The Throwing Athlete
Biomechanics: Function & Dysfunction

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Presentation Goals

- Provide an understanding of normal Scapular Function and Motion.
- Discuss the importance of the Scapula within the kinetic chain of the
  throwing athlete.
- Describe clinical examination techniques for evaluation of scapular
  function.
- Define Scapular Dyskinesis and the role it plays in shoulder injury and
  pathology.

Normal Scapular Function

Scapular Osseous Components

- Arise from several ossification centers with various stages of
  coalescence:
  - Coracoid: 14-18yo
  - Acromion: 19-20yo
  - Inferior Angle: 18-20yo
  - Glenoid Fossa: 20-25yo
Normal Scapular Function

**Basic Anatomy:** Scapula is enveloped by multiple muscular layers.

- **Anterior Scapular Muscle Attachments:**
  - Triceps
  - Biceps (Short and Long Heads)
  - Coracobrachialis
  - Subscapularis
  - Serratus Anterior
  - Pectoralis Minor
  - Omohyoid

- **Posterior Scapular Muscle Attachments:**
  - Triceps
  - Biceps (Long Head)
  - Omohyoid
  - Trapezius
  - Supraspinatus
  - Infraspinatus
  - Teres Major
  - Teres Minor
  - Levator Scapulae
  - Latissimus Dorsi
  - Deltoid
  - Rhomboideus Major and Minor

**Scapular Bursae:**

- **Infraserratus Bursa (Bursa Muscula Serrata):**
  - Lies between Serratus Anterior and Chest Wall
  - Inflamed = Inferior Angle Pain

- **Supraserratus Bursa (Bursa Muscula Angularis Superioris Scapulae):**
  - Lies between Subscapularis and Serratus Anterior
  - Inflamed = Superior Angle Pain

- **Scapulotrapezial Bursa:**
  - Lies between Supraspinatus and Trapezius
  - Contains the Spinal Accessory Nerve.
Normal Scapular Function

- **Scapular Anatomic Positioning at Rest:**
  - Anteriorly Rotated (relative to trunk) approx 30°
  - Medial Border Rotated
    - Inferior Pole Diverged 3-5° from Spine
  - Anteriorly Tilted 20° in sagittal plane

Normal Scapular Function

- **Scapulothoracic Anatomy & Function:**
  - **Scapular Postural Support**
    - Levator Scapulae & Upper Trapezius
  - **Scapular Retraction**
    - Middle Trapezius & Rhomboids
  - **Scapular Protraction**
    - Serratus Anterior
  - **Upward Scapular Rotation**
    - Serratus Anterior & Trapezius
  - **Scapular Elevation**
    - Upper Trapezius & Levator Scapulae

Normal Scapular Function

- A. Scapular Posterior Tilting
- B. Scapular Superior Rotation
- C. Scapular External Rotation
- D. Clavicular Elevation
- E. Clavicular Protraction
Normal Scapular Function

Dynamic Anatomy:
- Humeral movement in relation to Glenoid.
- Glenohumeral Ligament and Labral static constraint on Humeral Translation.
- Rotator Cuff dynamic constraint on Glenohumeral Motion.

The Scapula is intimately involved in each one of these functions.

Glenohumeral Articulation:
- Scapula must continually move to maintain instant center of rotation.
- Proper glenoid alignment optimizes function of articulations and rotator cuff to allow concentric GH-Motion.
- Scapulothoracic positioning determines position and inclination of both Glenoid and Inferior Glenohumeral Ligament.
- Improper alignment can lead to GH Instability.

Thoracic Wall Articulation:
- Scapular Retraction (external rotation) facilitate cocking position.
- Scapular Lateral Protraction (internal rotation) allows acceleration.
- Scapular Anterior Thoracic Translation allows maintenance of normal GH position and dissipation of deceleration forces.
Normal Scapular Function

**Acromial Elevation**
- Serratus anterior activation results in traction related superior acromial elevation.
- Occurs during cocking and acceleration phases of throwing, and during arm elevation.
- Allows for reduction of impingement and coracoacromial arch compression.

**Normal Scapular Function**

**Kinetic Chain**
- Scapula serves as a link in Proximal-to-Distal sequencing of velocity, energy, and forces of shoulder function.
  - Generation, Summation, Transference
  - Scapula serves as pivotal link of transference of large forces/high energy from lower body/core to the arm/hand.
  - Also allows arm stabilization to absorb force loads through long lever dynamics to reduce injury.

**Normal Scapular Dynamics:**
- Bilateral Posterior Tilting, External Rotation, & slight Superior Translation during elevation of arm.
- Symmetrical motion patterns.
- No prominent medial or superior scapular borders.
Scapular Dyskinesis

**Scapular Dyskinesis**
- Alterations in *STATIC* scapular position and *DYNAMIC* scapular motion resulting in scapular asymmetry in gross postural assessment and function movement.

## Scapular Dyskinesis

- Affects normal Scapulohumeral Rhythm (SHR).
- May lead to articular and/or soft tissue shoulder dysfunction.
- May result in shoulder pathology and injury.
- May result from injury causing inhibition of scapular stabilization.

**Nonspecific Response**: No specific pattern of dyskinesis is associated with a specific shoulder diagnosis.

## Contributing Factors

- **Bony Posture & Injury**
  - Increased Thoracic Kyphosis
  - Increased Protraction
  - Acromial Depression
  - Clavicle Fractures
  - AC Joint Injury
  - Disrupt normal progression of scapular rotation
Scapular Dyskinesis

**Contributing Factors**

- Muscle Function Alteration
  - Nerve Injury
    - Long Thoracic Nerve → Serratus Anterior
    - Spinal Accessory Nerve → Trapezius
  - Muscle Inhibition/Weakness
    - Common in Glenohumeral Pathology
    - Nonspecific response to shoulder pain
      - 68% RC Abnormalities
      - 94% Labral Tears
      - 100% GH Instability

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- Contracture/Inflexibility
  - Pectoralis Minor/Subscapularis
  - Anterior Tilted Scapula
  - GIRD
    - "Wind-Up" Effect
      - Glenoid and Scapula pulled in forward inferior direction
      - May result in ↑ protraction during arm-abducted position

- Associated Shoulder Pathology:
  - Subacromial Impingement
  - Glenohumeral Instability
  - Glenoid Labral Injury
  - Rotator Cuff Injury
Assessing Scapular Dyskinesis

**Clinical Examination**
- Kinetic Chain Evaluation:
  - Leg/Trunk Muscle Strength
  - Lumbar Lordotic Posture
  - Pelvic Alignment
  - Hip ROM
  - Thoracic Alignment/Posture
    - Thoracic Kyphosis, Scoliosis
  - Cervical Posture
  - Cervical Lordosis

Assessing Scapular Dyskinesis

- Examine patient from behind with arms at rest at sides.
- Examine Scapular Motion as arms are elevated and lowered within scapular plane.
- Examine Scapular Motion as arms are elevated and lowered within the sagittal plane.

Types of Scapular Dyskinesis

**Type I**
- Prominence of Inferior Medial Scapular Angle.
  - Primarily abnormal rotation around a transverse axis.
  - Results in excessive anterior scapular tilt.

**Type II**
- Prominence of entire Medial Scapular Border.
  - Results in abnormal rotation around a vertical axis.
  - Associated with excessive scapular internal rotation.

**Type III**
- Prominence of Superior Scapular Border.
  - Results in excessive superior scapular translation.

**Type IV**
- Normal, Symmetrical scapular motion.
Assessing Scapular Dyskinesis

**Observational Clinical Assessment**
- 4-Type Method versus Yes/No Method
- Easily available
- Wide variance of Inter-Rater Reliability
  - (4-Type) Sensitivity 10%-54%; Specificity 62%-94%
  - (Yes/No) Sensitivity 74%-78%; Specificity 31%-38%
- Limited assessment of multiple-plane asymmetries

**3D EM Kinematic Analysis**
- Lab-based; limited availability
- Allows for multiple-plane assessment
- Detected asymmetry may not be clinically relevant

Uhl et al; *Arthroscopy*, 25(11); 2009

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**Assessing Scapular Dyskinesis**

**Yes/No Method**
- Improved Inter-Rater Agreement (79%)
  - Allows consideration beyond a single-plane of motion
  - PPV = 74%
- Displays Sensitivity (76%) & Specificity (35%) similar to other clinical shoulder exam tests.
  - Clinical SLAP tests: Mean Sensitivity 57%; Specificity 41%
  - Clinical Instability tests: Mean Sensitivity 71%; Specificity 38%
  - Clinical Impingement tests: Mean Sensitivity 68%; Specificity 69%

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**Scapular Dyskinesis**

**Prevalence of Scapular Asymmetry**
- 71%-78% (3D Kinematics) of population at large
- Symptomatic vs. Asymptomatic
  - Additional Factors:
    - Ligamentous Laxity, Muscle Imbalance, Side Dominance
  - Plane of Assessment may determine clinical relevance
    - Forward Flexion Motion Asymmetry increased in Symptomatic (54%) versus Asymptomatic (14%) patients.
    - Increased Serratus Anterior activity
Effects of Scapular Dyskinesis

**Loss of Retraction/Protraction**
- **Retraction Loss**
  - "Cocking" point or base for arm elevation.
  - Impingement as scapula rotates inferior and anterior.
- **Protraction Loss**
  - Deceleration forces in GH Joint.
  - Functional Glenoid Anteversion.
  - Shear stresses on anterior stabilizing structures.
  - Posterior impingement.

**Loss of Superior Elevation**
- Decreased Acromial Elevation
  - Predisposes Subacromial Impingement.
  - Inhibition of Serratus Anterior and Lower Trapezius.

**Loss of Kinetic Chain Function**
- Disruption of transferal of lower extremity and core forces to the upper extremity.
  - Strength and Energy Use
  - Acceleration Velocity
References