Musculoskeletal Biomechanics

BIOEN 520 | ME 527

Session 15A
Biomechanics of the Shoulder
[Q]: What are the bones and anatomical joints that comprise the shoulder complex?

[Q]: What are the primary static and dynamic constraints for the shoulder?

[Q]: What is the normal range of motion of the shoulder and which joint(s) in the shoulder is/are responsible for most of the motion?

[Q]: What areas of biomechanical research have been investigated for the shoulder?
[Q]: What bones comprise the shoulder joint complex?

- Humerus
- Scapula
- Clavicle
- Sternum (manubrium)
[Q]: What are the main anatomical features of the scapula?

- Glenoid Fossa
- Acromion
- Coracoid Process
[Q]: What are the joints (articulations) that comprise the shoulder complex?

- Glenohumeral
- Acromioclavicular
- Sternoclavicular
- Scapulothoracic (Bone-muscle-bone... Not a “true” joint)

**Type:**
- Syn.
- Syn.
- Syn.
- N/A
[Q]: Which two of these joint motions have been studied the most?

- Glenohumeral
- Acromioclavicular
- Sternoclavicular
- Scapulothoracic
Glenoid fossa is very shallow, covering only 1/3 of the humeral head surface area. Unlike the hip, the glenohumeral joint is minimally constrained. This allows for greater mobility, but sacrifices stability.

[Q]: What are the primary *static* constraints for the glenohumeral joint?

- Capsule
- Labrum
- Ligaments

Names:
- Superior GH Ligament
- Middle GH Ligament
- Inferior GH Ligament
[Q]: What are the primary *dynamic* constraints for the glenohumeral joint?

Rotator Cuff... (4)
- Subscapularis
- Supraspinatus
- Infraspinatus
- Teres minor
[Q]: What is the normal range of motion for the shoulder complex?

- Flexion...  (≈180°)
- Abduction... (≈180°)
- Int/Ext rot... (≈90°)
Function & Properties...

[Q]: During shoulder elevation (flex/abduct), what is the relative contributions of glenohumeral and scapulothoracic motion?

2/3 GH -- 1/3 ST

≈120° glenohumeral
≈ 60° scapulothoracic

[Inmann, 1944]
Function & Properties...

JHU Videos...
Injury Mechanisms and Treatment...

[Q]: What are most common ways people injure their shoulder? *(Has anyone had one?)*

- Falls onto shoulder or outstretched arm
- Overuse... *(overhead sports)* *(ex: pitching/swimming/tennis)*
Injury Mechanisms and Treatment...

[Q]: What structures are typically injured?

- Falls onto shoulder → AC & SC sprains/dislocations
- Falls onto outstretched arm → Labrum or capsular tears; glenohumeral dislocation
- Overuse → Rotator cuff injury (disease): tendinitis/tears
Injury Mechanisms and Treatment...

[Q]: What are the usual treatments?

- Sprains and strains... → RICE (Rest, Ice, Compression, Elevation)
- Dislocations... → Reset & RICE
- Labrum/capsule tears... → Bankart, capsular shift
- Rotator cuff tears... → Arthroscopy (suture tears)
Injury Mechanisms and Treatment...

Newer Treatments...

- Electrothermally-assisted capsulorrhaphy (ETAC) to shrink capsule
- Total Shoulder Arthroplasty (TSA)
Biomechanics...

- Kinematics (motion studies)
- Stability
- Joint Forces
- Modeling
- Effects of surgical procedures

U. Mich, shoulder kinematics
Biomechanics...

Kinematics...

- Inmann et al, 1944
- Freedman and Munro, 1966
- Poppen and Walker, 1976

- Johnson et al, 1999 [...digital inclinometer w/ Polhemus]
Biomechanics...

Stability...

- H.S.S., 1992 - present [... Effect of compression, lesions, tendon transfer]
- U.W., 1989 - present [... Glenohumeral stability]

ASHS, shoulder laxity
Biomechanics...

UW Video...
Biomechanics...

Joint Forces...

• Poppen and Walker, 1978 [... GH forces during abduction]
• Ericson et al, 2002 [... Forces during isometric strengthening]
Biomechanics...

Modeling...

- Lindsay, 2001 [... 3-D inverse dynamics, 21 muscles]
- Boulic et al, 1998 [... Real-time animation w/ MoCap]
Biomechanics...

Effects of Surgery...

- Gerber et al, 2003 [... Effect of capsulorrhaphy on ROM]
- Tang et al, 2002 [... Effect of tendon transfer on stability]
“Brain Teaser”...

[Q]: What is the most common direction for shoulder (glenohumeral) dislocations?

Anterior: Falls onto an outstretched arm