An Exercise Progression from Shoulder Rehabilitation based on the available EMG Literature

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Context

- Therapeutic exercises are prescribed along a continuum
- A common goal to increase neuromuscular activity
- In order to stimulate neuromuscular & musculotendinous adaptations
- Thereby allowing the patient to return to “normal” physical

Objectives

- Describe Electromyography data collection and interpretation
- Outline an exercise progression through a phased rehabilitation process keeping physiological healing response and tissue reactivity in mind
  - Higher EMG activity greater muscular recruitment
- Rehabilitation exercises are often selected based on EMG research to facilitate specific muscle activation
  - Therapeutic exercises rarely isolate

“"The whole of science is nothing more than a refinement of everyday thinking.””
- Albert Einstein (1879 - 1955), Physics and Reality 1936

Context

- Better understanding the neuromuscular activity levels of therapeutic exercise allows us to match the exercise selected to the patient’s state of healing
- This knowledge also allows us to titrate the exercises prescribed up or down the continuum based on the patient’s response

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- Albert Einstein (1879 - 1955), Physics and Reality 1936
Electromyography (EMG)
• A technique to evaluate and record electrical activity from skeletal muscle
  – EKG/ECG – cardiac muscle
• Device is electromyograph
• Generates an electromyogram

When a Muscle Contracts
• Action potential travels down motor nerve to neuromuscular junction
• ACh causes breakdown of membrane to produce motor action potential (endplate potential)
• Potential is propagated along sarcolemma

Electromyography
• The recording and analysis of myoelectrical signals derived from motor unit activity
• Motor Unit
  – Nerve cell body in the spinal cord
  – The motor nerve (axillary)
  – The muscle fibers that the nerve innervates

Set-up for collecting EMG data
Set up for Indwelling Electrodes (Fine Wire)

- The recording electrodes (surface or indwelling) placed in parallel to the muscle fibers detect the relative voltage difference between the two electrodes as the action potential propagates along the muscle fibers.

Action Potential Propagation

Utilization of EMG in Rehabilitation and Research

- Initiation of muscle activation (Onset)
- How long is a muscle activated (Duration)
- Amount of muscle activation (Amplitude)
- Measures level of fatigue occurring in a muscle (Frequency shifts)

Which Muscle Turned on First?

- Force
- Velocity
- Supraspinatus
- Infraspinatus
- Posterior Deltoid
Utilization of EMG in Rehabilitation and Research

• **Measure of EMG Amplitude**
  – To determine how much muscular activity was recruited for a particular exercise

• **EMG activity is translated from Volts to percentage of muscle activity**
  – MVC – maximal voluntary contraction
  – RVC – reference voluntary contraction (task, set load)

Relative Amount of Muscular Activity

• **Normalization of EMG signal to an event or to a specific task**
  – Allows for comparison between subjects, days, muscles or studies
  – Soderberg & Knutson, Phys Ther 2000

Normalization

• **Specific positions identified for shoulder or MMT positions**
  – Rotator cuff
    – Kelly, J Ortho Res 1996
  – Scapular musculature
    – Michener, Phy Ther 2005

• **100% isometric contraction (MVIC)**
  – Most commonly used
  – Need to perform for 3-5 sec duration with 2-3 repetition with at least 30-90 sec. rest

• **The highest amplitude obtained during time interval is considered 100% (1 or ½ second)**

• **EMG data is expressed as a %MVIC or %RVC**

EMG Amplitude Categorization

• **0 – 20% Low activity**
  – 21 – 40% Moderate activity

• **41 – 60% High activity**
  – >61% Very High activity
    – DiGivone, JSES 1990

• **0 – 5% Minimal EMG activity (background noise)**
    – Perry, Gait Analysis 1992

• **<20% = Minimal activity**
  – 20-50% = Moderate activity

• **>50% = Marked activity**
    – McCann, Clin Orth Rel Res 1993

• **15%MVIC= 30N force conservative estimate to protect repair**
    – Long, JOSPT 2010

  – Assumptions: fraction of MVIC, CSA, specific tension, & fiber pennation
  – 44±15N load for 206 ±88 cycles generated 50% loss of rotator cuff repair
    – Bicknell, Arthroscopy 2005
Limitations of EMG

• Sources of interference
  – Movement artifact
  – External electrical noise (electrical outlets, ECG)
  – Possibility of “cross-talk” from other muscles (surface)
• Reducing interference by use good equipment, small electrodes, and careful electrode placement
• Not a measure of force or strength
  – Moderate correlation in an isometric conditions
    – Inman, EEG Clin Neurophysiol 1952

Rotator Cuff Tendon Rupture

• Not typically traumatic
• Degenerative overuse mechanism most common
• Combination of compression and eccentric overload
  – Lin et al., J Biom 2004

Biomechanical Properties of Healing Tendon

• Human tendon maximal strength ranges from 50 – 150MPa
  – Gelberman et al., Injury and Repair Musculoskeletal Soft Tissues 1987
• Rat maximal tensile load =25 ± 9 MPa
  – 6 wks = 8%
  – 12 wks = 12%
  – Repaired supraspinatus post-op does not approach intact values
    – Carpenter et al., JSES 1998

Rehabilitation Implications

• Following tendon repair first 3-6 wks loads across the tendon have to be minimal
• Animal model suggest Immobilization is beneficial over early mobilization
  – Increased organization
  – Less scar formation
  – Mechanically stronger
    – Thomopoulos, J Biom Eng, 2003
• Gradual introduction of stresses during the maturation process
  – Lower EMG activity
**Rehabilitation Progression**

- **Acute**
  - Injection
  - ROM
  - Bracing

- **Rest**
  - Modalities

- **Recovery**
  - Wound care

- **Functional**
  - Sport Specific

- **Power**
  - Kinetic Chain breakage

- **Strength**
  - Endurance

**Quick Motions of Contralateral Arm Increase Activity**

- **EMG Activity: 5 Basic Motions (Fast)**
  - skull pull
  - Cross body reach
  - Downward reach
  - Straight forward reach
  - Upward reach

**Other Precautions in Sling**

- **Post-operatively to protect healing rotator cuff avoiding drinking with involved side while in sling**
  - Long, JOSPT 2010

**Immobilization ≠ Inactivity**

- **EMG activity is present in immobilizer**
- **Caution for certain activities to protect of rotator cuff**
  - Bimanual tasks increases Biceps (7-16%) [SLAP]
  - Pulling open door activated Supraspinatus (10-20%) [Rot Cuff Repairs]
  - Pushing open a door quickly activate Infra. (65±45%) [Rot Cuff Repairs]
  - Reaching task with contralateral limb facilitate scapular musculature (20-60%) in the immobilized limb
  - Smith, J Sh Elb Surg 2004
Acute Phase Rehabilitation

- For proper healing need some period of immobilization
- Initiate ROM within physiological healing restraints and pain tolerances
- Can we find a balance

Hugh Owen Thomas  
Father of Immobilization

Respect Physiological Healing when Prescribing Exercises

What level of muscle activity is associated with PROM?

- Pendulum
- Supine Passive elevation  
  - w/ or without therapist
- Forward Bow
- CPM

Pendulum

- Small vs large circle
- Correct vs incorrect
- 13 Healthy subjects
- Concluded small circles (20cm) generated lowest EMG activity
  - Long, JOSPT 2010
Passive Exercises

- Surface EMG on 10 healthy subjects using MVIC for normalization
  - Pendulum
  - Pulley
  - Therapist assisted PROM
  - CPM
- Pulley most activity (p<.05)
  - Dockery, Orthopedics 1998

<table>
<thead>
<tr>
<th></th>
<th>Supra.</th>
<th>Infra.</th>
<th>Ant. Delt.</th>
<th>Trap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulley</td>
<td>Mn</td>
<td>Sd</td>
<td>Mn</td>
<td>Sd</td>
</tr>
<tr>
<td>Bar</td>
<td>Rise</td>
<td>Mn</td>
<td>Sd</td>
<td></td>
</tr>
<tr>
<td>PROM</td>
<td></td>
<td>Mn</td>
<td>Sd</td>
<td></td>
</tr>
<tr>
<td>CPM</td>
<td></td>
<td>Mn</td>
<td>Sd</td>
<td></td>
</tr>
</tbody>
</table>

- In 10 healthy subjects
- Supine Passive elevation performed by individual < 10%
- Forward Bow moving body around stationary arm <10%
  - Uhl, Phy Med Rehab 2010

Passive Exercise

- What level of muscle activity is associated with PROM?
  - Not truly passive
  - Overall levels below 15% suggests to be a safe estimate to protect tissue
- No evidence in post-operative cohort

Rehabilitation Progression

- Protect weakened tissues
- Regain motion & function
- Activate inhibited/weakened muscles gradually

Active-Assisted ROM Exercises

- Critical period to avoid abnormal movement patterns or substitution patterns
- Various assistive devices (Pulley, Stick, Wall & Water) to minimize loads on healing tissue
- Facilitates muscle activation and dynamic muscular control of the joint
- Caution using long lever arms may be too much demand for recovering tissues

Kinetic Chain breakage
Strength
Endurance
Neuromuscular Control
Rest
Injection
ROM
Bracing
Power
Sport Specific
Functional
Recovery
Acute
Gravity Minimized AAROM Exercises

- Water provides buoyancy
  - Slow elevation low demand on muscles <10%
  - Fast elevation generated more activity
    - Kelly et al. JOSPT 2000
- Wound considerations & availability to pool

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Supra</th>
<th>Infra</th>
<th>Ant. Delt.</th>
<th>Sub.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow</td>
<td>4 ± 4%</td>
<td>2 ± 2%</td>
<td>2 ± 2%</td>
<td>2 ± 1%</td>
</tr>
<tr>
<td>Fast</td>
<td>17±15%</td>
<td>21±6%</td>
<td>17±13%</td>
<td>11±4%</td>
</tr>
</tbody>
</table>

Incremental Loading ↑ EMG activity

- Neer’s 3 phases demonstrated a progression
  - Supine PROM
  - Upright AAROM
  - Upright AROM
  - Resistive
- RVC 2.25 (5lb) abd. to 150°
- Not all AAROM are equal
  - Minimal – Moderate levels
    - McCann, Clin Ortho Rel Res 1993

University of Washington Exercise Program

- Rehabilitation program which progresses patients from PROM to RROM.
- Similar to Neer’s program but emphasizes more scapular motion (protraction) and does not incorporate as much isometric and elastic resistance exercises.
  - Rockwood & Matsen, The Shoulder 1998

Kinetic Chain Exercise Program

- Incorporates legs and trunk to initiate and facilitate arm elevation
  - Kibler, Med Sci Sport Ex 1998
  - McMullen & Uhl JAT 2000
- Utilizes patient’s hand in contact with surface to unload the weight of the arm for AAROM exercises
  - Wise, JSh Elb Surg 2004
Active Motion

Relevance

- Passive = some Active-Assistive Exercises
- Active exercise in repaired flexor tendons is necessary to regain neuromuscular control (plasticity)
  - Session 1: immediately after immobilization and PROM
  - Session 2: 6 weeks of active exercise
    - Coert J Hand Surg (EUR) 2009
- Deltoid progression supports the Reading protocol for massive cuff tears

Subdividing Active-Assistive Elevation Exercises

- Gravity Minimized
- Upright Assisted
- Upright Active
- Ball Roll
- Standing T-bar
- Wall walk
- Active forward elevation
- Standing T-bar w/ active lowering
Results

• AFE > Assisted Ex’s
  – Supraspinatus
  – Anterior Deltoid
• Anterior Deltoid activity increased at each level
  – Gravity Minimized< Upright assisted< Active
• Wall walk exercise was most demanding of upright exercises for Supraspinatus
  – Reserve for later stage in recovery
• Supine T-Band 90 – 150° although using resistive exercise was relative low demand on cuff musculature

Post-operative Subjects

• Previous literature has used healthy subjects Is the progression similar in post-operative subjects?
• Study Purposes:
  • To identify order of exercises of increasing muscular activation amplitude in post-SLAP

Methods / Subjects

• 20 subjects between 18 - 50 y/o
  – healthy group vs. post-SLAP group, 4-6 wk s/p Type II repair
  – No concomitant RC repair
• Muscles
  – Supraspinatus
  – Infraspinatus
  – Biceps
  – Serratus
  – Up. Trapezius
  – Ant. Delt.

<table>
<thead>
<tr>
<th></th>
<th>Healthy Group</th>
<th>Post-SLAP Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 10</td>
<td>n = 10</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>28 ± 6</td>
<td>28 ± 9</td>
</tr>
<tr>
<td>Height (meters)</td>
<td>1.77 ± 0.1</td>
<td>1.81 ± 0.1</td>
</tr>
<tr>
<td>Weight (kilograms)</td>
<td>84 ± 19</td>
<td>90 ± 20</td>
</tr>
</tbody>
</table>

EMG Normalization

• Reference Contractions- sub-maximal
  – Yang, APMR 1983
• Shoulder Muscles:
  – AFE –McCann, CORR 1993
  – 5lb Isometric Forward Elevation @ 45°
• Biceps and Infraspinatus:
  – 5 lb Bicep curl
  – 5 lb Isometric External Rotation @ 45°
3 PROM Exercises

UE Ranger
http://www.ueranger.com/

Active-Assisted (AAROM)

T-bar not illustrated

AAROM & AROM

EMG - Results

- No difference between groups for any muscle studied
- EMG amplitudes
  - Lowest for passive ex’s
  - Greatest for Active Forward elevation
- Active-Assistive
  - Supported Active Assistive = PROM
  - Wall Walk = AFE
Progression through Recovery

- Re-establish coordinated UE movement before adding significant loads
- Enhance strength by increasing loads
  - Resistance
  - Speed
  - Lever arm
- Increase Endurance

Subtle Lever Arm Changes Muscular Activation Levels

- Wise, J Sh Elb Surg 2004
Developing Scapular Stabilization Exercises

- Low Row and Inferior Glide
  - Isometric exercises biasing serratus and lower trapezius
- Lawnmower & Robbery
  - Dynamic exercises integrating trunk and scapular musculature
- These exercises are appropriate for intermediate phase scapular strengthening – Kibler, AJSM 2008

Low to Moderate Muscular Demands (20-40%)

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Inferior glide</td>
<td>8 ± 6</td>
<td>19 ± 27</td>
<td>23 ± 20</td>
<td>5 ± 2</td>
<td>9 ± 6</td>
</tr>
<tr>
<td>Low row</td>
<td>10 ± 8</td>
<td>15 ± 12</td>
<td>28 ± 21</td>
<td>17 ± 13</td>
<td>42 ± 23</td>
</tr>
<tr>
<td>Lawnmower</td>
<td>22 ± 16</td>
<td>31 ± 19</td>
<td>26 ± 21</td>
<td>6 ± 4</td>
<td>16 ± 11</td>
</tr>
<tr>
<td>Robbery</td>
<td>32 ± 17</td>
<td>27 ± 21</td>
<td>21 ± 17</td>
<td>7 ± 6</td>
<td>14 ± 9</td>
</tr>
</tbody>
</table>

Lawnmower & Robbery

Increase activation of Lower Trapezius when contralateral hip extensor are activated. This phenomenon is suggested to occur due to tightening of thoracolumbar fascia in the direction of contralateral scapula within the kinetic chain – Maenhout Br J Sports Med 2010

Elastic Resistance Exercises

- Rubber tubing for shoulder exercises
- Developed for throwing athletes (on-field)
- Identified 7 exercises that moderately activated primary muscle involved in throwing
  - (* indicates key exercises) – Myers JAT 2005
### Elastic Resistance Exercises

**High to Very High Category**

<table>
<thead>
<tr>
<th></th>
<th>Ant. Delt</th>
<th>Mid. Delt</th>
<th>Low Trap</th>
<th>Ser. Ant.</th>
<th>Sub- scap</th>
<th>Supra</th>
<th>Infra</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ER 0</strong></td>
<td>6 ± 6</td>
<td>8 ± 7</td>
<td>48 ±25</td>
<td>18 ±19</td>
<td>72 ±55</td>
<td>20 ±13</td>
<td>46 ±20</td>
</tr>
<tr>
<td><strong>ER 90</strong></td>
<td>22 ±11</td>
<td>50 ±21</td>
<td>88 ±51</td>
<td>66 ±39</td>
<td>57 ±50</td>
<td>50 ±21</td>
<td>51 ±30</td>
</tr>
<tr>
<td><strong>IR 0</strong></td>
<td>6 ± 6</td>
<td>40 ±3</td>
<td>44 ±30</td>
<td>21 ±4</td>
<td>74 ±47</td>
<td>10 ± 6</td>
<td>32 ±51</td>
</tr>
<tr>
<td><strong>IR 90</strong></td>
<td>28 ±18</td>
<td>41 ±21</td>
<td>54 ±39</td>
<td>54 ±32</td>
<td>71 ±43</td>
<td>41 ±30</td>
<td>24 ±21</td>
</tr>
</tbody>
</table>

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### Elastic Resistance Exercises

Scapular Punch  
Low Row  
Shoulder Flexion w/ axial load  
Shoulder extension

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### Elastic Resistance Exercises

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<th>Infra</th>
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<tbody>
<tr>
<td><strong>Scap Punc</strong></td>
<td>45 ±36</td>
<td>36 ±24</td>
<td>32 ±32</td>
<td>67 ±45</td>
<td>69 ±47</td>
<td>46 ±31</td>
<td>35 ±17</td>
</tr>
<tr>
<td><strong>Low Row</strong></td>
<td>19 ±13</td>
<td>34 ±23</td>
<td>44 ±32</td>
<td>22 ±14</td>
<td>69 ±50</td>
<td>46 ±38</td>
<td>29 ±16</td>
</tr>
<tr>
<td><strong>Sh. Flex</strong></td>
<td>60 ±41</td>
<td>32 ±14</td>
<td>49 ±35</td>
<td>67 ±37</td>
<td>99 ±37</td>
<td>42 ±22</td>
<td>47 ±34</td>
</tr>
<tr>
<td><strong>Sh. Ext</strong></td>
<td>19 ±15</td>
<td>27 ±16</td>
<td>53 ±40</td>
<td>30 ±21</td>
<td>97 ±55</td>
<td>29 ±21</td>
<td>50 ±57</td>
</tr>
</tbody>
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### Elastic Resistance Exercises

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<th>Supra</th>
<th>Infra</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Throw Accel</strong></td>
<td>27±20</td>
<td>22 ±12</td>
<td>53 ±46</td>
<td>55 ±35</td>
<td>93 ±51</td>
<td>36 ±32</td>
<td>33 ±22</td>
</tr>
<tr>
<td><strong>Throw Decel</strong></td>
<td>29±16</td>
<td>44 ±16</td>
<td>63 ±42</td>
<td>48 ±32</td>
<td>69 ±48</td>
<td>64 ±32</td>
<td>45 ±21</td>
</tr>
</tbody>
</table>
What about Weight Bearing Exercises?

- Fixed Boundary Axial Load
  - Lephart & Henry JSR 1996
- Greater joint congruency thereby decreasing shear forces
- Football & Wrestling – sport specific
- EMG activity highly correlated to load $R^2 = .95$

$6 \pm 3 \text{ BW\%}$

7 Common CKC Exercises

- Prayer
- Quadruped
- Tripod
- Pointer
- Push-up
- Push-up feet elevated
- One arm push-up
  - Uhl et al. JOSPT 2003

$16\% \text{ BW } + 2\%$

$33\% \text{ BW } + 3\%$

Push-up elevated and One Arm Push-up

- $40\% \text{ BW } + 4\%$
- $60\% \text{ BW } + 6\%$

EMG Activity for Exercise Position

<table>
<thead>
<tr>
<th>Exercise Position</th>
<th>EMG Activity (% MVIC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prayer</td>
<td>160</td>
</tr>
<tr>
<td>Quadr</td>
<td>140</td>
</tr>
<tr>
<td>Tripod</td>
<td>120</td>
</tr>
<tr>
<td>Pointer</td>
<td>100</td>
</tr>
<tr>
<td>Push-up</td>
<td>80</td>
</tr>
<tr>
<td>Push-up elevated</td>
<td>60</td>
</tr>
<tr>
<td>One arm push-up</td>
<td>40</td>
</tr>
</tbody>
</table>

- Supraspinatus
- Infraspinatus
- Ant-deltoid
- Post-deltoid
- Pec-major
Scapular Muscular Activation

- Ipsilateral leg ext. biases Serratus Anterior (#3)
- Contralateral leg ext. biases Lower Trapezius (#2)
- EMG low – moderate 15-45%

Unstable Surface does not Increase Muscular Activation

<table>
<thead>
<tr>
<th>Unstable Surface</th>
<th>Serratus Anterior</th>
<th>Lower Trapezius</th>
<th>Middle Trapezius</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

Injury Effects Neuromuscular System

- Serratus Anterior inhibition
- Substitution of upper trapezius & rhomboids
  - Scovazzo et al., AJSM 1991
- 80 ms delay in activation of Serratus anterior, indicating poor muscular control
- Increased Upper Trap activity & decreased Serratus Anterior activity with a load
  - Ludewig & Cook, PT 2000

Serratus Progression

- Least to most challenging based on average amplitude of MVIC
- Shoulder Extension (5±3)
- Press-up (32±28)
- Forward Punch (34±15)
- Scaption (38±10)
- Knee Push-up Plus (40±15)
- Serratus anterior Punch (44±12)
- Dynamic Hug (50±15)
- Push-up Plus (58±17)
  - Decker, AJSM 1999
Lower Fibers of Serratus Anterior

- Protraction focuses on upper fibers
- Elevation above 120 deg is needed to address lower fibers of Serratus Ant.
- Diagonal Flexion / Adduction / Ext. Rot.

  – Ekstrom et al., JOSPT 2003

Serratus Anterior Exercises (%MVIC)

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Mosely '92</th>
<th>Ekstrom '03</th>
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</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>96 ± 45</td>
<td>NT</td>
</tr>
<tr>
<td>Abduction</td>
<td>96 ± 53</td>
<td>NT</td>
</tr>
<tr>
<td>Scaption &gt; 120°</td>
<td>91 ± 52</td>
<td>96 ± 24</td>
</tr>
<tr>
<td>Diag Flex/ Horiz Add/ Ext. Rot.</td>
<td>NT</td>
<td>100 ± 24</td>
</tr>
<tr>
<td>Military Press</td>
<td>82 ± 36</td>
<td>NT</td>
</tr>
<tr>
<td>Unilateral shoulder press</td>
<td>NT</td>
<td>62 ± 19</td>
</tr>
<tr>
<td>supine w/plus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Push up w/plus</td>
<td>80 ± 38</td>
<td>NT</td>
</tr>
<tr>
<td>Push up w/ hands wide</td>
<td>57 ± 36</td>
<td>NT</td>
</tr>
<tr>
<td>Bilateral scapular protract.</td>
<td>NT</td>
<td>57 ± 22</td>
</tr>
</tbody>
</table>

Biasing Serratus Anterior (SA) over Upper Trap (UT)

- Push-up plus is better than wall push-up to activate SA relative to UT
  – Ludewig AJSM 2004
- Exercises favoring early LT & MT over UT activation
  – Prone Ext
  – Prone Horiz Abd
  – Side-lying ER
  – De Mey JOSPT 2009

Rotator Cuff Core Exercises

- Protect anterior capsule

- Prone extensor
- External rotator osteotomized
- Oblique rotator with dorsal rotation
- Throwing motion
Supraspinatus
Subscapularis
Infraspinatus
Deltoid

Rehabilitation Progression

- Increase Power
- Integrate specific functional demands

Acute
Rest
Modalities
Wound care
Injection
ROM
Bracing

Kinetic Chain breakage
Strength
Endurance
Neuromuscular Control

Functional
Sport Specific

Rectangular Prism

Baseball Throwing Tasks

Phases of Throwing

Plyometrics

- Overhead plyometric simulate and prepare body to return throwing activities

Injection
ROM
Bracing

Cordasco et al. AJSM 1996

EMG Activity (% MVIC)

Infraspinatus
Supraspinatus
Subscapularis
Deltoid

Infraspinatus
Supraspinatus
Subscapularis
Deltoid
Serratus Anterior
Trapezius

% MVC

0 25 50 75 100 125 150 175 200

Early Cocking Late Cocking Acceleration Follow Through

Kibler, Functional Rehabilitation 1998
Plyometrics Posterior Shoulder

- No EMG evidence
- Several studies indicate benefit
  - Injury reduction
    - Swanik J Sport Rehab 2002
  - Strengthening
    - Carter, J Strength Cond Res. 2007
    - Swanik, JSES 2002

Key Points: Acute Phase & Early Recovery

- Consistently low EMG activity for PROM
  - 15% MVIC appears to be most safe
- AAROM exercises can be performed in a position or with support that equals PROM and requires less activation than AFE
  - Establish proper movement with support or in gravity minimized position prior to initiating unsupported upright or resistive exercises
    - Neural reorganization
    - Upper trapezius activation increases as upright positions

Key Points: Recovery Phase

- Resistance can be advance many ways
  - Lever arm
  - Load
  - Speed
- Many exercises overlap muscular activations be efficient with exercise selection
  - Subscapularis active with several functional exercises

Key Points: Functional Phase

- EMG studies can help you select appropriate exercise for your patient but must consider sport/work demands
  - Not all tasks or exercise activation levels are known
- There are often multiple variations to activate the muscle
  - Think along a continuum of exercises
- Design program based:
  - Tissue physiology
  - Your clinical judgment
  - Available evidence
Thanks Y’all

My Old Kentucky Home
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