Shoulder Biomechanics

Lecture originally developed by
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Outline

- Anatomy
- Biomechanics
- Problems
Shoulder Complex

- Greatest ______________
- Greatest Predisposition for Dislocation
- Little _____ Stability (Mainly Ligaments)
- Range of Motion Starts at _____° or Greater in all Planes and Decreases with Age (activity slows this process)
Bones

- Humerus
- Clavicle
- Scapula
- Ribs
Humerus

- Articular Surface (33-55 mm)
- ____° from Shaft
- 32° Retroverted (Rotated ________)
Scapula

- Glenoid Fossa
  - 41 by 25 mm
  - Pear Shaped
  - _____ Degree Tilt (Posterior)(Retrotilted)

- Glenoid Labrum
  - Joint Capsule
  - Glenohumeral Ligaments
  - Long Head of the Biceps Tendon

- Minimal ___________ Contact (Large Range of Motion)
Joints

- Glenohumeral
- ______________
- Acromioclavicular
- ______________
  - Last 3 Collectively Called Shoulder Girdle
Ligaments

- Glenohumeral
  - Superior, Middle, Inferior Glenohumeral
- Acromioclavicular
  - Conoid
  - Trapezoid
- Sternoclavicular
  - Sternoclavicular
  - Costoclavicular
Glenohumeral Joint Movement

- Flexion (___)/Extension (___) (Sagittal)
- Abduction(180)/Adduction (-75) (___________)
- Internal(____)/External Rotation(-90) (___________)
- Horizontal Abduction(____)/Adduction(-45) (Flexion/Extension)
- Primarily Rotational (___)
Elevation Planes

- Frontal
- Sagittal
- Scapular

____________
Advantageous

FIG. 12–2
A. Forward flexion. The humerus is in the sagittal plane. B. Abduction. The humerus is in the frontal plane.

FIG. 12–3
Elevation in the scapular plane, which is midway between forward flexion and abduction. The humerus is in the plane of the scapula.
Shoulder Girdle Movement

- Upward/ Downward Rotation (_______)
- Protraction/ Retraction
  (_________/_________)(Transverse)
- Upward/ Downward Tilt (__________)
- Elevation/Depression (__________)

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Elevation and Tilting

Movements of the scapula

These movements were shown in external view on page 102. We will now look at the bones themselves.

In elevation, the scapula moves upward and away from the ribcage.

In depression, it moves downward and fits more snugly against the ribcage.

Figure 7–1.
Figure 7–1. Resting position of the scapula on the thorax.

Figure 7–2.
Figure 7–2. Elevation/depression of the scapula at the scapulothoracic joint.
Protraction and Rotation

**Figure 7-3.** Abduction/adduction of the scapulothoracic joint.

**Figure 7-4.** Upward-downward rotation of the scapula at the scapulothoracic joint.
Large Range of Motion

- Motion Spread Through All articulations (Synchronous and Simultaneous)
- Glenoid Fossa Mobility (Scapular Motion)
- Optimal Portion of Length-Tension Curve
- Minimal Constraints
Joint Movement Patterns

- Many Ways a Joint Could Move
- Glenohumeral Joint Initial movement
  - ___° Flexion
  - ___° Abduction
- Spine
- Reasons for Different Opinions
  - Measurement Techniques
  - Planes
  - Anatomic Variations
Opinions on Movement

<table>
<thead>
<tr>
<th></th>
<th>Glenohumeral / Shoulder Girdle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innman (1944) Flexion/Abduction</td>
<td>2/1 after 60°/30° - 120°/60° Total Motion</td>
</tr>
<tr>
<td>Freedman (Scapular Plane)</td>
<td></td>
</tr>
<tr>
<td>Doody (Scapular Plane)</td>
<td></td>
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<tr>
<td>Saha (Scapular Plane)</td>
<td></td>
</tr>
<tr>
<td>Poppen (Scapular Plane)</td>
<td></td>
</tr>
</tbody>
</table>
Codman’s Paradox

- Flex
- Horizontally Abduct
- Adduct
- Rotation with out Rotation
Joint Stability

- Glenoid Fossa
  - >___% Longitudinal Length
  - >___% Transverse Length
- __________ Tilt of Glenoid Fossa
- Humeral Head Retroversion
- Intact Capsule and Glenoid Labrum
  - _____________ Pressure
- Muscular Function of the Rotator Cuff
  - Subscapularis
  - Supraspinatus
  - Infraspinatus
  - Upper Teres Minor

*Glenoid Osteotomy*
Glenohumeral Muscles

- Deltoid (A, Middle, P)
- Rotator Cuff
  - ____________
  - ____________
  - ____________
  - ____________
- Teres Major
- Coracobrachialis
Scapulothoracic Muscles

- Trapezius
- Rhomboids
- Levator Scapulae

____________________

- Pectoralis Minor
Multiple Joint Muscles

- Pectoralis Major
- Latissimus Dorsi
- Biceps Brachii
- Triceps (__________)
## Muscular Motions
### Glenohumeral

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Movements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ant. Deltoid</td>
<td>Flex, Add &lt;90, Abd &gt;90, ________ Rotation, Horiz. ________</td>
</tr>
<tr>
<td>Middle Deltoid</td>
<td></td>
</tr>
<tr>
<td>Pos. Deltoid</td>
<td>Extend, Add &lt;90, Abd &gt;90, Ext. Rotation, Horiz. Abd</td>
</tr>
<tr>
<td>Supraspinatus</td>
<td>Abduct, Int. Rotation</td>
</tr>
<tr>
<td>Infraspinatus</td>
<td></td>
</tr>
<tr>
<td>Teres Minor</td>
<td></td>
</tr>
<tr>
<td>Subscapularis</td>
<td>Int. Rotation</td>
</tr>
<tr>
<td>Teres Major</td>
<td>Extend, Int. Rotation, Add, Horiz. Abd</td>
</tr>
<tr>
<td>Coracobrachialis</td>
<td>Flex, Horiz. Add</td>
</tr>
</tbody>
</table>
## Muscular Motions

### Scapulothoracic

<table>
<thead>
<tr>
<th>Muscles</th>
<th>Motion Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trapezius</td>
<td></td>
</tr>
<tr>
<td>Levator Scapulae</td>
<td>Add, Downward Rotation, Elevation</td>
</tr>
<tr>
<td>Serratus Anterior</td>
<td></td>
</tr>
<tr>
<td>Pectoralis Minor</td>
<td>Abd, Inf-Upward Rotation, Depression, Sup-Downward Rotation, Elevation</td>
</tr>
</tbody>
</table>
## Muscular Motions of Multiple Joint Muscles

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pectoralis Major</td>
<td></td>
</tr>
<tr>
<td>Biceps Brachii</td>
<td>Extend, Int. Rotation, Add, Horiz. Abd</td>
</tr>
</tbody>
</table>

- **Pectoralis Major**
- **Biceps Brachii**
Outline

- Anatomy
- Biomechanics
- Problems
Reasons for Biomechanical Analysis

- Rehabilitation
  - Therapy Loads
  - Repair Strengths
- Injury
  - Motions That Transfer Higher Loads
  - Injury Mechanisms
    - Dislocation
- Prosthetic Design
  - Stress (Load) Analysis
Injuries

- Broken Bones
  - Clavicle
  - Scapula
  - Humerus

- Impingement
  - __________
  - Biceps Tendon

- Bursitis

- Dislocation
  - Subluxation
- Tendon Ruptures
  - __________
  - Biceps
Impingement

- Compartment
- Inflammation
- Increase in Pressure
- Feedback
Dislocation

- ________________ Most Common
- Superior Subluxation Difficult
  - Acromion
  - Coracohumeral Ligament
  - Coracoacromial Ligament
- Rotator Cuff
  - Provides Dynamic Stability
  - Protects Inferior, Anterior, Posterior Displacements
Rotator Cuff Repair

- Suture Anchor
- Bioscrew
- Tack
- Cyclic Loads to ___N (2/3 Max Contraction Force)
- 45°
Testing

- Suture Anchor Good Overall
- Tack Best for Good Cuff-Weak Bone
- Screw Best for Strong Bone-Any Cuff
Joint Replacement

- Loosening
  - Cemented
  - Uncemented
- Prostheses Design
- Stress Shielding

Figure 6-60
Glenoid loosening patterns are consistent with increased superior forces across the glenohumeral joint, noted particularly during the first 60 degrees of elevation.
Troubles with Biomechanical Analysis

- Mobility
  - High Number of Degrees of Freedom

- Muscles
  - Large Number of Muscles Contributing
    - Different Contributions
      - ____________.
      - ____________.
      - Angle of Elevation
  - Multiple Movements
  - Arm Position (example: Biceps)
    - Abductor while humerus is Externally Rotated
Multiple Motions of Single Muscle

- Anterior Deltoid - Muscle Flexion/Internal Rotation
- Teres Major - Muscle Extension/Internal Rotation

__________
Coupling - Forces Acting in Different Directions to Produce the Same Movement

- **Downward Rotation**
  - Rhomboids-Pectoralis Minor-Serratus Anterior (Superior)

- **Upward Rotation** *(figure)*

- **Elevation (Frontal)**
  - A. Deltoid-Teres Minor-Infraspinatus

*Figure 7.1.* Representation of the action of the serratus anterior and the lower fibers of the trapezius in a force couple.
Muscle Pair Ratios

- **Flex:** $\text{Extension} (\text{__})$
- **Abd:** $\text{Add} (\text{__})$
- **Internal:** $\text{External} (\text{__})$
- Adduction-Extension-Flexion-Abduction-Internal Rotation-External Rotation
Forces at the Shoulder
(Innman et al., 1944)

- 90° Abduction
- Deltoid ___ Extremity Weight (70% BW)
- GH Joint ___ EW (90% BW)
- Rotator Cuff ___ EW (85% BW)
- Load Bearing (Approximately 1BW)
Forces at the Shoulder (Poppen et al., 1978)

- Abduction in the Frontal Plane Elevation
- Bent Arm Reduces Shoulder Force by __%
Shoulder Dynamics

- Fatigue and Injury (Working with Arm Elevated)
  - Supraspinatus
  - Trapezius
- Supraspinatus Tendonitis
- Neck Pain (Trapezius Fatigue)
- Less Fatigue (Herberts, 1980)
  - A. Deltoid (45° and 90°)
  - Supraspinatus (45°)
  - Trapezius (45°)
- ___________ had Highest Fatigue
Simplified Joint Force

- 1 Muscle
- Segment Weight
- Vector Addition
Joint Force and Stability

A

B

a. 0°
b. 30°
c. 45°
d. 60°
e. 90°
Moment (Hinrichs, 1981)

- Reference Line from Anthropometric Data
- Average Limb Weight (BW)
- Average Center of Mass Distance
- $F \times d = \text{Moment}$
Outline

- Anatomy
- Biomechanics
- Problems
Problem #1 (1-D)

\[ \sum M = 0 \]
Problem #2 (2-D)

- \( \Sigma F_x = 0 \)
- \( \Sigma F_y = 0 \)
- \( \Sigma M = 0 \)
Problem #3 (3-D)

- $\Sigma F_x=0$
- $\Sigma F_y=0$
- $\Sigma F_z=0$
- $\Sigma M=0$