Rehab of the Thrower’s Shoulder

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Key Principles

- Thrower’s shoulder must be loose enough to allow excessive ER, but stable enough to prevent humeral head subluxation.

Key Principles

- Demands of throwing requires a delicate balance between mobility and stability.
External Rotation Importance

The throwing athlete acquires increased external rotation in abduction over time compared to the non-throwing shoulder. Result is hyper-external rotation. The longer the arc of rotation thru which angular acceleration is achieved the greater the velocity of the hand.

Pathomechanics in Atraumatic Shoulder Instability

Loose Joint Capsule Alterations of Passive Stabilizers Insufficiency Of Active Stabilizers Flat Concavity of Glenoid

What can we do as rehab professionals?

- Must understand that without controlling excessive/abnormal translation of the humeral head we will not effectively manage the athlete’s dysfunction.
**Loss of Humeral Head Centering**

- Shoulder Instability
- Labral Pathology (SLAP tears)
- Under surface Cuff Tears
- Soft Tissue Restriction

**Pathomechanics**

- GIRD
  - Glenohumeral Internal Rotation Deficit
- Posture and Scapular Dyskinesis
- Dynamic Control of Rotator Cuff
- Neuromuscular Coordination/ Timing of muscle firing
- Throwing Mechanics

**Stabilizers of GH Joint**

- Glenohumeral Ligaments
  - We will be focusing on IGHL
    - Posterior Band of Inferior Glenohumeral Ligament
- Labrum
- Rotator Cuff Musculature
  - Strength, Neuromuscular Coordination, and Dynamic Stability
- Scapular Musculature
  - Control and Coordinated Force Couples
Shoulder Biomechanics in Throwing

- The flexibility needed to achieve ROM for throwing motion must come from
  - Capsule both Anterior and Posterior
  - Muscles Anterior and Posterior
  - Stable Scapular Base

Shoulder Biomechanics in Throwing

- With hypomobility or hypermobility of any of these structures you will have a breakdown in glenohumeral and/or scapulothoracic mechanics
- Poor Throwing Mechanics

Throwing

- Angular Velocity of shoulder 7000 deg/sec
- Elbow extension velocity 3000-4000 deg/sec
Phases of Throwing

- Windup
- Early Cocking/Stride
- Late Cocking
- Acceleration
- Ball Release/Deceleration
- Follow Through


Phases of Tennis Serve

- Ball toss - early cocking - late cocking
- Acceleration - follow thru - deceleration

Early Cocking/Stride - Ball Toss
Early Cocking/ Stride

- Begins as leg reaches max height
- Stride increases the distance over which acceleration occurs
- Pelvic tilt and rotation occur
- Deltoid is active early to aid in abduction
- Supraspinatus, infraspinatus, and teres minor are active late to initiate shoulder ER
- Ends at lead foot contact
Late Cocking

- Occurs between foot contact and max external rotation
- Scap retracts and tilts upward via rhomboids, levator, and trapezius
- Abduction and external rotation primarily from infraspinatus/teres minor
- Supraspinatus functions mainly for GH compression and humeral head depression
- Max Pelvic Rotation
- Increased trunk rotational and angular velocities
- Ends as subscap, pec major and lats eccentrically fire to terminate ER

Late Cocking/Acceleration

- Max ER to ball release
- Scapula protracts and anteriorly tilts with increased serratus activity
- Shoulder muscle forces shift to concentric to generate velocity
  - Subscap activity at its highest
- Max elbow extension velocity
Ball Release/ Deceleration

Most violent phase of pitching
Excessive Distraction and post/inf shear on GH joint
Eccentric loading of posterior cuff to resist distraction forces
High Eccentric biceps activity to slow elbow extension
Distraction Forces as high as 81% body weight (Werner et al. JSES 2007; 16(1):37-42)

Deceleration

Follow Through – Arm motion ends into fielding position
Pathophysiology of the Overhead Athlete

- Tightness of Posterior Capsule
  - CAM effect hyper-external rotation
  - Posterior band tightness – angulation
  - Eccentric loading of external rotators
- Posture and scapular control/position
  - Scapular rotator weakness = GIRD
- Weakness of posterior cuff musculature
  - Fatigue of Rotator cuff – instability-impingement-RC tears

Glenohumeral Internal Rotation Deficit

GIRD

GIRD Glenohumeral Internal Rotation Deficit

- Repetitive loads placed on the posterior band of the IGHL (Inferior Glenohumeral Ligament) cause tightening and thickening
Posterior Band of IGHL

- Strain of throwing motion leads to scarring and thickening of the posterior capsule.

- Increased passive muscle thickness and increased muscle stiffness.

GI RD

- Passive test Internal rotation

Izumi, Tomoki et al., AJSM 2008

30E abduction in the Plane of Scapula (30E) & internal rotation: Superior & Middle fibers of posterior capsule.

30E of extension & internal rotation: upper lower fibers posterior capsule (lift off test position).
**GI RD**

- Starts to develop at a young age
- Progresses with age and length of play
- **IS REVERSIBLE WITH SPECIFIC STRETCHING TECHNIQUES**

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**Morgan has introduced the “rotational unity rule”**

An overhand throwing athlete will maintain normal glenohumeral mechanics if the internal rotational deficit is less than or equal to the external rotational gain.

A humeral posterior superior shift will occur if the internal rotation deficit is greater than the external glenohumeral gain.

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**Disabled Throwing Shoulder**

Burkhart, Morgan, Kibler Arthroscopy 2003

- 3 Part Series on Pathology in the throwing shoulder
  - Peal down effect of Labrum
  - Contracture of Posterior band of the inferior G-H ligament
  - Pathology of SLAP tears
  - Evaluation
  - Treatment
Internal & External Rotation Effects on Inferior Capsule During Throwing

- Normal Hammock effect of the anterior and posterior bands of the IGHL complex fixed central position of the glenoid rotation
- O’Brien AJSM 1990

Cam Effect of the G-H Joint

- Cam effect of the major tendon and capsuloligamentous structures between resting (solid lines) and Ext Rotn 90E abd. (dotted lines)
- PIGHL under humeral head

Role of G-H Ligaments and Capsule in Overhead Throwing Athletes

- Ext. Rotation at 90E abduction is supported by the anterior & posterior band of the IGHL act as independent cables
- Hammock to support the humeral head
**Inferior Glenohumeral Capsular Complex**

- Anterior & Posterior Bands of the Inferior Glenohumeral Capsule
- Attached to inferior Labrum

**Tightening of the Posterior Band of the IGHL Complex with throwing**

- The posterior cable shortens (contracted posterior band) G-H contact point shifts posterior/superiorly and the arch of external rotation increases clearing the greater tub. Before internal impingement

**GIRD-Follow Through**

- Anterior superior translation of humeral head
- Shear on labrum
- Scapular protraction to compensate for the tightness
- Limited cross body adduction during follow through
Treatment of GIRD

- Sleeper Stretch

Adduction in Sidelying (Scap Blocked)

Manual Passive IR Stretch
**Treatment of GIRD**

- Stretching should be done on a daily basis with low load prolonged stretch to facilitate permanent changes in tissue length.
- Should begin to see some progress in a few weeks.
  - Progress with younger throwers often much faster due to pliability.
  - The more an athlete has thrown the longer it may take.

**GIRD and UCL Injury**

- AJSM 37(3)2009 Dines, et al.
- Pathologic internal rotation deficit may be associated with valgus instability of the elbow.
- Important in both preventing UCL injury and during rehab after UCL repair.

**Non-Responders to Stretching**

- Burkhart, Morgan, Kibler Arthroscopy 19(4)2003
- 10% of throwers do not respond.
- Tend to be older elite pitchers who have been throwing for years and have been on the severe end of GIRD spectrum.
- Usually have other associated chronic pathology.
Non-Responders to Stretching
Burkhart, Morgan, Kibler Arthroscopy 19(4) 2003

- Arthroscopic findings usually include severely contracted and thickened posterior band of IGHL complex and in most cases is 6mm thick or more
- Refer back to physician
- It is unusual for high school and college pitchers to be non responsive to stretching

Labral Pathology – Long Head Biceps Peel down Effect

- SLAP Tears
  - Superior Labrum Anterior to Posterior
  - Long Head of Biceps attachment
- LH Biceps Most ”wound up” in abduction
  - i.e. good throwing position

Stabilizing Effect of the Biceps

- The long head of the biceps at 60 & 90 degrees of abduction & external rotation
- Increases Torsional Rigidity
- Compressive forces to the humeral head & controls translations
**Labrum**

- 80% of asymptomatic baseball pitchers have some degree of labral pathology
- In most overhead athletes, the labrum will be hypermobile
- Needs mobility to perform demands of extreme external rotation
- MRI findings not 100% that patient will need surgery
  - Must address other deficits in shoulder before decision for surgery is made

**Labrum**

- Lesions of Posterior Shoulder PIGHL leads to increased shear on superior labrum and creates "peel back" lesion

**Role of the scapula**

- Stable base
- Position of the glenoid
- Optimal length tension of cuff
Scapular Position
Burkhart, Morgan, Kibler Arthroscopy 19(6) 2003

- Scapular Dyskinesis
- “SICK” Scapular Malposition, Inferior medial border prominence, Coracoid pain, and Dyskinesis of scapular movement
- Asymmetric position of scapula in the dominant throwing shoulder

Scapular Dyskinesis

- Factors affecting scapular position and control
  - Weakness of Scapular muscles
    - Lower Traps
    - Rhomboids/Mid Traps
    - Serratus Anterior
  - Tightness of Pectoralis Minor
  - Tightness of Posterior Capsule

Baseball player - Tommy John Surgery & SLAP
SICK Scapula      GIRD 45E
Scapular Control
Burkhart, Morgan, Kibler Arthroscopy 19(6) 2003

- Force couples created by scapular rotators
- Provide both movement and stabilization
- Suggests underlying muscle activation alterations that lead to abnormal kinematics of scapula during movement

Kibler
3 scapular patterns related to shoulder injuries in the overhead throwing athlete

- 1: The lack of retraction: resulting in the loss of the ability to place the scapula in the position of full cocking, thus the loss of acceleration.
- 2: The lack of protraction: resulting in increased deceleration forces on the shoulder and an altered safe zone for the glenohumeral joint in acceleration.
- 3: Excessive protraction: resulting in a scapula that is positioned rotated downward and forward.

Potential Factors for Scapular Dysfunction
Uhl, T Scapular Mechanics and Assessment Jan. 2006

- Glenohumeral Pathology
- Muscle Weakness
- Muscle Tightness
- Muscle Fatigue
- Pain
- Loss of Neuromuscular Control
- Neuropathy
Treatment of Scapular Dyskinesis

- Pec Minor Stretching
- Posterior Capsule Mobilization
- Scapular Muscle Strengthening
- Neuromuscular Control/Timing of firing avoiding upper trap dominance

Primary Muscles involved in scapular dysfunction

- Upper Trap Dominance
- Mid Trap, Lower Trap, Serratus Anterior, and Rhomboid weakness
- Posterior cuff weakness

Posture

Kebatase '99

- With Slouched Posture the scapula is more elevated in abduction ROM 0-90 degrees
- Less posterior tilting of the scapula as shoulder elevation continues upward
  - Creates a hinging effect in throwers: internal impingement
- Less available ROM: impingement
- Decreased strength production
Differences in Scapular Upward Rotation Between Pitchers and Position Players

- AJSM 2007. Laudner, Stanek, and Meister
- Compared professional baseball pitchers vs. position players
- Looked at scapular upward rotation at 60, 90, and 120 degrees elevation
- Pitchers have less scapular upward rotation than position players especially at 60 and 90 degrees of abduction

Scapula in Throwing

- Max ER of shoulder during throwing 165-175 degrees of ER – approximately 25-30E is from scapula protraction
- Small degree of error in scapular position can lead to significant shoulder pathology

Overhead Athletes with impingement symptoms

- Compared normalized trap activity and intramuscular balance in athletes with and without pain.
- Looked at Abduction and External Rotation
- In Painful Shoulders
  - Significant increase in upper trap activity during both abduction and external rotation
  - During Abduction Decreased activity of Lower Trap
  - During External Rotation decreased middle trap
Scapular Muscle Balance

- Altered ratio with Abduction of upper/middle trap and upper/lower trap
- Altered ratio of all 3 during external rotation
- So How do we restore muscle “Balance” with our scapular rehab exercises?

Scapular Muscle Balance

- First need to identify how to isolate these muscle to evaluate their strength
- Find and prescribe the exercises that are the most effective at activating the muscles that are weak or inhibited without continuing to strengthen the dominant muscles—which is almost always the upper trap

Serratus Anterior

- Supine with Elbow extended
- Protract Scap forward Punch
- Give resistance through fist
Lower Fibers of Serratus Anterior

- Lower fibers important for scap control in higher range of elevation
- Test position flexion or POS 120-140
- Looking for increased winging of the lateral border of the scapula

Rehab of Scapular Muscle Balance
Which Exercises to Prescribe, Cools et al. 2007

- Clinicians should find the exercises during rehab with high activation of Lower and Mid Trap
- Low activity of the Upper trap

Rehab of Scapular Muscle Balance
Which Exercises to Prescribe, Cools et al. 2007

- For LT balance best exercises are
  - Prone shoulder extension
  - Side-lying External Rotation towel roll
  - Prone Horiz Abduction in external rotation
LT Balance Exercise
Forward Flexion in Sidelying

Start

Finish

Lower Trap Strengthening

- Prone Flexion “Y”, prone empty can, horiz abd 100 with ER
- Bilateral ER with tubing
- 90/90 lift Ekstrom, Donatelli, Soderberg JOSPT 2003

Serratus Muscle Activity

- Decker et al. 1999
  - Push up Plus and Dynamic hug were 2 highest for Serratus
- Donatelli
  - Bench and Reach
**Scapular position**

- Evaluation of scapular muscles is important to proper rehab and exercise prescription.
- Avoid upper trap biased exercises until balance restored, focus especially on middle and lower trap exercises.
- Make sure rehab is a progression once the stable base is restored, moving to more aggressive exercises too soon feeds into the pathology.

**Rotator Cuff Strength**

- Supraspinatus
- Infraspinatus
- Teres Minor
- Subscapularis

**Anterior and Posterior Cuff**
Rotator Cuff Strength

- Force Couple of the G-H Joint
- Role is to give dynamic stability to GH Joint
- Centering of humeral head
- Oppose upward translation of humeral head due to pull of deltoids
- Prevent traction force to shoulder during follow through

Rotator Cuff Fatigue & G-H Kinematics in Patients without Shoulder Dysfunction

Deydre et al. Journal of Athlete Training 2008

- Fatigue protocol was indicated by a 54% reduction in prone horizontal abduction strength average prefatigue strength was 7.75 kg postfatigue 3.16 kg average time to fatigue was 84.2 seconds.
- Blackburn et al determined that abduction in the prone position with the thumb up position isolated the supraspinatus, infraspinatus and teres minor muscles

Results

- Increase in superior of the humeral head during arm elevation increases with rotator cuff fatigue in individuals without shoulder dysfunction
- Average subacromial space is between 2mm and 14mm
- The magnitude of superior migration may represent a 6% to 40% reduction in subacromial space.

Digital Fluoroscope video assessment of shoulder kinematics
Posterior G-H pain in overhead throwing athletes
Superior Glenoid Impingement
Jobe, Clin Ortho 1996

External rotation 90 deg.
Abduction and horizontal extension (early part of the acceleration phase of overhead throwing)
• Impingement of inner fibers of the RC & post sup. labrum between the grt. tub and post sup. glenoid
• Secondary to lack of resistance from the subscapularis causing angulation of the humeral head instead of translation

Internal Impingement

• Impingement of deep surface of the subscap tendon and the reflection pulley on the ant/sup glenoid rim: Gerber et al. / Sh Elbow Surg 2000
• Increased internal rotation with 150 deg flexion the lesser tuberosity and biceps tendon are brought closer to the ant/sup glenoid rim and the superior GH lig becomes lax.
• At 90 deg, flexion and internal rotation the deep surface of the subscap is impinging against the glenoid rim

ER/ IR Ratio

• 65-70% External to Internal Rotator Ratio
• If Ratio is diminished you will be at risk to develop problems during the deceleration phase of throwing where eccentric control of the teres minor and infraspinatus is critical
Posterior Cuff Exercises

- Blackburn, et al. 1990
  - Supraspinatus: prone horizontal abduction with external rotation at 100 degrees
  - Infraspinatus: Teres Minor: prone external rotation at 90/90
  - Horizontal abduction with external rotation
  - Prone external rotation

Scapular Kinematics During Supraspinatus Exercise
Full Can vs. Empty Can

- Reinhold et al. 2007
  - All 3 exercises produced similar activity of supraspinatus
  - Full can: significantly less activity of deltoid muscles and may be best position for rehab and muscle testing
  - Empty can: good exercise to recruit middle delt in addition to supraspinatus
  - Prone Full can: good exercise to recruit the posterior deltoid as well

EMG Analysis of Common ER Exercises

  - Sidelying ER produced highest activity for infraspinatus and teres minor
  - Highest supraspinatus, middle delt during prone horizontal at 100 with cuff pathology or impingement
External Rotation

- ER in scapular plane
  - Safe position to strengthen and can often push more weight to work strength and eccentrics than in 90/90 position
  - Especially in rehab situation progression from side to functional position

Improving Strength of Shoulder Rotators in Teenage Baseball Pitchers

- Isokinetic 500 degrees/sec
- Isotonic mode 80% Max effort thru out the range of rotation
- Results: Isotonic group significant increase in throwing velocity and external rotation strength
- Ave. increase in speed 2-3 mph
- Wooden et al. JOSPT 1992
Tennis serve velocity changes with strength training on Isokinetic device

- 3 groups (control, eccentric, concentric)
- Isokinetic training was used 90-210 deg. Per second
- Significant concentric and eccentric gains were obtained in both groups
- Increase serve velocity average 11mph
- Monte et al, AJSM 1994

Dynamic Control

- Must teach patients to relearn motor control and movement patterns

Functional Stab Exercises

- External Rotator Eccentrics
Side-Lying Deceleration

Functional Stab Exercises
- ER Eccentric Follow Through

Returning the Athlete to Sports
Overhead throwing Athlete
Abnormal Arm Position Leading Elbow
Poor knee flexion Angle

Leading Elbow – Medial Collateral Ligament Strain

- Elbow pain in overhead throwing athletes means someone missed shoulder problems months ago
- Shoulder deficits in ROM = GIRD
- SICK scapula
- Rotator cuff strength poor

Poor foot contact – Stride Length Fault

A Short stride    B Foot Right Angle to Plate
Thoracic Spine Facet Strain in Baseball Pitcher: Case College Baseball Pitcher – chest pain with deep breath and during late cocking and acceleration phase

Watkins reports the rib cage is responsible for 30% of the stability of the thoracic spine in axial rotation.

College baseball pitcher complaining of chest pain and difficulty breathing was a consequence of faulty pitching mechanics and hip and trunk muscle deficits, which resulted in rib facet and costovertebral joint dysfunction.

In the late cocking phase of pitching, between foot contact and extreme shoulder external rotation, there is maximum pelvic rotation, increased trunk rotation, and angular velocities. External rotation of the leg allows the foot to point toward home plate and facilitates transmission of the pelvic and trunk rotations into the lower limb from late cocking phase to acceleration and release.

Poor foot posture and stride length

In this case, the pitcher no externally rotate of the lower limb at foot contact: the foot made contact with the ground in a closed position. (right angle to the plate)
The transmission f the trunk and pelvic rotations into the lower limb were limited. The lack of distribution of rotation forces through the pelvis into the lower limb prolonged rotation of the thoracic spine, resulting in increased strain to the thoracic rib facets and costovertebral joints.

Treatment
The reproduction of the athletes' pain within the upper and middle thoracic spine segments was elicited upon passive testing of the costovertebral articulations, hypomobility.
Mobilization of the restricted segments, strengthening of the posterior lateral hip muscles, and changing the pitching mechanics resolved this problem.

Is This Good Mechanics?
Andy's arm angle was considered to be detrimental to his shoulder @ 138mph serve he would never last???
Returning the Injured Overhead Throwing Athlete to Sports

How I got ride of Andy Roddick’s wrist, elbow, and shoulder pain and hit a 155mph serve? 17mph
- Strengthen RC and Scapula rotators
- Normalize GIRD
- Assess posterior capsule integrity
- Assess posture/scapular position as well as scapular kinematics with movement
- Balance - Vestibular - Proprioceptors
- Hip and Trunk Strength/Endurance