Diagnosis & Treatment of Cervical and Shoulder Dysfunction: Movement System Impairment Syndromes (MSI)

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Objectives

• Describe the MSI approach to evaluation and treatment of neuromusculoskeletal pain conditions.

• Describe the normal alignment and movement patterns of the cervical spine, scapula and humerus during selected movements.

• Discuss principles to guide treatment.

• Recognize the importance of individualizing exercise programs for each patient.

Website: https://pt.wustl.edu/Education/ContinuingEducation/Pages/ContinuingEducation.aspx

Mosby 2001

Elsevier 2010
The Human Movement System

The Body System for which Physical Therapists are Responsible.

The System of our Expertise
Our Identity – APTA 2013

The Movement System

- Movement is an essential function of life at all levels of living organisms.
  - From ions moving through membranes to moving your limbs to moving in your environment

http://pt.wium.wustl.edu/AboutUs/Pages/HumanMovementSystem.aspx

Expertise in a Body System is Important

- Highly respected health professions achieved their status by having expertise in an anatomical or a physiological body system
- Pathophysiology of specified anatomical body system
  - Neurologists, orthopaedists, cardiologists, dentists, podiatrists
- Physiological systems
  - Internists (all physiology), endocrinologists

Movement System Function Changes With Growth, Activity & Aging:
PT needs to be Life Span Practitioner

- Monitoring and guiding the development of and changes in the Movement System
  - Alignment, movement patterns, strength, endurance
  - Identifying structural variations

If the Oral Cavity needs life-long monitoring the movement system certainly does.

Critical Questions

- Is having precise joint movement important?
  - Are there signs before there are symptoms? (Chol, Blood Sugar, BP)
- Why would the precision of joint movement change – become impaired?
  - From daily activities
  - From sports and fitness
- How should impaired joint motion be corrected?
  - Stretching
  - Strengthening
  - Retraining

Pain Models:

- Pathokinesiologic Model: Pathology is source of pain
  - Disease/Pathology/Injury → Altered Movements & Postures → Tissue Stress → Musculoskeletal Pain → Tissue Injury Micro/Macro

  Hislop HT, Phys Ther, 1975; 19:1069-1080
  Sahrmann SA, 2002

- Kinesiopathologic Model: Imprecision of movement results in pathology
  - Repeated Movements/Postures → Altered Movements & Postures → Tissue Stress → Musculoskeletal Pain → Tissue Injury Micro/Macro

  Hiskup HI, Phys Ther, 1975; 19:1069-1080
  Sahrmann SA, 2002
Why Does Movement Become Impaired?

• Repeated movements and prolonged postures associated with everyday activities induce adaptive changes in movement system components.

• The adaptive changes vary because of intrinsic (genetics, sex, age) and extrinsic (fitness, work activity) factors.

Why Does Movement Become Impaired?

• The body follows the law of physics and follows the path of least resistance for motion which contributes to subtle hypermobility.

• The way everyday activities are performed reinforces this hypermobility and the movement pattern.

• Muscle performance is determined by the pattern of movement. Altered movement patterns impair proper muscle performance.

Working Theory

• Musculoskeletal pain is:

  1. Related to lifestyle similar to many other health conditions

  2. A progressive condition
     • Starting with acute pain – first indication of tissue damage
     • High recurrence rate – leading to chronic problem

  3. The result of tissue changes associated with
     • Aging-related degeneration and
     • Activity-induced tissue injury from impaired joint movement

The Challenge: Keeping the Acute Problem From Becoming Chronic

• Acute symptoms subside
  • With time
  • With variety of interventions addressing symptoms

• However recurrence is common!
  • Pathoanatomic structures are traditionally considered the cause.
  • Unfortunately, the impaired movement is not considered as cause.
  • Therefore has not been identified & addressed.

What is MSI?
(Movement System Impairment Syndromes)

• Utilizes the kinesiopathologic model to drive evaluation and treatment of neuromusculoskeletal pain conditions

• Deviations in alignment and the precision of joint motion (movement impairment) create microtrauma that can lead to macrotrauma

• In cases of trauma, alterations of normal movement or alignment will perpetuate the pain
The Challenge: Keeping the Acute Problem From Becoming Chronic

- To minimize recurrence, must identify the movement cause & contributing factors
- Develop a treatment program that includes:
  - Patient specific exercises
  - Correction of performance of basic daily activities
  - Correction of performance of work, recreation, fitness, & sports activities

repetition of Impaired Movement may accelerate the development of osteoarthritis

OA Mechanical Mechanisms

- Cartilage degradation can be correlated with abnormal excessive articular contact stress
  - [Dekeland & Weissman, 1978; Brandt 2006; Radin 1978; Jackson 2004; Fontana, 2007]
- This abnormal contact stress may result both
  - from excessive load acting on a normal joint or
  - from normal loading acting on a weakened articulation: ligament laxity, periarticular muscle weakness, or reduced proprioception
  - may all lead to articular instability,
  - exposing the joint to sudden impulsive loads and finally to high peak pressure
  - (Brandt 2006; McGonagle 2010; Felson 2000)

Unfavorable Biomechanical Conditions Contributing to Development of OA

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mechanism of Relative Overload</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mal-alignment</td>
<td>Abnormal load distribution - shifting of center of pressure</td>
</tr>
<tr>
<td>Loss of meniscal tissue</td>
<td>Peak pressure</td>
</tr>
<tr>
<td>Cartilage lesions</td>
<td>Stress on lesion rim</td>
</tr>
<tr>
<td>Joint instability - ligamentous laxity</td>
<td>Abnormal load distribution - shifting of center of pressure</td>
</tr>
<tr>
<td>Trauma</td>
<td>Cartilage damage</td>
</tr>
</tbody>
</table>


Degeneration of Cervical Discs

- Most affected segments: move with greatest frequency and range of motion
  - Singer 1993

Movement System Impairment (MSI) Syndromes – Guiding Theory

- Little things mean a lot!!!
- Underlying problem: micro-instability:
  - Accessory motion (roll, spin, glide) becomes excessive in one or more directions (hypermobility/micro-instability)
  - Micro-trauma from shear force and points of high contact pressure
  - Becomes macro-trauma
Joint Micro-Instability

- Characterized by moving:
  1. In range that is more than optimal (joint surfaces not optimal during movement)
  2. More often than is optimal
  3. More readily in specific directions
- Results in accessory motion micro-instability
- Can progressively increase
- Can occur with physiological motion that is
  - Normal
  - Excessive
  - Limited

Assessment of Intra-Joint Micro-Instability & Relative Flexibility

- Assess by physiological motions
  - Passive and active
  - Use hands to feel the precision of joint motion
  - “Going along for the ride”
  - Manually correct the motion during physiological active & passive motion

Muscle Stiffness

- Resistance to Passive Stretch
- Highly correlated with muscle size
  - > size = > stiffness

Relative Stiffness

- In a multi-segmented system,
  - Movement occurs at the segment with the least resistance/greatest relative flexibility
  - Takes the path of least resistance (law of physics)
- Contributes to development of inter-joint relative flexibility
  - Compensatory movement in specific direction

MSI Approach

- Systematic examination used to evaluate, diagnose and treat neuromusculoskeletal pain problems
  - Based on anatomy and kinesiology
  - Exam is based on symptom alleviation, not just provocation
Cause versus Source
Operational Definitions

**Cause**
- The mechanical factor (movement) that results in tissue irritation
- e.g. scapular depression, humeral anterior glide

**Source**
- The tissue or pathoanatomical structure that is symptomatic
- e.g. rotator cuff tendinitis, ositis, opathy

MSI Approach

- Emphasis is on the **CAUSE** (movement) vs. **SOURCE** (pathoanatomy) of symptoms
  - Identification of the pathoanatomical structure that is the source of symptoms may be useful for prognosis/staging but does not necessarily direct treatment.
  - Often > 1 pathoanatomical source

Movement Exam

- To date, whether the movement impairment is the cause or result of the pain is unknown.
- But if during the exam, correcting the movement impairment immediately alleviates the symptoms, then treatment may be most effectively directed by a *movement diagnosis* (Ludewig PM 2009, Kibler WB 2013)

Why Give a Diagnosis?

- Direct treatment and describes the syndrome
  - Shoulder pain vs. Insufficient Scapular Upward Rotation
- Enhance communication
  - Intra- and extra-professional
- Informs other health professionals of the movement patterns and relationships to pain problems
  - Facilitate recognition of the profession as movement system experts
  - Need label to inform others that we can determine the problem
- Group conditions
  - Prognosis, etiology, improve treatment, research

Movement Exam → Diagnosis

- PTs must establish a diagnosis of the condition they are treating to ensure most effective treatment (*APTA House of Delegates 1994, 1995*)
- Diagnosis named according to the impairment(s) observed
  - Frequency
  - Magnitude
  - Production of symptoms
  - Response to modification of movement
- Diagnosis directs treatment

Movement Examination

- Consists of:
  - Alignment tests
  - Movement tests performed in a variety of positions (standing, supine, prone, quadruped, sitting)
  - Analysis of functional activities
Movement Examination

• During the examination, the patient’s preferred alignment and movements are analyzed to determine their precision and effect on symptoms.

• The preferred pattern is followed immediately by a secondary test modifying the movement to determine the effect on symptoms.

• Goal: Determine the site that is relatively too flexible (e.g. moves too much)
  • Accessory motion that occurs too readily (ex. Superior or anterior glide)
  • One joint moving too readily compared to the adjoining joint (ex. GHJ vs scapula)

Vicious Cycle

- Sitting erect
- Uncomfortable
- Back muscles cramp
- Feels wrong
- Lumbar flexion
- Sitting/cycling
- Working
- Shoulders forward of hips
- In sitting – flexion moment on lumbar spine
- Pelvis tilts posteriorly
- Hamstrings become short/stiff
- Minimal energy expenditure
- Abdominals become shorter
- Flex thoracic and lumbar spine
- Knee extension
- Tills pelvis posteriorly
- Flexes lumbar spine
- Sitting/cycling
- Working
- Uncomfortable
- Back muscles cramp
- Feels wrong

- Most people who experience neck pain do not experience a complete reduction of symptoms.

- 50% to 80% will have a reoccurrence in the next 1-5 years

- Prognosis:
  - Better: Younger
  - Poorer: poor health, prior neck pain episodes, poor psychological health, worrying.

Movement System Impairment
Syndromes of the Cervical Spine
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“Neck pain is multifactorial in its etiology and in its impact on affected persons.

Future research should be directed to assessing the impact of modifiable risk factors through innovative treatment approaches.

Changes in public policy which address these risk factors may significantly reduce the burden and cost of neck pain in society.”

Optimal Alignment

- Reduces likelihood of postural deformities
- Reduces stress on tissues
- Contributes to optimal movement patterns
- Promotes optimal muscle length and pattern of muscle activation

Kendall FP 1993

Alignment: Cervical Spine

Examination

Link to (most) MSI examination videos and some lecture content

https://wustl.app.box.com/s/mp56h509ie7djm4sp4mi41frjxhi
**Normal Cervical Spine Alignment**

- **Inward Curve**

  - Influenced by length of:
    - Intrinsic muscles of cervical spine
    - Muscles of shoulder girdle that attach to cervical spine

  - Affected by alignment of thoracic and lumbar spines

  *Kendall, FP et al, Posture & Pain.*

**Forward Head**

- ↑ thoracic curve = ↑ cervical lordosis = forward head position

- Facets are approximated

- Cervical spine extended and translated

- Increased length of anterior cervical flexor muscles and suprathyroid, infrahyoid muscles

- Decreased length of posterior extensor muscles

*Kendall, FP et al, Posture & Pain.*

**Consideration of Adjacent Regions**

- Scapular Alignment

- Thoracic Spine Alignment

- Lumbar Spine Alignment

- Weight of the extremities

- Movement of the extremities

*Black KM et al, Spine 1996*

**Additional Contributing Factors – Shoulder Girdle**

- The alignment of the shoulder girdle should be addressed in the treatment of cervical pain problems.

- The musculature of the shoulder girdle affects the alignment and stress on the cervical spine structures.

- Scapular UR & posterior tipping are decreased in flexed head position (Ludewig 1996)

- Position of scapular depression results in increased stress on upper trapezius muscle (Azevedo 2007)

**Neutral sitting posture**

- Reduces the demand on the cervical extensor muscles

- Improves neck range of motion

*Edmondston 2010, Caneiro 2010, Cleland 2009, Lau 2010*

**Correcting lumbar, thoracic alignment before correcting cervical spine alignment is critical.**

- Ex. Thoracic alignment = kyphosis or sway
  - Depressed chest
  - Well-developed abdominals
Cervical Motion Restricted by Shoulder Girdle Muscles

- Passive elevation of shoulder girdle increases ROM and decreases pain
- Why? Compressive loading of the cervical spine from a transfer of weight of the upper extremities to the cervical region through cervicoscapular muscle attachments

Ha S et al. Man Ther 2011
VanDillen LR et al Clin J Ph 2007
Andrade GT et al JOSPT 2008
McDonnell MK et al JOSPT 2005

Elevated Shoulder Girdle Test

Procedure:
1. Assess AROM and pain/symptoms.
2. Fully support UEs with muscles relaxed.
   Reassess AROM and pain/symptoms.

- Can use any cervical active motion, though rotation most common.
- Decreases sx/increases ROM with rotation (VanDillen 2007)
- Decreases pain with extension (VanDillen 2007, Ha 2011)

Selected Movement Tests: Cervical Spine

Vertebral Motions of the Cervical Spine

- Flexion/Extension: Coupled motion of translation and sagittal rotation
- Sagittal rotation = “Rolling” = rotation about a frontal axis
- Flexion - 63°
- Extension - 79°
  [young adults]

Cervical Range of Motion

- Generally, females have greater ROM than males
- Decreases significantly with age

<table>
<thead>
<tr>
<th>Age</th>
<th>Rotation</th>
<th>Sidebending</th>
<th>Extension</th>
<th>Flexion</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>70°</td>
<td>45°</td>
<td>85°</td>
<td>65°</td>
</tr>
<tr>
<td>70-79</td>
<td>50°</td>
<td>25°</td>
<td>55°</td>
<td>50°</td>
</tr>
</tbody>
</table>

Youdas JW et al. PTJ '96

Program in Physical Therapy
### Cervical Flexion
- Lengthening of posterior structures
- Separation of spinous processes
- Full flexion of cervical spine includes upper thoracic flexion

Kendall, FP et al, Posture & Pain.

### Common Muscle Impairments With Faulty Cervical Flexion
- **Intrinsic neck flexors** become weak or long - compromise fine control of vertebral motion
  - Longus capitis, longus colli
- **Extrinsic neck flexors** become dominant, adding to compressive, rotational, & shear forces exerted on the cervical spine
  - Anterior and middle scalenes, sternocleidomastoid
    - Increase recruitment during anterior translation with flexion (O’Leary 2011)

### Deep/Intrinsic Neck Flexors
- Impairments of the deep neck flexors with patients with dx of Cervicogenic Headaches (CH) & Chronic neck pain patients
  - Watson DH et al. Cephalgia ’93
  - Beazell JR JOM Man & Manip Th ’93
  - Placzek et al. JOM Man & Manip Th ’99
  - Juil et al. Cephalgia ’99
  - Falla D et al., CI Neurophys’ 06
  - O’Leary KT et al. Man Ther ’11
- Significant decrease in STRENGTH & ENDURANCE of the deep neck flexors

### Common Muscle Impairments With Faulty Cervical Extension
- **Intrinsic neck extensors** become weak or long - compromise fine control of vertebral motion
  - Semispinalis capitis & cervicus, splenius, suboccipitals
- **Extrinsic neck extensors** become dominant adding to compressive, rotational, & shear forces exerted on the cervical spine
  - Levator scapulae, upper trapezius

### Movement Impairment Diagnoses of Cervical Spine
- Extension
- Extension-Rotation*
- Flexion
- Flexion-Rotation
- Rotation

* Most common in my practice
**Cervical dx often have an associated scapula and/or humeral movement diagnosis

### Common Muscle Impairments With Faulty Cervical Rotation
- **Intrinsic neck rotators** become weak or long - compromise fine control of vertebral motion
  - Rectus capitis posterior major, oblique capitis inferior, oblique capitis superior, splenius
- **Extrinsic neck rotators** become dominant - can produce not only cervical rotation but also lateral flexion, extension and/or forward translation
  - Sternocleidomastoid, scalenes, upper trapezius, levator scapulae

### Common Muscle Impairments With Faulty Cervical Rotation
- **Intrinsic neck rotators** become weak or long - compromise fine control of vertebral motion
  - Rectus capitis posterior major, oblique capitis inferior, oblique capitis superior, splenius
- **Extrinsic neck rotators** become dominant - can produce not only cervical rotation but also lateral flexion, extension and/or forward translation
  - Sternocleidomastoid, scalenes, upper trapezius, levator scapulae
Cervical Extension – Rotation syndrome

Cervical Alignment

- Most common:
  2. Forward head posture (degenerative disc disease) anterior translation limit extension range of motion.
  3. Upper cervical extension greater than lower

- May present with rotation or sidebend

Alignment

- Thoracic kyphosis → increases cervical lordosis
- Scapula depression or abduction
  - Upper trapezius & levator in a lengthened position → downward pull exert compressive force on facets → narrows intervertebral foramen → traction on the brachial plexus

Movement Impairments

- Flexion ROM limited or cervical spine does not flex at all segments
- Poor control of motion during active cervical extension and/or rotation
- Shoulder flexion compensatory cervical extension or rotation
- Quadruped rocking compensatory cervical extension

Cervical Motion Induced by Shoulder Motion

- Shoulder flexion can cause cervical rotation
- Cervical spine relatively more flexible (mobile) than UT or levator

Cervical Extension/Rotation Syndrome

- Key muscle changes:
  - Short cervical extensors & Long cervical flexors
- Muscle Impairments:
  - Lengthened intrinsic neck flexors - test weak, decrease endurance
  - Dominant extrinsic neck flexors
    - Contributes to anterior shear, poor rotation
  - Dominant levator / upper trapezius
    - Contributes to extension and poor rotation
Key Tests

- Pain with neck extension and/or rotation
- Passive elevation of girdle - decrease pain with extension and/or rotation
- Limited cervical flexion and/or rotation ROM
- Poor performance of the deep neck flexors

Van Dillen 2007, Ha 2011

Limited cervical flexion and/or rotation ROM

Treatment

- Start with correct alignment of lumbar, thoracic and scapula before cervical spine alignment
- Improve extensibility of posterior cervical muscles
- Improve intrinsic cervical muscle control and strength
- Improve length of cervical extensors
- Increase support from middle, lower trapezius & serratus anterior to support extremities

Schuldt K, Scand J Rehabil Med. 1987
Andrade GT, JOSPT 2008; Ha, Man Ther 2011

Treatment – Other Education

- Unload spine - support upper extremities
- Make patient aware of positions and habits that assume positions of extension
  - Habitual nodding
  - Use of bifocals
  - Sleeping with arms overhead
  - Position of computer

Activities That Contribute

- Make patient aware of positions and habits that assume positions of rotation
  - Holding telephone with shoulder
  - Sitting with head turned watching TV
  - Sleeping prone with arm overhead and head turned to opposite side
  - Sleeping on couch with head resting on arm rest
  - Falling asleep sitting up
  - Location of computer screen

Movement System Impairment Diagnoses – Cervical Spine

- Cervical Extension: Summary
  - Thoracic kyphosis (increased cervical lordosis)
  - Scapula depression or abduction (lengths UT and levator – downward pull compresses facets, narrows intervertebral foramen)
  - Lengthened anterior cervical muscles \(\rightarrow\) decreased strength (especially intrinsics)
  - Shortened, dominant extensors
Movement System Impairment Diagnoses – Cervical Spine

• Cervical Rotation: Summary
  • Often coupled with Extension
  • Segmental rotation – insufficient control of intrinsic neck flexors and/or extensors
  • May have pain/excessive cervical movement with unilateral shoulder movements because of attachments of levator scapula and upper trapezius
Link to (most) MSI examination videos and some lecture content

https://wustl.app.box.com/s/mp56h509le7dsmjnm4spc4mi41frjxhi

Movement System Impairment Syndromes of the Scapula and Humerus
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Definitions of Scapular Movements

• Adduction (clavicular retraction-SC):
  • the scapula translates medially along the rib cage toward the vertebral column.

• Abduction: (clavicular protraction-SC)
  • translates laterally
  • During these motions there is associated scapular internal or external rotation occurring at the AC joint.
  • Because the scapula follows the ribcage
  • Thus shape of ribcage is important

Definitions of Scapular Movements

• Elevation: (clavicular elevation-SC)
  • a movement in which the scapula translates along the ribcage in a cranial direction.

• Depression: (clavicular depression-SC)
  • translates in a caudal direction.

Definitions of Scapular Movements

• Upward rotation (lateral rotation):
  • AC joint
  • a movement of the scapula about an axis perpendicular to the plane of scapula
  • inferior angle moves laterally
  • glenoid fossa rotates to face cranially.
  • SC joint
  • posterior axial rotation of clavicle also contributes to UR.

Ludewig PM et al. 2009

Definitions of Scapular Movements

• Downward rotation (medial rotation):
  • inferior angle moves medially
  • glenoid fossa rotates to face caudally.

Ludewig PM et al. 2009

Definitions of Scapular Movements

• Anterior tilt/tipping:
  • AC joint
  • a movement of the scapula about an axis parallel to the scapular spine
  • coracoid moves anteriorly and caudally
  • inferior angle moves posteriorly and cranially.

• Posterior tilt/tipping:
  • coracoid moves posteriorly and cranially
  • inferior angle moves anteriorly and caudally.

Ludewig PM et al. 2009
Definitions of Scapular Movements

- Internal rotation:
  - AC joint
  - rotation of the scapula about a vertical axis
  - lateral border of the scapula moves anteromedially
  - vertebral border moves posterolaterally such that the costal surface of the scapula faces more toward the midline of the body

- External rotation:
  - lateral border of the scapula moves posterolateral
  - vertebral border moves anteromedial

Ludewig PM et al. 2009

Definition of Scapular Movements

- Winging:
  - AC Joint
  - abnormal movement of the scapula about a vertical axis
  - vertebral border moves in a posterior direction away from the ribcage (Hall, CM, Brody LT.)

Normal Resting Scapulothoracic Alignment

- Slope of shoulders: slight downward slope

- Clavicle:
  - 6° to 29° elevation
  - 19° retraction

Ludewig PM 2009; Todd TW 1912

Resting Scapulothoracic Alignment

- Scapula:
  - Root of scapular spine 3” from spinal column
  - 30 - 40° internal rotation (relative to frontal plane)

Ludwikiewicz 1999, Neumann 2010, Ludewig PM 2009

- Vertebral border vertical or very slight upward rotation (5°)

Ludwikiewicz 1999, Neumann 2010, Ludewig PM 2009

- 10-15° of anterior tilt

Ludewig PM 2009

- Root of spine level with T3

Kendall FP 1993, Hoppenfeld S 1976
Normal Resting Humeral Alignment

- Humerus
  - *With the scapula aligned correctly:*
    - slight humeral medial rotation – antecubital crease faces anterior/slightly medial (Ludewig PM 2009)
    - arm at side (0° abd)
    - shaft of humerus vertical (0° flexion)
    - No > 1/3 humeral head anterior to anterolateral corner of acromion
      - Can reliably palpate (Bryde 2004)

Is Alignment an Initial Indicator of Pattern of Movement?

Alignment may play a greater role in UE pain than other regions of the body
(Swift TR 1984, Borstad JD 2006)

Selected Movement Tests:
Shoulder Examination

Clinical Assessment: Criteria for Normal Scapular Motion During Arm Elevation

- Scapula externally rotates during arm elevation especially at the end ranges. (Ludewig 2009, Borstan 2008)
- Scapula should elevate slightly (6-10°) (Ludewig PM 2009)
- Vertebral border of scapula should remain in contact with thorax
- Normal GH:ST rhythm is 2.1: for abduction; 2.4:1 for flexion; 2.2:1 for scapular plane abduction (Ludewig PM 2009)

Clinical Assessment: Criteria for Normal Humeral Movement During Arm Elevation

- The humerus laterally rotates relative to the scapula as the arm is elevated in all planes
  - GH LR should be about 60° by the end range of arm elevation
  - GH LR increases the volume of the subacromial space (Ludewig PM 2009)
- During shoulder flexion, humeral head should stay centered on the glenoid (movement is primarily spinning) (Neumann DA 2002)

Clinical Assessment: Criteria for Normal Scapular Motion For Shoulder Flexion

By the end range of arm elevation:

- Acromion should be aligned with C6-7
- Root of spine of scapula should be aligned with T3
- The vertebral border of the scapula should reach 55-60° (± 5°). (Inman 1944)
- Normal scapular abduction is 3° from the vertebral spine to the root of the spine of the scapula.
- Scapula should posteriorly tilt 10° (Ludewig PM 2009)
- Scapula should externally rotate so it is 10-20° anterior to the frontal plane (Ludewig PM 2009)
Clinical Assessment: Criteria for Normal Scapular Motion During Arm Lowering

- Pattern of motion should be mirror image of arm elevation (in reverse)
  - No prominence of vertebral border
  - Scapular posterior tilt should be slightly greater during arm lowering (Ludewig PM 2009)
  - There should be decreased scapular relative to GH movement during arm lowering compared to arm raising (Kramar JF 2009)

Clinical Assessment: Criteria for Normal Scapula/Humeral Motion - Shoulder Rotation

- Scapula should remain relatively stable
  - The pull of the rotator cuff muscles should be counteracted by the scapulothoracic muscles (Reinold 2009, Sahrmann 2002)
  - Humeral rotation should occur about the long axis of the humerus – spinning of humeral head to center on the glenoid (Neumann 2002)
  - Translation of the humeral head should not be visible or palpable

Movement System Impairment Diagnoses: Scapulohumeral

<table>
<thead>
<tr>
<th>Scapula</th>
<th>Humerus</th>
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<tbody>
<tr>
<td>• Scapular Internal rotation/ Anterior tilt</td>
<td>• Humeral Anterior Glide</td>
</tr>
<tr>
<td>• Scapular Depression</td>
<td>• Humeral Superior Glide</td>
</tr>
<tr>
<td>• Scapular Downward Rotation</td>
<td>• Glenohumeral Medial Rotation</td>
</tr>
<tr>
<td>• Scapular Winging</td>
<td>• Glenohumeral Hypomobility</td>
</tr>
<tr>
<td>• Scapular Elevation</td>
<td>• Glenohumeral Multidirectional Accessory Hypermobility</td>
</tr>
</tbody>
</table>

* Revisions to naming of scapular diagnoses may be coming soon, though faulty movement pattern still the same

Scapular and Humeral Diagnoses

- Both a scapular & humeral diagnosis can be assigned, if appropriate
- Most patients receive both a scapular and a humeral diagnosis

Scapular Diagnoses: Symptoms

Any of the scapular diagnoses can be associated with:
- Impingement symptoms:
  - GHJ pain, worse with overhead motions or lying on involved side
  - Compromise of the brachial plexus (Thoracic outlet syndrome):
    - paraesthesia or weakness in the arm; pain in scapula, arm or hand
  - Glenohumeral joint instability:
    - c/o clunking or sensation of shoulder slipping out of socket
  - AC or SC joint pain
  - Cervical pain
  - Thoracic pain

Evidence for Scapular Movement Impairments - Impingement

- Decreased scapular posterior tilting
  - Lukasiewicz AC et al, JOSPT 1999
  - Ludewig PM & Cook TM, Phys Therapy 2000
  - Hebert Lj et al, Arch Phys Med Rehabil, 2002
  - Endo K et al, J Orthop Sci 2001
  - Lin JI et al 2006
- Decreased scapular upward rotation
  - Ludewig PM & Cook TM, Phys Ther 2000
  - Endo K et al, J Orthop Sci 2001
  - Lin et al 2006
  - Lawrence RL 2014
- Increased scapular internal rotation
  - Ludewig PM & Cook TM, Phys Ther 2000
Other Findings of Scapular Movement Impairments in Patients with Impingement

- Increased elevation
- Increased upward rotation
- Decreased internal rotation

The most frequent finding across studies seems to be increased anterior tilt and internal rotation.

From oral presentation
Capstone – Emily Schmidt, Jan 2012

Evidence - Impingement

- Ludewig PM & Cook TM 2000
  - Increased scapular internal rotation with increased load in symptomatic group (with 5 and 10 lb. load)
- Hebert LJ et al, 2002
  - Found 3 subgroups in subjects with SIS:
    - Measured only posterior tilt but some had less, some same and some more than controls
    - Good start at classifying patient into movement impairment categories

Evidence for Scapular Movement Impairments - Multidirectional Instability

- Decreased scapular upward rotation and increased scapular internal rotation

Evidence for Humeral Movement Impairments

- Impingement
  - Increased anterior translation
    - Ludewig PM & Cook TM, JOSPT, 2002
    - Jobe FW et al, Orthop Rev 1989
  - Increased superior translation
    - Deutsch A et al, J Shoulder Elbow Surg 1996

- Healthy Individuals
  - Increased superior translation with muscle fatigue
    - Chen SK et al, 1999

Definitions

- Axiohumeral muscles:
  - Muscles from the trunk to the humerus (ie. lats, pectoralis major)
- Axioscapular muscles:
  - Muscles from the trunk to the scapula (ie. traps, rhomboids, serratus ant, pec minor)
- Scapulohumeral muscles:
  - Muscles from the scapula to the humerus
    - Rotator cuff – supra & infraspinatus, teres minor, subscapularis
    - Teres major
    - Deltoid

Scapular internal rotation with anterior tilt
Scapular Internal Rotation With Anterior Tilt

Movement impairments
1. Insufficient scapular external rotation and posterior tilt at the end range of arm elevation (Ludewig PM 2000 and Lukasiewicz AC 1999, Hebert LJ 2002)
2. Scapular internal rotation and anterior tilt on the return from arm elevation or during early arm elevation due to an issue with patterns of muscle activation

Balance between the serratus anterior and the trapezius is key.

Contributing Factors
• Too much scapular internal rotation (often seen with excessive abduction)
  • Trapezius not performing well, too long, or not as stiff as muscles that IR and abduct scapula
  • Serratus anterior not balanced adequately by trapezius
  • Scapulohumeral muscles pulling harder on scapula than serratus and trapezius
• Too much scapular anterior tilt
  • Serratus anterior and lower trapezius not performing well or not as stiff as muscles that anteriorly tilt scapula
  • Pectoralis minor too stiff or short

Scapular IR – Primary Focus of Intervention

**Anterior Tilt and Abduction**
• Increase stiffness & activation of posterior axioscapular muscles
• Improve timing of activation and hypertrophy
• Stretch
  • SH muscles while maintaining scapular position
  • Pectoralis minor

**Anterior Tilt - muscle activation**
• Dissociating GH from ST motion
• “Letting go” with SH muscles
• Maintain correct alignment of the scapula during arm motions

Scapular Depression With Insufficient Upward Rotation

Movement Impairment - Insufficient elevation
• Acromion depresses in the first 90 degrees of shoulder flexion or abduction
• Acromion does not begin to elevate after about 30 degrees of arm elevation
• Acromion below C6-7 at end range
• Scapula depresses when a load is placed on the arm or during prone tests

Impairments
• Lengthened or weak
  • Upper trapezius
  • Serratus Anterior

• Activation
  • Excessive – latissimus dorsi and lower trapezius
  • Insufficient – upper trapezius
Scapular Depression
With Insufficient Upward Rotation

Primary Focus of Intervention:

- Patient education regarding the alignment and movement impairments and how to modify them during daily activities
- Arm support
- Correcting stiffness, length, activation, and strength impairments of the upper and middle trapezius

Functional Cues

- Reaching:
  - Gradually lift shoulders (shrug) especially after 90° shoulder flexion
  - On return from flexion, don’t let shoulders drop all at once
- Sitting
  - Support arms at the correct height when sitting to lift acromions.
  - Bra
  - Decrease load on acromion – sports bra vs. traditional bra

History

- Pain - anterior or posterior GH joint line > deltoid region
- Impingement - worse with overhead motions or reaching especially backward
- Instability - Complain of clunking or shoulder slipping out of socket; may be associated with trauma; more common in younger population
- Labral Tear - complain of catching or popping deep in the joint, often worse with rotation in elevated arm position

Humeral Anterior Glide

- May have general hypermobility
- Activities/habits
  - Racquet or throwing sports, volleyball, swimming
  - Stand with hands clasped behind back
  - Standing with arms crossed across chest
  - Reaching out to the side or behind

Movement Impairment

- Excessive or abnormal anterior motion of the humeral head during shoulder motions
  - May decrease the volume of subacromial space

Relative Flexibility

- The anterior joint capsule is more flexible than the posterior joint capsule and/or the lateral rotators
Humeral Anterior Glide

Alignment Impairments
• forward shoulders
• greater than 1/3rd of the humeral head anterior of the acromion
• proximal humeral head anterior to the distal end of the humerus
• indentation below acromion posteriorly

Humeral Anterior Glide

Impairments in Muscle Activation and Lengths
• Dominance of posterior deltoid over infraspinatus & teres minor during lateral rotation resulting in:
  • GH extension or horizontal abduction
  • Associated with scapular internal rotation/anterior tilt
• Dominance or shortness of pectoralis major over rotator cuff muscles

Humeral Anterior Glide

Impairments in Muscle Strength, Stiffness, and Length
• weak or lengthened subscapularis > teres major
  Turkel SJ 1982, Pennock 2011
• short or stiff posterior capsule & scapulohumeral lateral rotators (infraspinatus, teres minor, posterior deltoid)

Humeral Anterior Glide

Short or stiff posterior capsule of GH joint
• Tests to assess the length/stiffness of the posterior structures of GH joint are supine MR, horizontal adduction, and shoulder flexion at 90 degrees with MR.

Key Tests

Standing
• Shoulder abduction - GHJ in horizontal abduction
• Shoulder lateral rotation

Supine
• GHJ medial rotation (MR) – ROM limited and anterior glide present
• GHJ lateral rotation (LR) – ROM may be excessive, anterior glide present
• Horizontal adduction – ROM limited

Prone
• Prone middle trapezius test – muscle recruitment pattern vs. muscle strength test
**Treatment**

- Correct scapular motion during glenohumeral motion: elevation, posterior tilt, upward rotation or external rotation/adduction  
  McMahon PJ 1996
- Training for precise humeral rotation pattern before strengthening  
  Falla A 2003
- Lengthen lateral rotators & posterior capsule  

**Stretch posterior capsule**

- Horizontal adduction of humerus  
  “Improvement in IR from cross-body stretch was greater than for the sleeper stretch” McClure 2007
- Sleeper stretch- too much compression on joint
- Assess this also with the shoulder in LR

**Support in Literature for Stretching Posterior Structures (Patients with Impingement)**

- Harryman DT et al, 1990
- Bang MD, Deyle GD, 2000
- Budoff JE, 2005
- Ludewig PM, Borstad JD, 2003
- Matsen FA, Arntz CT, 1990
- McClure PW et al, 2004
- Tyler TF et al, 2000
- Wilk KE et al, 2002

**Treatment**

- Decrease activation of posterior deltoid – alignment
- Decrease recruitment of pectoralis major and latissimus  
  Jaggi A 2012
- Shorten/stiffen subscapularis  
  Arroyo 1997, Glousman R 1988
  Habermeyer P 2004, Jobe CM 1996
  - Perform isometrics in as much IR as possible to isolate subscapularis vs. pectoralis major, lats, teres major (Suenaga N 2003, Pennock AT 2011)
  - Perform isotonics in >45° abduction (Ackland DC 2011)

**Functional Cues**

- During humeral horizontal abduction or reaching to the side - lead with scapular adduction/external rotation and possibly increase thoracic/trunk rotation
- Educate: relationship of the humeral position - distal vs proximal end
- Avoid humeral positions that elongate ant/inf capsule

**General MSI Treatment Guidelines**
“Muscle performance is determined by the pattern of movement. Correction of faulty patterns is best achieved by training the correct pattern and not by isolated 'strengthening' of a muscle.

The critical issue is how an activity is performed not just performing the activity.”

(MSI Syndromes of the Extremities, 2011)

**General Treatment Goals**

- Redistribute movement to appropriate joints
- **Correct the movement pattern** that is causing the tissue to become painful rather than direct treatment to the affected tissue.
- Training proper movement patterns will induce appropriate muscular (strength, length) and biomechanical adaptations that will reinforce the development of optimal neuromuscular action

**Treatment**

- Movement Diagnosis directs treatment
- Correct alignment and movement during functional activities
- Prescribe corrective exercise program:
  - Emphasizes precise motion
  - Individualized to the patient
- Practice performing movements using the corrected or modified strategy

- Because treatment is addressing cause of symptoms, pain reduces as tissue stresses are reduced
  - Recurrence less likely if cause of pain is addressed
  - Source of pain indirectly addressed

Mueller and Maluf 2002

**Take Home Messages**

- The body follows the path of least resistance for motion which contributes to subtle hypermobility.
- The way everyday activities are performed reinforces this hypermobility and the movement pattern.
- Muscle performance is determined by the pattern of movement. Altered movement patterns impair proper muscle performance.

**Treatment of Relative Flexibility**

Incorporate the following principles into functional activities and exercises as often as possible

- Prevent repeated stretching of flexible site
- Improve performance of stabilizing muscles
  - Active contraction at desired length
- Stiffen and shorten long muscles
- Stretch short/stiff muscles

**Treatment**

- Movement Diagnosis directs treatment
- Correct alignment and movement during functional activities
- Prescribe corrective exercise program:
  - Emphasizes precise motion
  - Individualized to the patient
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- Muscle performance is determined by the pattern of movement. Altered movement patterns impair proper muscle performance.
Take Home Messages

• During exam, when a movement does not appear ideal or causes symptoms, try to modify movement.
  • Doing this repeatedly during the exam helps confirm diagnosis

• Think “big picture” – how do the findings of the exam relate to one another?

• Diagnosing is based on pattern recognition

Take Home Messages

• Treatment:
  1) Correct the pattern of motion to restore more precise joint motion
  2) Correct functional activity performance
  3) Individualized to each patient
Shoulder References


8. Borstad JD, Ludewig PM: Comparison of scapular kinematics between elevation and lowering of the arm in the scapular plane. *Clinical Biomechanics* 17:650-659, 2002


33. Hassett DR, Phadke V, Braman JP, LaPrade RF, Ludewig PM. Thoracic contributions to normal scapular kinematics. JOSPT. 2007:37(1);A63-64. Abstract


37. Ide J, Kataoka Y, Yamaga M, Kitamura T, Takagi K. Compression and stretching of the brachial plexus in thoracic outlet syndrome:correlation between neuroradiographic findings and symptoms and signs produced by provocation


64. Ludewig PM, Reynolds JF. The association of scapular kinematics and glenohumeral joint pathologies. *JOSPT* 2009;39(2):90-104

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WASHINGTON UNIVERSITY SCHOOL OF MEDICINE
PROGRAM IN PHYSICAL THERAPY

UPPER QUARTER EXAMINATION

For each exam item, observe the patient’s preferred alignment or movement strategy and obtain symptom response from the patient. If an impairment of alignment or movement is observed, repeat the exam item with the appropriate correction/modification and again obtain the patient’s symptom response.

A. STANDING
   1. Alignment: head, neck, thorax, shoulders, scapula, clavicle, humerus (UQ)
   2. Thoracic flexion (UQ)
   3. Thoracic rotation (Th)
   4. Thoracic side bending (Th)
   5. Bilateral shoulder flexion and return from flexion (UQ)
   6. Shoulder abduction (UQ)
   7. Single shoulder flexion (CS, Th)
   8. Shoulder external rotation with arm at side and elbow flexed (Sh)
   9. Ventilation (Th)
  10. Cervical Range of Motion (CS) (can be performed in standing or sitting)
      • w/ passive elevated shoulder girdle test

B. SUPINE
   1. Alignment: head, neck, thorax, shoulders, scapula, humerus (UQ)
   2. Pectoralis minor length test (UQ)
   3. Latissimus dorsi length test (UQ)
   4. Scapulohumeral length test (UQ)
   5. Pectoralis major length test (UQ)
   6. Passive shoulder abduction (UQ)
   7. Shoulder internal and external rotation arm abducted (muscle performance and ROM) (Sh)
   8. Shoulder external rotation with arm adducted (Sh)
   9. Posterior deltoid/capsule length test (Sh)
  10. Biceps brachii length test (Sh)
  11. Cervical flexion (ROM and Intrinsic cervical flexor muscle performance) (CS)
  12. Cervical rotation (CS)
  13. Lower Abdominal muscle performance (UQ)
      • Subcostal margin (Th)

C. PRONE
   1. Shoulder external and internal rotation (muscle performance and ROM) (Sh)
   2. Lower trapezius muscle performance (UQ)
   3. Middle trapezius muscle performance (UQ)
   4. Rhomboids muscle performance (UQ)
   5. Cervical extension

D. QUADRUPED
   1. Alignment: head, neck, thorax, shoulders, scapula, humerus (UQ)
   2. Cervical flexion, extension, rotation (CS)
   3. Rocking backward (UQ)
   4. Shoulder flexion (CS, Th)

E. SITTING TEST
   1. Serratus anterior muscle performance (UQ)
   2. Upper trapezius muscle performance (Sh)
   3. Cervical rotation (CS)
      • w/ passive elevated shoulder girdle test
F. FUNCTIONAL ACTIVITIES (UQ)
   1. Sitting alignment
      • Arm support
   2. Sleeping position
   3. Work station
      • Phone use
      • Filing
      • Computer/monitor location
   4. Sporting/Fitness activities
   5. Reading position
      • Bifocals
      • Driving

G. ADDITIONAL TESTS
   1. Shoulder flexion and abduction with back against the wall (UQ)
   2. Shoulder flexion facing the wall (UQ)

Abbreviations
   CS = Test items performed to assess movement impairments of the cervical spine.
   Sh = Test items performed to assess movement impairments of the shoulder.
   Th = Test items performed to assess movement impairments of the thoracic spine.
   UQ = Test items performed to assess movement impairments of the upper quarter.