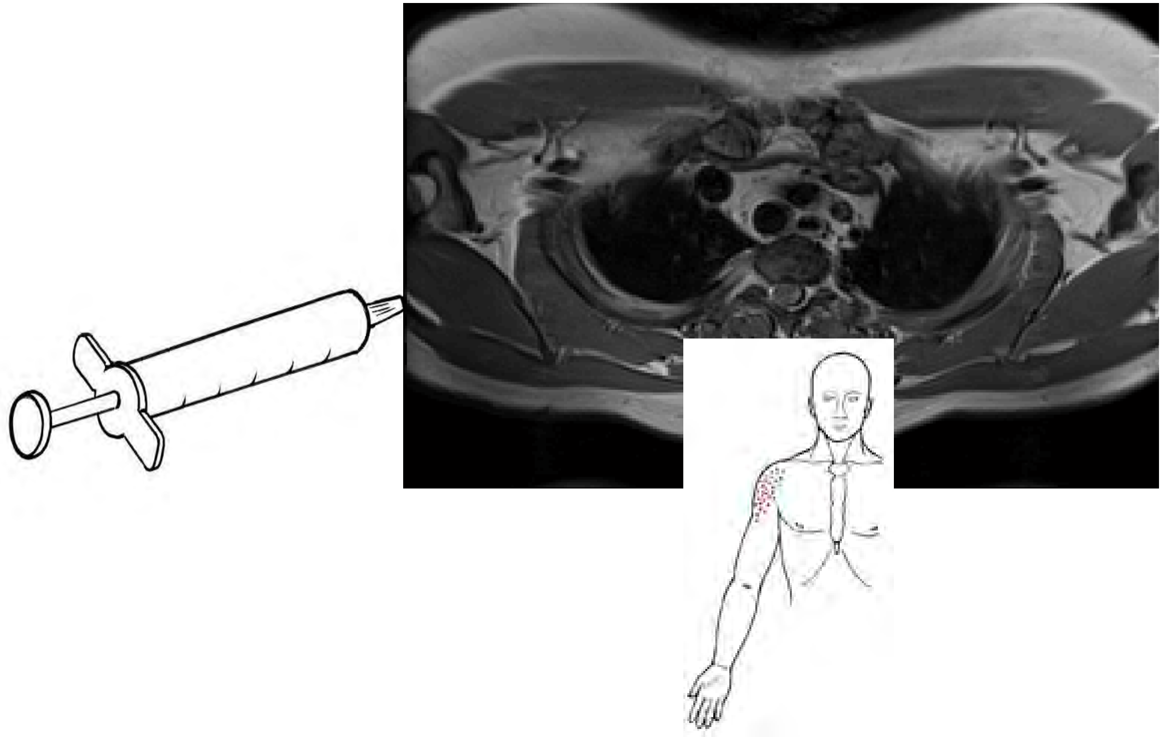
CAUSE – CONSEQUENCE?

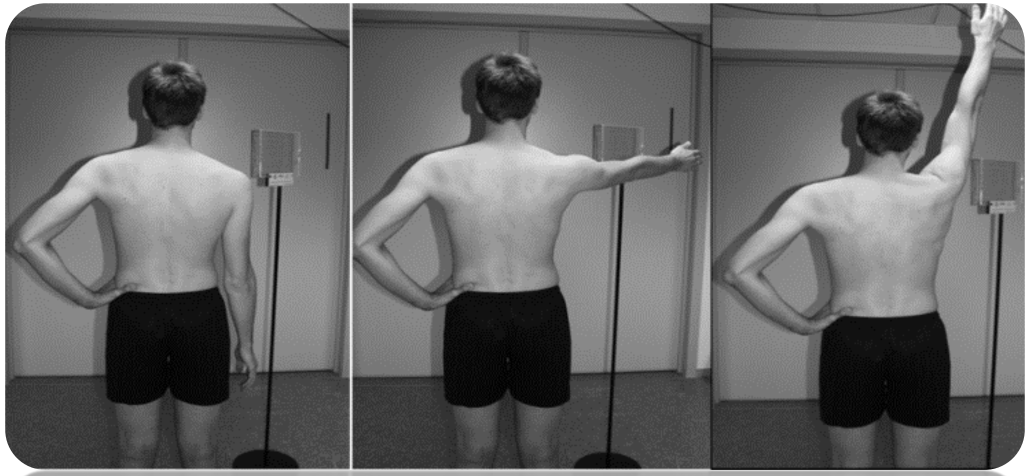


Experimental pain



- injection a bolus of 1 mL of hypertonic saline (5%) into the SS of the dominant arm
- the distribution of pain after the injection; similar to that described in patients with SIS.

EVALUATION OF THE EFFECT OF EXPERIMENTAL SHOULDER PAIN ON THE ACTIVITY OF THE GLENOHUMERAL AND SCAPULOTHORACIC MUSCLES DURING THE PERFORMANCE OF AN ELEVATION TASK IN THE SCAPULAR PLANE



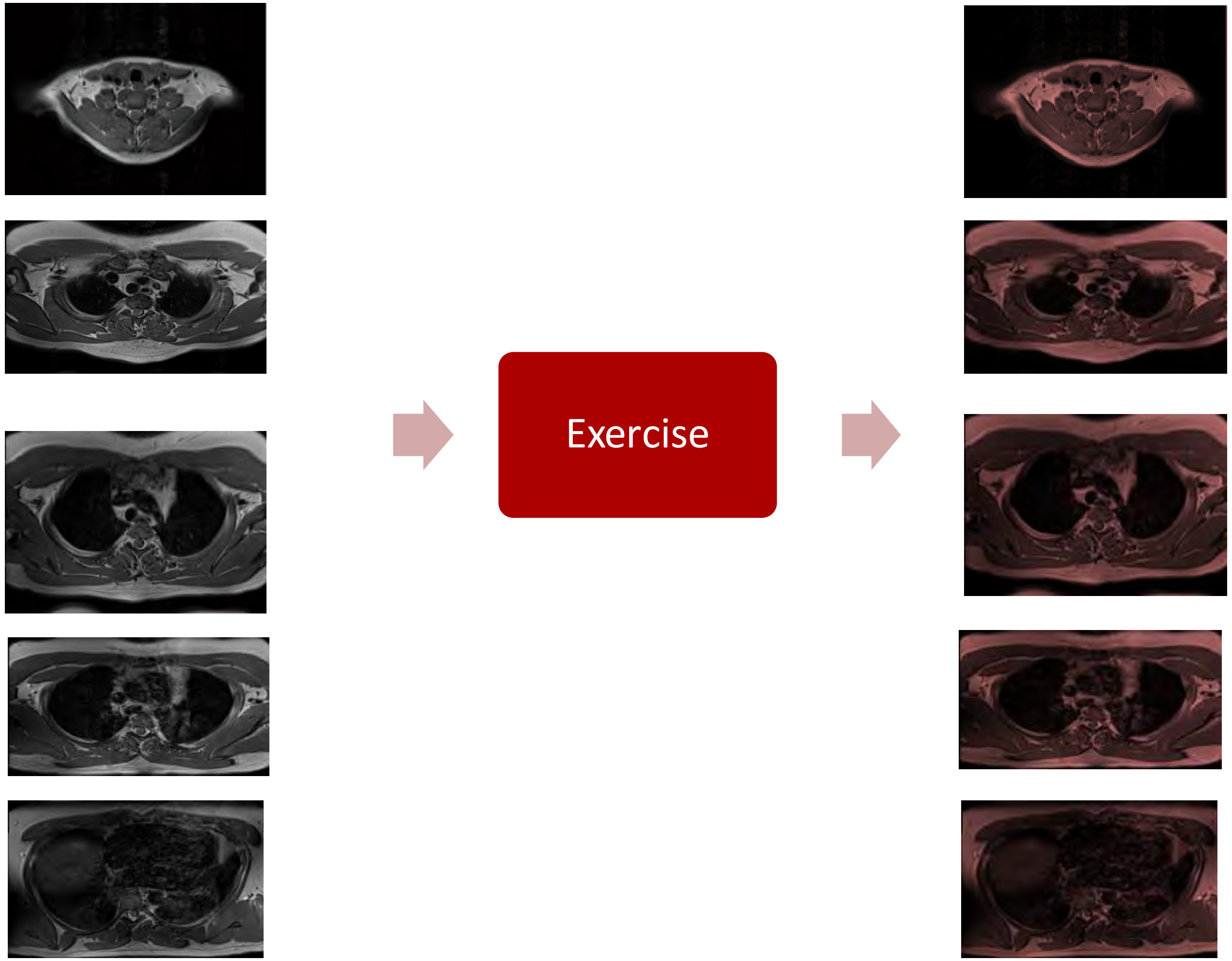
Muscle functional MRI

- Non invasive technique based on the differences in water relaxation values (T2 relaxation of the muscles) of the muscles

- Activity of the muscles: acute activity-induced increase in T2 relaxation times

=> The shifts in T2 values upon exercise relate to the amount of work performed by the muscle

MR image at rest → Exercise → MRI image after exercise


Exercise

METHODS

- 25 healthy individuals, performing elevation in the scapular plane

  (3 sets of 10 reps)

- Tested under 2 conditions: first without pain and then with experimental shoulder pain

MR image at rest → Exercise → MRI image → Exercise **while having muscle pain** → MRI image






- Scans were obtained at 4 different levels, parallel to:
  - C6-C7
  - T2-T3
  - T3-T4
  - T6-T7

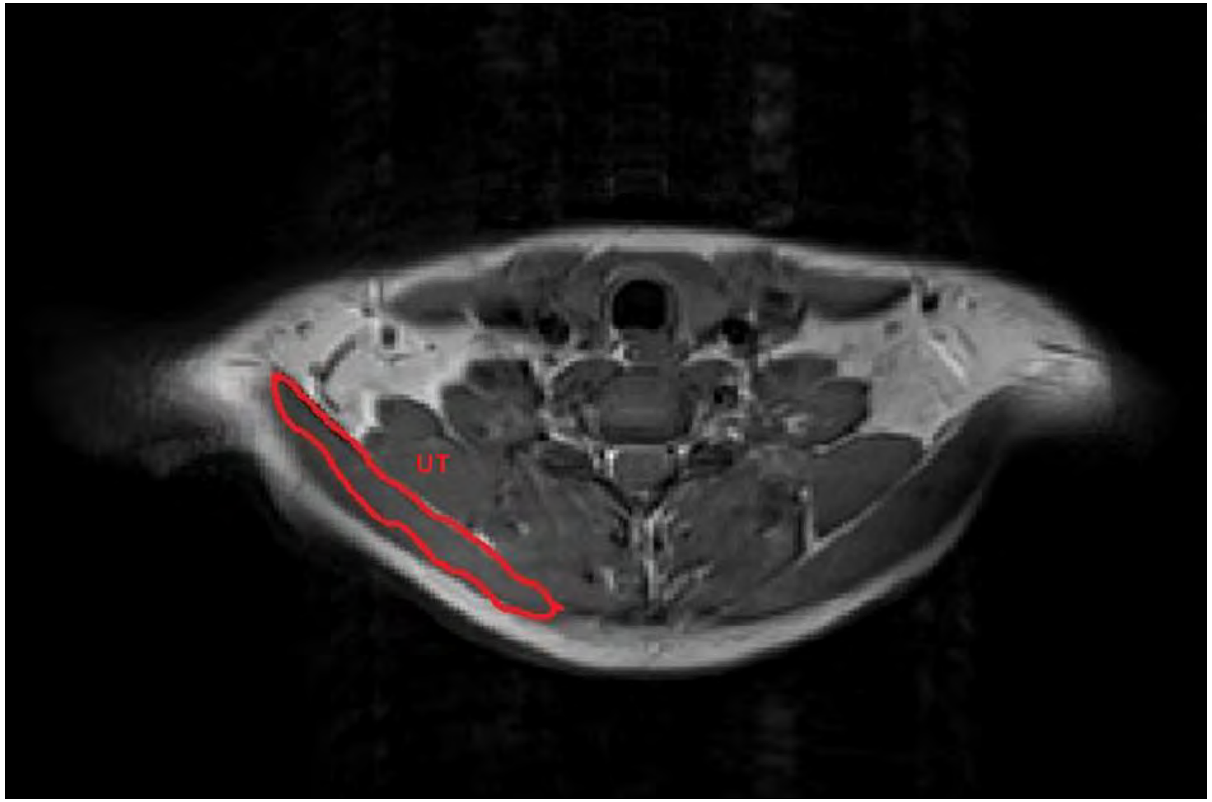


Figure 1 Region of interest (*red outline*) for the upper trapezius (*UT*) muscle in the T2-weighted (T2 map) image at the level parallel to C6-C7.

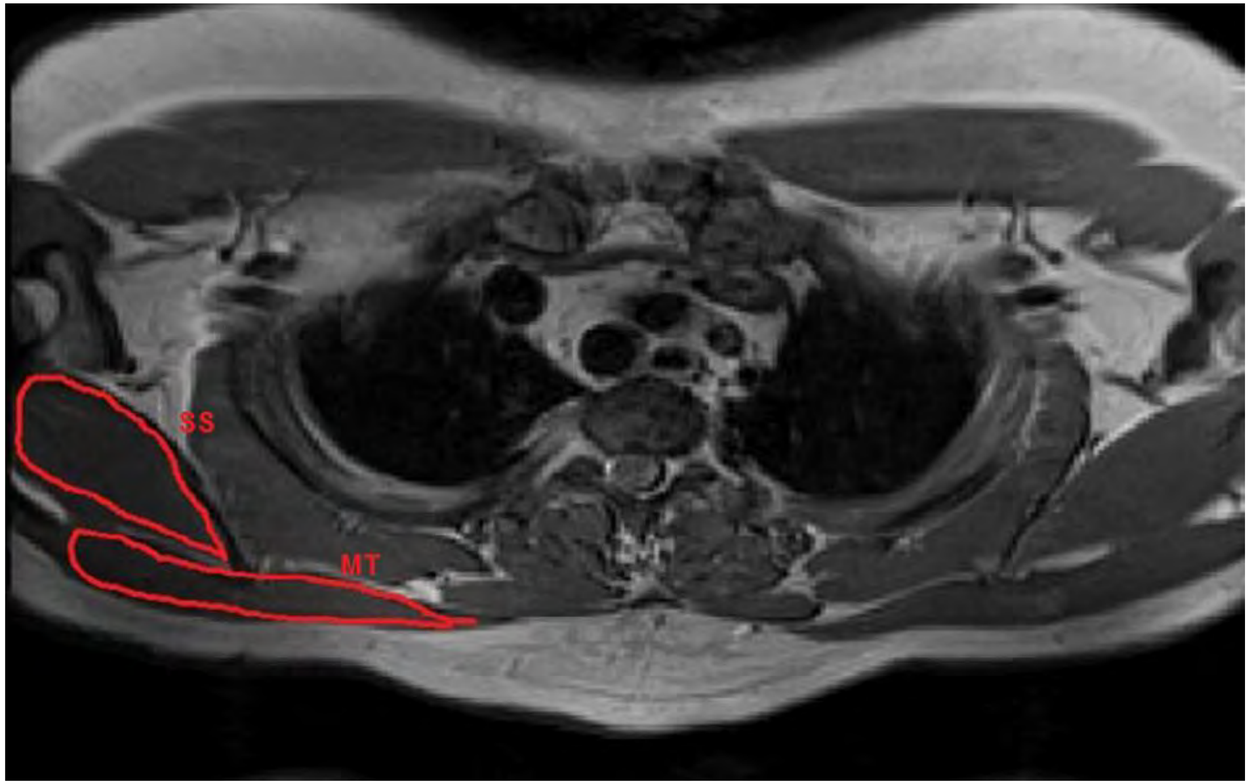


Figure 2 Region of interest (*red outline*) for the supraspinatus (*SS*) and middle trapezius (*MT*) muscles in the T2-weighted (T2 map) image at the level parallel to T2-T3.

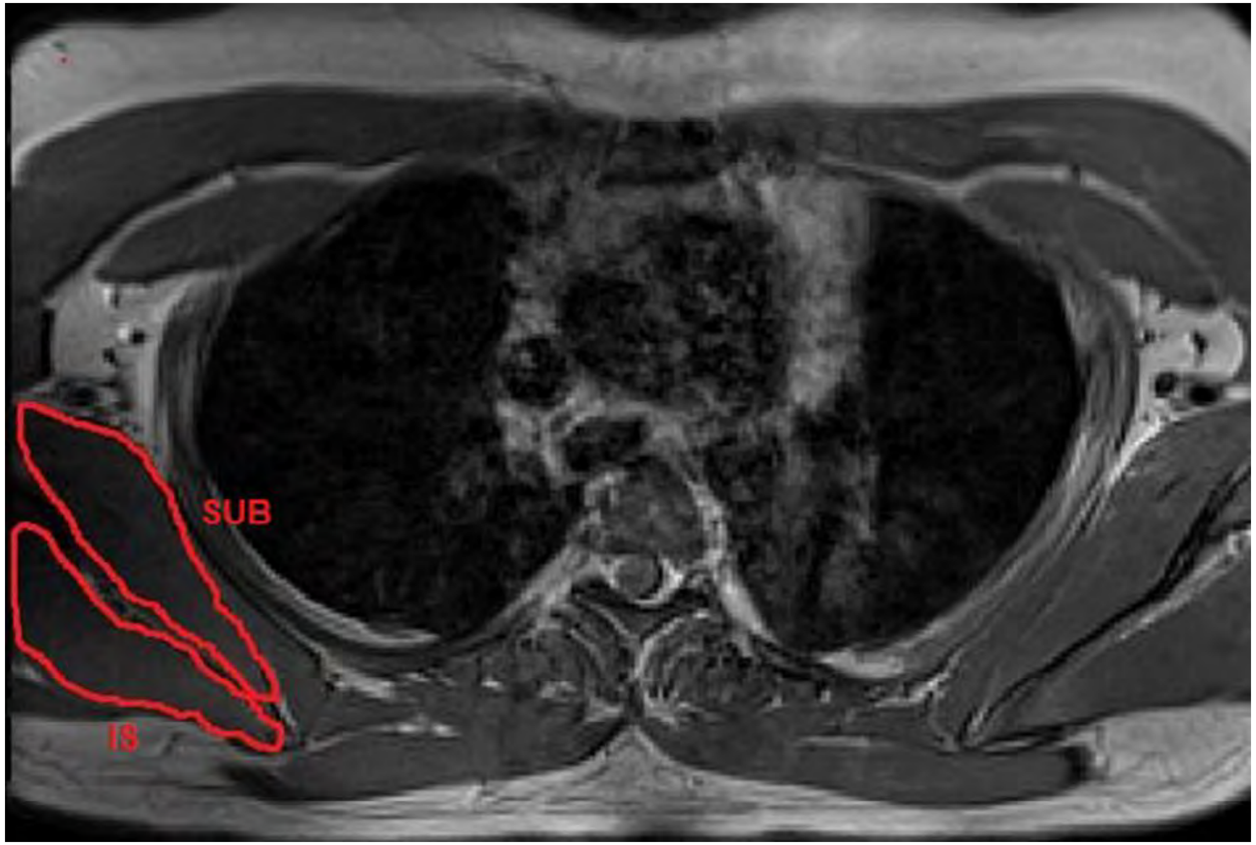


Figure 3 Region of interest (*red outline*) for the subscapularis (*SUB*) and infraspinatus (*IS*) muscles in the T2-weighted (T2 map) image at the level parallel to T3-T4.

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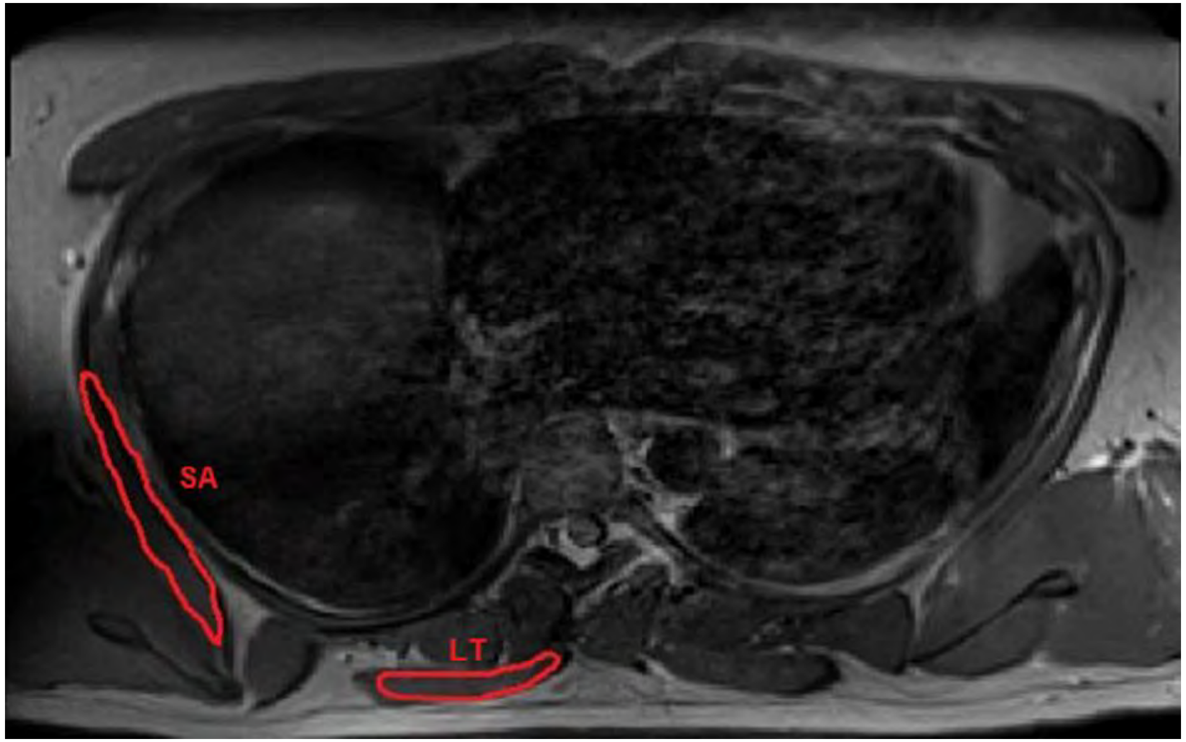

Figure 4 Region of interest (*red outline*) for the serratus anterior (*SA*) and lower trapezius (*LT*) muscle in the T2-weighted (T2 map) image at the level parallel to T6-T7.

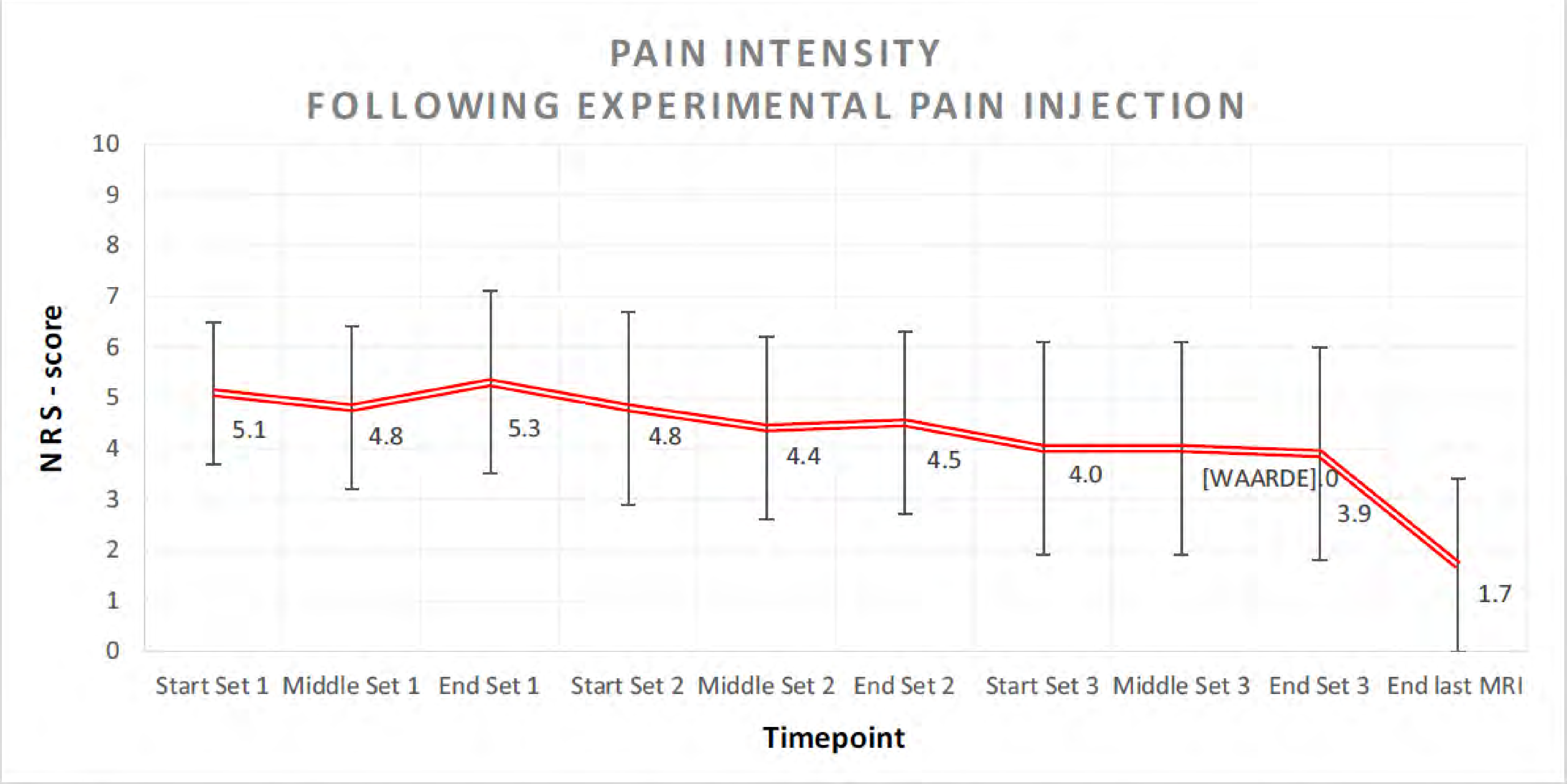

Figure 5 Pain intensity (0-10) according to the Numeric Rating Scale (*NRS*) after injection of hypertonic saline into the supraspinatus. Data are shown as the mean ± standard deviation (*range bars*).

Table II Absolute T2 values for all muscles during the rest condition, the condition after the exercise (*Post*), and the condition after the exercise performed with pain (*Postpain*)

Muscle	Rest Mean ± SD, ms	Post Mean ± SD, ms	Postpain Mean ± SD, ms
Trapezius			
Upper (C6-C7)	38.7 ± 2.4	46.6 ± 5.0	45.1 ± 5.3
Middle (T2-T3)	39.8 ± 2.3	44.6 ± 4.2	44.7 ± 3.3
Lower (T6-T7)	35.6 ± 2.3	41.7 ± 3.0	41.3 ± 3.0
Serratus anterior (T6-T7)	40.3 ± 3.2	48.2 ± 5.7	47.4 ± 5.0
Infraspinatus (T3-T4)	47.2 ± 3.7	56.6 ± 6.0	54.6 ± 4.7
Subscapularis (T3-T4)	44.0 ± 3.3	49.2 ± 5.3	48.5 ± 4.4
Supraspinatus (T2-T3)	48.8 ± 3.9	61.8 ± 6.9	58.5 ± 4.2

SD, standard deviation.

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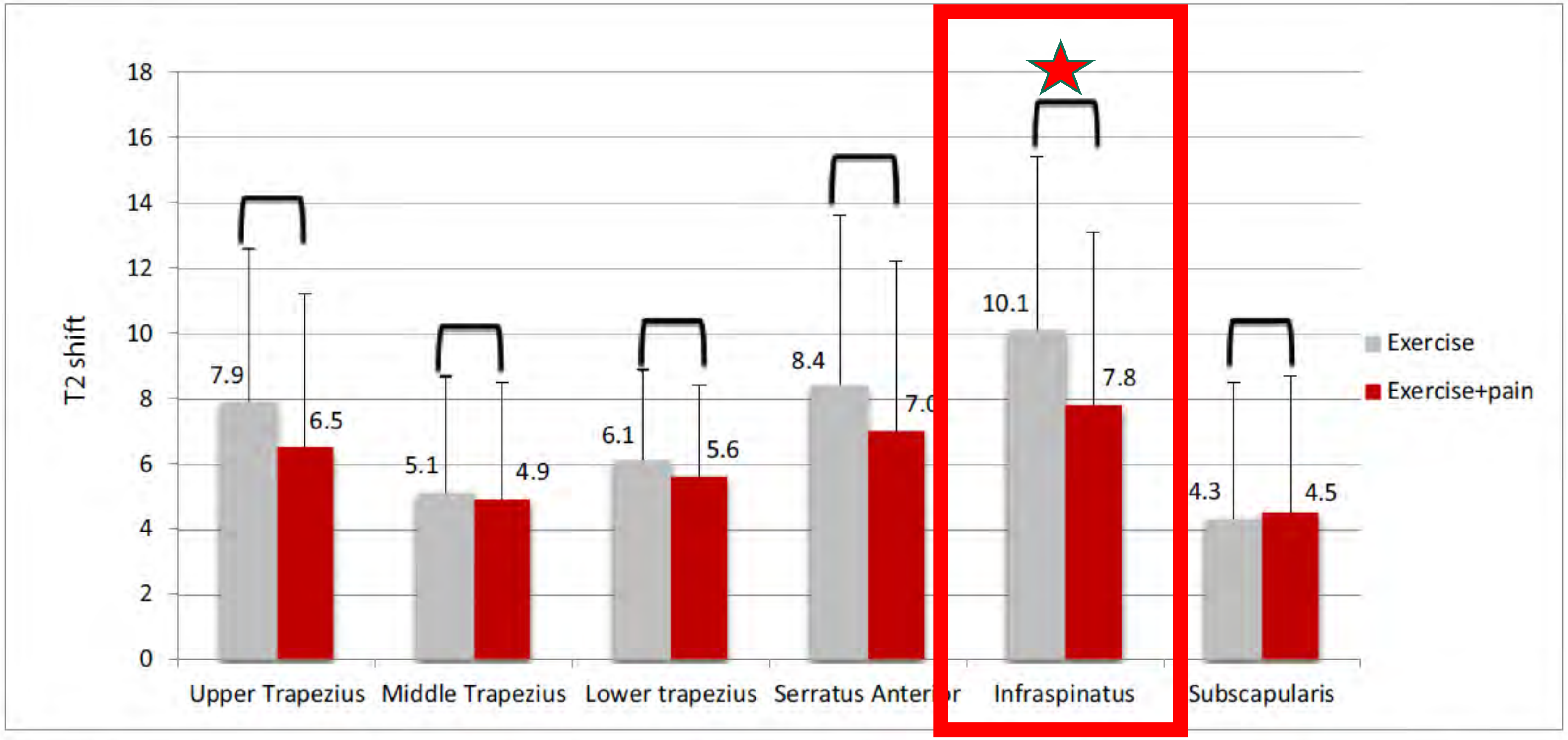

Figure 6 T2 shifts for the nonpain and pain conditions and *P* values for comparisons of the T2 shifts between the 2 conditions. Data are shown as the mean ± standard deviation (*range bars*). No values are given for the supraspinatus because this muscle was injected with saline and the saline might have changed the signal intensity of the injected muscle, and as a consequence, artificially influence the T2 values. $^*P < .05$ indicating statistical significance.

ROLE OF M. INFRASPINATUS

- stabilizes the humeral head during arm elevation
- depresses humeral head to avoid contact and impact with coracoacromial arch

INHIBITION OF INFRASPINATUS?

=> Inefficient humeral head depression during humeral elevation leading to shoulder impingement

- Acute experimental pain?

  different from chronic pain or acute traumatic pain

CONCLUSION

Acute experimental shoulder pain has an inhibitory effect on the activity of the IS (reduction in T2 shift) during elevation of the arm

- Possible implications:
  - rotator cuff muscle function (IS) should be a consideration in the early managing of patients with shoulder pain

Any questions?

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