Kinetic Chain Approach for Shoulder Rehabilitation

Open Kinetic Chain (OKC)
- Exercise or movement pattern where the distal aspect is not fixed to an object (free in space)
  OR
- Distal motion around a fixed proximal segment
  OR
- The force applied by the body is great enough to overcome the resistance
Steindler, 1955

Closed Kinetic Chain (CKC)
- Exercise or movement pattern where the distal aspect is fixed to an object (static in space)
  OR
- Proximal motion over a fixed distal segment
  OR
- The force applied by the body is NOT great enough to overcome the resistance
Steindler, 1955

History
- 1970’s: free weights, Schwarzenegger
- 1980’s: OKC Isokinetics, Nautilus
- 1990’s: “Functional” CKC
- Current: Appropriate isolation, integration, and combination of multiple exercise methodologies

Functional?
- CKC was considered more functional, particularly in the LE
- OKC and CKC used and needed for function, recovery and progression
  (Noyes, Barber, Tegner, Wilk, others)

Function Example
- Function-serial CKC and OKC e.g.:
  - Walking Gait: 65% CKC; 35% OKC
  - Running Gait: 65% OKC; 35% CKC
  (Wilk, Athletic Training, 1995)
Which to choose?

- CKC alone does not provide adequate stimulus to the quadriceps for functional recovery after surgery (Snyder-Mackler, J Sport Rehab, 1996)
- Critical assessment, biomechanical knowledge, and application required for all chain applications (Davies, J Sports Rehab, 1995 and all of us!)

OKC vs. CKC

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Open Chain</th>
<th>Closed Chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress Pattern</td>
<td>Rotary</td>
<td>Linear</td>
</tr>
<tr>
<td># Axes</td>
<td>1 primary</td>
<td>Multiple</td>
</tr>
<tr>
<td>Segments</td>
<td>1 fixed, 1 mobile</td>
<td>Both mobile</td>
</tr>
<tr>
<td># Joints</td>
<td>Isolated</td>
<td>Multiple</td>
</tr>
<tr>
<td>Planes of Motion</td>
<td>Single</td>
<td>Multiple</td>
</tr>
<tr>
<td>Muscle(s)</td>
<td>Isolated (Group)</td>
<td>Multiple/Co-contraction</td>
</tr>
<tr>
<td>Pattern</td>
<td>Usually non-functional</td>
<td>Function oriented</td>
</tr>
</tbody>
</table>

OKC vs. CKC

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<tr>
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<tbody>
<tr>
<td>Joint Surfaces</td>
<td>Traction</td>
<td>Compression</td>
</tr>
<tr>
<td>Use</td>
<td>Arthritis, Meniscal, Labral</td>
<td>Instability</td>
</tr>
</tbody>
</table>

KINETIC CHAIN: Comparative Analysis

KINETIC CHAIN

Creates interactive moments

Forces from position/motion of adjacent segments

\[
\text{Equation for the proximal segment:} \\
J_{Mpp} + (r_{Pmp}sin\theta_p + r_{Pma}sin\theta_d)\text{App} - (r_{pmc}cos\theta_p + j_{pmc}cos\theta_p)\text{App} - (r_{pmc}cos\theta_p + j_{pmc}cos\theta_p)\text{App} \\
- (r_{pmc}cos\theta_p + j_{pmc}cos\theta_p)\text{App} - j_{pmc}sin\theta_p\text{App} - j_{pmc}sin\theta_p\text{App} \\
= \text{Net moment on proximal segment}
\]

Putnam, 1993
CONSIDERATIONS PRIOR TO CHAIN APPLICATIONS
- Pathology
- Local alterations
- Scapular alterations
- Core proficiency
- Distal alterations

Segment Control
- Correct early in rehab
- Core/trunk > scapula
- Scapula > rotator cuff
- No GH shoulder motion possible
- Restore normal physiology/proprioception

Link Sequencing
- Link sequencing describes the development and transfer of forces in serial linkage (legs, trunk, scapula, and arm) to accomplish acceleration


Scapular Link
- Loss of scapular protraction control causes alterations in scapular roles
- Scapular traction control (pro/retraction) must be re-established

Normal Scapular Motion is Multiplanar providing:
- Optimal muscle length-tension ratios
- Reduces the muscular energy requirements of the rotator cuff
- Aids in glenohumeral stability

Rotator Cuff
- Compressive action of RTC action
- Co-contraction force couple
- Most efficient working form stabilized, optimally positioned base - THE SCAPULA
Rotator Cuff

- G-H emphasis in shoulder rehabilitation is in later stages
- Integrated, not isolated
- Closed chain when appropriate

Chain Principles

- Patterns sequentially use the leg, core, and scapular musculature to activate/facilitate shoulder musculature
- Gain active range of motion and increase strength
- Functional movement patterns and closed kinetic chain exercises could be incorporated throughout the rehabilitation process depending on pathology

Chain Application

- Protocols often integrate the shoulder with the rest of the body late in the rehabilitation process.

Keys to Application

- Pelvis control over planted leg
- Hip/trunk (core stability)
- Scapular position
- G-H rotation
- Rotator cuff activation

Applications and Advantages

- Consistent with biomechanical models
- Applies biomechanical and motor control activation
- Works toward sport specificity
- Designed to stimulate weakened tissue by motion and force production in the adjacent kinetic link segments.

Kinetic Chain Shoulder Rehabilitation

- Legs and trunk are integrated into (most) shoulder exercises from onset
- Reinforces normal movement patterns
- Reduces the challenge of learning new movements during rehabilitation.
THEORETICAL FOUNDATION

- Common biomechanical model for sports is an open-linked system of segments used in a proximal-to-distal sequence.

- The proximal segments (legs and trunk) accelerate the entire system and sequentially transfer the momentum to the next distal segment.

- Conservation of Momentum—Newton’s Second Law, F=MA

Motor Programs

- Coordinated groups of muscles and joint movements (Synergies)
- Learned behaviors
- Often in a proximal-to-distal fashion
- Simplify movement tasks

Kinetic Chain Motor Programs

- Kinetic chain shoulder exercises employ these natural motor programs
- Focuses on the neuromuscular system rather than isolated movement and muscle activation.

Kinetic Chain Rehabilitation

**Concepts from PNF**

- Motor behavior is a sequence of total patterns
- Goal-directed movement and posture depend on synergies to balance muscular activity

**Concepts from PNF**

- Normal motor development occurs in a proximal-to-distal direction
- Stronger component patterns augment weaker components by the irradiation reflex.
Irradiation Reflex

- As the intensity of an applied stimulus increases, the area of response increases.
- Example: Thoracic extension can stimulate scapular retraction. Resistance to thoracic extension should increase this stimulus and elicit an increase in scapular retraction.

Kinetic Chain Exercises Can Aid in Attaining Flexibility but...

- Stretching
- Joint mobilizations
- Massage
- Therapeutic modalities

Scapula Muscular Flexibility

- Upper trapezius and the pectoralis minor are common sites of myofascial tightness and hypertonia in athletes.

G-I-R-D

- Gleno-humeral
- Internal Rotation
- Deficit
- Commonly overlooked

UE Chain Musculature

- Core: hips and trunk

Kinetic Chain Exploitation

- Kinetic chain rehabilitation: exaggerating the role of the hip extensors in instances of limited forward elevation.
- Forcing hip extension by including an ipsilateral step-up with a shoulder flexion exercise facilitates shoulder flexion.
Kinetic Chain Exploitation

- Verbal cue to "get tall," encourages the thoracic extension necessary for complete arm elevation
- Resistance to hip extension may stimulate an irradiation reflex

Kinetic Chain Exploitation

- Proximal-to-distal muscle activation in rotational patterns consistent with PNF can facilitate shoulder rotation.
- Patterns promote sequential muscle activation and coordination of proximal segment
- Example: "Shoulder Dump"

“Shoulder Dump”

To attain right shoulder external rotation and scapular retraction:
- Assume a left-foot-forward stance
- Begin with the left hip flexed, trunk flexed and rotated to the left, and right arm at knee level

Modified “Dump”

Exercise Adaptation

- Determine and control the proximal load and scapular position by varying stance and posture
- Functionally strengthen the rotator cuff in preparation for open-chain exercises

Exercise Modification

- Maintaining shoulder abduction at less than 45°
Exercise Modification

- Shoulder extension at less than 15°

Exercise Modification

- Hand spacing less than 1.5 times the bi-acromial width

Exercise Prescription: Functional ADL

- Full arm elevation requires full scapular retraction...
- Which requires spinal extension...
- Which requires hip extension...
- And so on...

Chain Function

- Hips and trunk position the thoracic spine for appropriate scapular motion
- Core provides stability for effective function of the shoulder girdle.
- Forward arm elevation demonstrates ipsilateral activation of hip extensors before deltoid activation

SCAPULAR FUNCTION AND CONTROL

- Trunk rotation and thoracic extension with scapular retraction to inhibit scapular elevation.
- Manual resistance to medial border of the scapula assists active scapular depression and retraction.

Kibler et al., AJSM, May 2006

SCAPULAR FUNCTION AND CONTROL

- Adjustments in the direction and amount of trunk motion minimize muscular compensations
- Increase trunk rotation and thoracic extension with scapular retraction to inhibit scapular elevation.

Single leg stance requires compensatory trunk rotation for balance
Closed Chain Exercise Prescription

- Accommodate pathology
- “If in doubt, leave it out”
- Paucity of research
  - Kibler et al 1995
  - Ellenbecker and Davies 2001
- Some suggestions......

Legs and Core

Core Hypertrophy

Stabilization Isometrics (Left)

- Primary Muscles: serratus, pectorals, deltoids, cuff, triceps
- Indications: early scap. stabilization
- Contra-indications: posterior pathology early repairs

Stabilization (Bilateral)

- Primary Muscles: serratus, pectorals, deltoids, cuff, triceps, core
- Indications: scap. stabilization, throwers
- Contra-indications: posterior pathology

Closed Chain Prescription

- Primary Muscles: serratus, pectorals, deltoids, cuff, triceps, core
- Indications: scap. stabilization, throwers
- Contra-indications: posterior pathology
Push Ups

- Primary Muscles: serratus, pectorals, deltoids, cuff, triceps, core
- Indications: scap. stabilization, throwers
- Contra-indications: posterior pathology

Ball Flys

- Primary Muscles: serratus, pectorals, deltoids, cuff, triceps, core
- Indications: scap. stabilization, throwers
- Contra-indications: posterior pathology

Bridge Ups

- Primary Muscles: pectorals, triceps, rhomboids, traps, lats, serratus, core
- Indications: winging, gen. strength, rhythm stability
- Contra-indications: acute RTC, Imp., SLAP, AC

Triceps Dip

- Primary Muscles: pectorals, triceps, rhomboids, traps, lats, serratus, core
- Indications: winging, gen. strength, rhythm stability
- Contra-indications: acute RTC, Imp., SLAP, AC

Lateral Press Up

- Primary Muscles: serratus, pectorals, deltoids, cuff, triceps, lat. core
- Indications: scap. Stabilization
- Contra-indications: tears/repairs

Progression

- Reducing feedback
- Adding resistance
- Changing the stabilizing surface
- Altering the movement pattern as gains in rotator cuff strength and scapular control occur
Monitor Spine and Scapula

Closed Kinetic Chain Functional Rehabilitation

- Monitor exercise volume to avoid overloading the involved tissue when integrating multiple segments
- Continuously monitor scapulothoracic rhythm (early indicator of a compensation)

Not too fast!

Summary

To progressively load the distal segments, the exercises advance from:
- Static closed kinetic chain to...
- Dynamic axially loaded to...
- Open kinetic chain

CONCLUSIONS

- Nontraditional approach to rehabilitation that concentrates on movement patterns
- Proximal-to-distal kinetic link model
- Addresses glenohumeral motion through scapular control
  AND
- Scapular control through trunk movement

Thank You!