Internal Impingement in Overhead Athletes

Part I: Understanding the Pathology, Throwing Biomechanics, and Clinical Presentation

Dr. Christian Coulon, PhD, PT, OCS, CSCS, Cert. MDT
• Objectives
  – Define internal impingement and its associated pathology
  – Demonstrate 4 clinical signs and symptoms of internal impingement
  – Explain potential causative factors in internal impingement
  – Explain where in the throwing motion internal impingement occurs
  – Demonstrate the progression of the pathology

• Impingement syndromes (Neer, 1972)
  – SIS two main mechanistic theories:
    • Neer’s impingement theory
      – Focuses on extrinsic mechanisms (primary)
      – Focuses on intrinsic mechanisms (secondary)
  – Two less classic forms:
    • Internal impingement
    • Coracoid impingement
• Extrinsic mechanisms (primary)

• Intrinsic mechanisms (secondary)
• Internal impingement
  – First observed in 1992 (Walch et al.)
    • 17 overhead athletes
    • Unexplained shoulder pain on throwing
  – Preoperative clinical examination:
    • Localized pain on full external rotation (ER) and 90° abduction
    • Signs of rotator cuff rupture
    • Positive impingement sign
  – 10 cases CT arthrogram showed evidence of abnormality at posterior edge of the glenoid

• During athletes shoulder arthroscopy
  – Arm placed in full external rotation and 90° abduction
    • The throwing position
  – Impingement between posterosuperior glenoid border and undersurface of tendinous insertions of supraspinatus and infraspinatus
• Halbrecht et al., 1999
  – MRI confirmation of supraspinatus tendon undersurface contacting posterior-superior glenoid in baseball pitchers in 90° abduction and 90° ER position
  – 10 of 10 examined had physical contact
  – ABER view

• Paley et al., 2000
  – Published series on arthroscopic evaluation (inside GH joint) of 41 professional athletes dominant throwing shoulders
    • 41 of 41 had posterior undersurface impingement
    • 93% had undersurface fraying of rotator cuff tendons
    • 88% showed fraying of the posterior-superior glenoid
• Internal impingement typically affects:
  – Individuals involved in repetitive abducting and externally rotating arm motions or positions (i.e. throwing)
    • Baseball pitcher (most commonly)
    • Tennis, volleyball, javelin throwing, and swimming are at risk
  – Young to middle-aged adults (<40 y.o.)

• What is “Internal Impingement”?  
  – One of most frequently observed conditions in overhead throwing athlete
  – Physiological contact occurring between the posterosuperior glenoid and the greater tuberosity
    • Position of hyper-abduction and external rotation
  – Thought to cause friction and mechanical abrasion of the undersurface of the supraspinatus and infraspinatus against the anterior or posterior glenoid rim or glenoid labrum
• Literature is not clear on the exact cause-effect relationship in internal impingement
• 4 theories attempt to explain
  – Anatomic theory\textsuperscript{29,4}
  – Anterior laxity theory of instability theory\textsuperscript{30,31,32,33,34}
  – Posterior capsule tightness theory
  – Microinstability-Over rotation theory

• Anatomic theory\textsuperscript{29,4}
  – Contact between posterior rotator cuff and glenoid caused by anatomic differences in ROM, laxity, humeral retroversion, or a combination
• Anterior laxity theory of instability theory\textsuperscript{30-34}
  – Tensile stress in late cocking/early acceleration leads to gradual stretching of capsule over time leading to anterior capsule laxity
  – Anterior band of inferior glenohumeral ligament complex elongates
    • Increases anterior inferior capsule translation
  – Will allow humeral head to translate anterior during cocking phase causing impingement of RTC undersurface

• Posterior capsule tightness theory\textsuperscript{18}
  – Posterior capsule tightness causes loss of glenohumeral internal rotation and posteriosuperior humeral head translation
• Microinstability-Over rotation theory
  – Encompasses a combination of the prior theories
  – Internal impingement is a mix of several pathological entities including:
    • Partial-thickness articular sided rotator cuff tear
    • Superior labrum degeneration and tearing
  – Resulting due to capsular microinstability, excessive external rotation, and humeral retroversion

• All of these theories attempt to explain the development of internal impingement, but literature unclear.
  – Therefore internal impingement may be a combination of a group of findings
• Identifying the signs of internal impingement in overhead athlete?
  – Posterior shoulder pain when the arm is abducted to 90° with ER
    • Late cocking phase of throwing
  – Glenohumeral internal rotation deficit (GIRD) (Burkhart et al., 2003)
  – Posterior shoulder tightness (Tyler et al., 2012)
    • Posterior capsular thickening and contracture (Jobe, 1996)

• Internal impingement in the overhead athlete
  – Typically symptoms are vague
  – May report only a gradual onset of loss of velocity or control during competition
    • Often known as dead arm syndrome (Budoff et al., 2003)
• Current literature suggests that symptomatic internal impingement may result from a combination of multiple factors including (Spiegl et al., 2014):
  – Repetitive overhead activity
  – Physiological remodeling of the throwing shoulder
  – Posterior capsule contracture
  – Scapular dyskinesis
  – Fatigue

• Internal impingement is most likely caused by:
  – Fatigue of shoulder muscles from a lack of conditioning or from over-throwing (Burkhart et al., 2000)
• Internal impingement caused by fatigue:
  – As the shoulder girdle muscles become fatigued, the humerus drifts out of the scapular plane (Myers et al., 2006)
  – This has been termed hyperangulation or “opening up”
    • Leads to tensile stressing of the anterior aspect of the shoulder capsule

• Contributing factors:
  – Posterior deltoid may cause additional harm if the rotator cuff muscle are not properly functioning
    • Posterior deltoid’s angle of pull pushes the humeral head against the glenoid, accentuating the skeletal, tendinous, and labral lesions (Jobe & Pink, 1994)
• Contributing factors:
  – Presence of anterior translation of the humeral head with maximal ER at 90° of abduction
    • This has been confirmed arthroscopically during the subluxation relocation test
    • Can produce mechanical rubbing and fraying on the undersurface of the RTC tendons

• In order to understand the contributing factors, it is important to understand the phases of overhead throwing since internal impingement occurs in throwers
• A complete throw lasts less than two seconds.
• Fleisig et al., 1996 defined six phases of the throwing motion:
  – Phase I (wind-up)
  – Phase II (early cocking)
  – Phase III (late cocking)
  – Phase IV (acceleration phase)
  – Phase V (deceleration phase)
  – Phase VI (follow through)
• Phase I (wind-up)
  – The center of gravity is raised and minimal stress put on shoulder

• Phase II (early cocking)
  – The arm is abducted to 90° and prepared for maximum external rotation
• Phase III (late cocking) the shoulder is externally rotated maximally
• Elite athletes reach up to 170° of rotation. This position leads to a humeral head posterior translation
• This position will exert maximum stress on the anterior capsule

• In phase III (late cocking)
  – Ball velocity is most directly related to the amount of external rotation that the shoulder achieves
  – This position is identified as a cause of posterior shoulder pain in overhead athlete with internal impingement (Lombardo et al., 1977)
  – The first three phases take approximately 1.5 seconds
• Phase IV (acceleration phase, 0.05 seconds)
  – Highest angular velocities and largest rotational movement happens
  – Peak rotational velocity close to 7,000°/s

• Phase V (deceleration phase)
  – Most violent phase of the throwing motion
    • From ball release to the point of 0° of rotation
  – Marked eccentric contraction of rotator cuff to slow down the arm motion
  – Point of maximal posterior capsule stress
    • Joint loads approach posterior shear of 400 N, inferior shear of 300 N, and compressive forces of 1,000 N, distractive forces of up to 950 N.
  – These forces approach the ultimate tensile strengths of the soft tissues that support the shoulder
    • Scapular function major contributor to transfer the kinetic energy from lower limbs/trunk to upper extremity
• Phase VI (follow through)
  – Rebalancing phase in which the muscles return to resting levels.
• The final two phases last approximately 0.35 seconds
• Biomechanical etiology of internal impingement
  – Controversial but a possible cause reported is the theory of rotational instability
    • Describes ability of throwing shoulder to over rotate into position of hyper-external rotation during the late cocking /acceleration phase

• Causes:
  – Throwing motion places enormous stress on both dynamic and static stabilizers of shoulder
    • Repetitive forces cause adaptive soft tissue and bone changes
      – Lead in the longer term to shoulder pathologies
  – The anterior capsule to be stressed during the late cocking phase whereas the posterior capsule is widened and traumatized during the deceleration phase
• The Shoulder Capsule

Shoulder Capsular Anatomy

1. Superior Glenohumeral Ligament
2. Middle Glenohumeral Ligament
3. Anterior band of Inferior Glenohumeral Ligament
4. Inferior Glenohumeral ligament complex / Axillary Pouch
5. Posterior band of inferior glenohumeral ligament
6. Posterior capsule
7. Long head of Biceps tendon
8. Supraspinatus, Infraspinatus, Teres minor tendons
9. Subscapularis tendon
10. Glenoid

• Anterior Capsule Stress may cause:
  – Loss of integrity of the anterior capsule (Kirchhoff & Imhoff, 2010)
    • Compromised obligatory posterior rollback of humeral head
    • Leads to anterior translation and causes the undersurface of rotator cuff to contact the margin of the glenoid and labrum
• Consequence of anterior capsule stress:
  – Micro-instability with posterior capsular hypertrophy
    • Leads to increased external and decreased internal rotation
    • Increases labral strain by 160% during late cocking due to anterior instability
  – In this context the term glenohumeral internal rotation deficit (GIRD) was formed (Burkhart et al., 2006)

• Normal ROM in overhead throwers
  – 372 Pitchers PROM
    • ER=129°±10° at 90° of abduction
    • IR=61°±9° at 90° of abduction
    • Non-throwing arm: 7° less ER and 7° more IR
    • No difference in total motion (ER+IR=total motion)
    • After pitching
      – Decrease IR 10° and present 24 hours
        » Due to muscle damage from eccentrics
• Normal ROM in overhead throwers

  • Humeral retroversion
    – Asymptomatic=40˚
    – Symptomatic=24˚
    – 16˚ difference
    – Nonathlete=24˚ bilaterally
  • Measured with CT and MRI
  • \( ↑ \) retroversion is associated with \( ↑ \) external rotational ROM and \( ↓ \) internal rotation ROM
  • In development ages 12-13 have max \( ↑ \) in retroversion
    – Some IR loss

• Humeral retroversion vs Humeral Torsion

  • Humeral torsion angle is measured at the intersection of one line that evenly bisects the articular surface of the humeral head proximally, and the second being the trans-epicondylar line distally
  • Humeral retroversion is this angle measured in the opposing direction.
Exists if total arc of motion=25° × contralateral shoulder
“Total Motion Concept”=ER+IR

GIRD=Post-Inf Capsule Contracture
“Total Motion Concept”=ER+IR

Wilk et al, AJSM 2002
Ellenbecker et al, MSSE 2002
Wilk et al, JOSPT 2009
• Studies (Ruotolo et al., 2006; Myers et al., 2006) have shown that a loss of total motion correlates with a greater risk of injury in overhead athletes
  – Maintain motion over the course of a season
  – Total motion should be maintained equal to that of the nondominant shoulder by frequently performing gentle stretching
  – Caution against overaggressive stretching in an attempt to gain mobility

• GIRD in the theory of rotational instability
  – Describes first step in a developing cascade of a contracture of the posterior band of the inferior glenohumeral ligament (PIGHL) and the posteroinferior capsule
• GIRD in the theory of rotational instability
  – Biomechanically causes the central contact point of the glenohumeral joint to shift in a posterosuperior direction leading to a greater arc of external rotation before the normal contact of internal impingement
    • Lead to $\uparrow$ in pathological peel-back mechanism with $\uparrow$ vector of the biceps in the cocking position transmitting heightened shearing of the biceps anchor (leads to SLAP tears)
    • This notion is supported by several authors,
      – Report $\uparrow$ incidence of SLAP-lesions following internal impingement

• Central contact point Shift
• The amount of horizontal abduction during the late cocking phase is important!!
  – Articular portion of supraspinatus & infraspinatus tendons > contact pressure against posterior superior glenoid (Mihata et al., 2010)
    • 30°-45° of horizontal abduction
  VS
  • scapular plane at 15° of horizontal abduction

– Clinical Ramifications: important to have proper mechanics and look for overhead athletes with greater amounts of horizontal abduction (arm-lag or hyperangulation positions)

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**Table 1: Neer classifications of lesions in impingement syndrome**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Characteristics</th>
<th>Typical Age of Patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I</td>
<td>Edema/hemorrhage of bursa and cuff, reversible conservative treatment</td>
<td>&lt; 25 y.o.</td>
</tr>
<tr>
<td>Stage II</td>
<td>Irreversible changes, fibrosis and tendinitis of RTC</td>
<td>25–40 y.o.</td>
</tr>
<tr>
<td>Stage III</td>
<td>partial or complete tears of RTC and/or biceps tendon; acromion and/or AC joint pathology</td>
<td>&gt; 40 y.o.</td>
</tr>
</tbody>
</table>
Internal impingement may lead to:
- Tendinopathy
  - Tendinitis
  - Peritendinitis
  - Tendinosis
- Articular-sided partial thickness rotator cuff tears
- Posterior superior labrum lesions
- SLAP-lesions (superior labrum from anterior to posterior)
- Humeral head cystic changes

Internal impingement has also shown an association with a number of other findings including:
- Glenohumeral internal rotation deficit
- SICK scapula syndrome
- Posterior humeral head lesions
- Posterior glenoid bony injury
- Bankart and inferior glenohumeral ligament lesions
• The causes of internal impingement are obviously multifactorial and the lesions of internal impingement commonly may include:
  – Articular-sided rotator cuff tears
  – Labral lesions

• Treatment of internal impingement
  – Initially treated with conservative, non-operative methods:
    • Phase-adapted progressive physical therapy or rehabilitation
    • Strengthening the shoulder complex
    • Anti-inflammatory measures
• Treatment of internal impingement
  – **SURGICAL INTERVENTION ONLY IF:**
    • Significant structural injuries such as an acute rotator cuff tear, dislocation, or SLAP lesion
    • Indications include:
      – Failure of conservative treatment with an inability to return to competition despite a prolonged rehabilitation protocol
  – After an appropriate period of rest and relief of symptoms:
    • Throwing resumed with an interval throwing program
    • When athlete free of pain:
      – Intensity is advanced based on symptoms, or the lack thereof, with the goal of returning to effective throwing

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[CASE REPORT #1: Subjective]

– 20 y.o. male right handed college pitcher with c/o right shoulder pain only during throwing and an aching pain after in his shoulder and deltoid. He reports his pitching has suffered with decreased velocity (FB loss 10-15mph) and control. Also, he reports after he throws he feel like is arm is “dead”. He reports he is still throwing and would like to continue if possible. He reports he has been pitching more frequently at practice to work on his location and placement of his curve ball. He also reports he is prepping for a scouting showcase.

– PMHx: unremarkable
– (-) imaging
CASE REPORT #1: Objective

- Palpation: tenderness noted over posterior shoulder on supraspinatus and infraspinatus tendinous insertions
- PROM pain with R IR and ER at end ROM
- AROM in supine
  - R ER=132°*, R IR=35°
  - L ER=120°, L IR=60°
- MMT/Special tests
  - Full can and Empty Can (+) both 4/5*
  - Infraspinatus Test (+) 4/5*
  - Teres Minor 5/5*
  - Subscapularis 5/5
  - Lower Trapezius, middle trapezius 4/5
- Scapula dyskinesis noted during lowering phase of abduction on R UE
- Joint assessment: Painful posterior and superior glenohumeral glides, hypomobility noted in posterior to inferior quadrants
- (+) internal impingement sign

*=painful
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CASE REPORT #1: Assessment

- WHAT DO YOU THINK IS IMPORTANT???
- Palpation: tenderness noted over posterior shoulder on supraspinatus and infraspinatus tendinous insertions
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  • (+) internal impingement sign

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• CASE REPORT #1: Assessment
  – Internal impingement with partial thickness tearing of supraspinatus/infraspinatus
  – GIRD present
  – Fraying and damage of the labrum

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CASE REPORT #1: Treatment Main Focus

- Capsular tightness
  - Modified sleeper stretch (correct GIRD)
  - Joint mobilization in posterior-inferior directions

- Cuff damage and weakness
  - Therex initially focused on endurance progressing to strengthening (EMG based)
    - Supraspinatus
    - Infraspinatus
    - Lower and Middle trapezius
  - Eccentric supraspinatus and infraspinatus to remodel and tendon damage/degeneration along with soft tissue work

Internal Impingement in Overhead Athletes

Part II: Clinical Evaluation, Rehabilitation, and Surgery
Dr. Christian L. Coulon, PhD, PT, OCS, CSCS, Cert. MDT
• Objectives
  – Perform and accurate evaluation on Internal Impingement and its associated Pathology
  – Demonstrate clinical signs and symptoms of Internal impingement
  – Explain Treatment of pathology associated with internal impingement
  – Explain rehabilitation program for internal impingement
  – Discuss possible surgical intervention of Internal impingement

• Overhead athletes
  – Occurs during abduction & excessive external rotation
  – Late cocking Phase of pitching
  – Loss of velocity, stiffness
• Supraspinatus/Infraspinatus rubs on the posterosuperior glenoid rim and labrum
  – Fraying of RTC and labrum
  • Andrews, 1988: Tech Orthop
  • Wölch, 1991: JSES
  • Jobe et al., 1993: JSES
**Pathology associated with internal impingement**

- Tendinopathy (tendinitis, peritendinitis and tendinosis)
- Scapula dyskinesis
- Articular-sided partial thickness rotator cuff tears
- Lesions in the posterior superior labrum
- SLAP-lesions (superior labrum from anterior to posterior)

**Tendinitis or Peritendinitis**
- Active rest
- Ice, Modalities
- Iontophoresis “patch”
- NSAID
- Injection???
- MRI beneficial

- Avoidance???
- Enhance flexibility (posterior)
- Improve dynamic stability
- Gradual progression of applied loads
- Key: diminish soft tissue inflammation
• Tendinosis
  – Treatment significantly different
  – Promote tendon healing: ↑ blood flow
  – Heat and Ultrasound??
  – Stretching musculo-tendinous unit
  – NO NSAIDS
  – Eccentric muscle training
  – Transverse massage, soft tissue
  – RTC strengthening
  – Gradual increase of applied load
  – Key: stimulate healing response and collagen synthesis

• Differential diagnosis tendinitis VS tendinosis
  – Tendinitis: acute injury (<14 days ago), constant aching diffuse pain
    • Inflammation in the tendon
    • Recovery time: 2 weeks
    • Likelihood for full recovery: 99%
  – Tendinosis: duration of injury (>21 days), chronic problem, pain not constant and specific to tendon involved
    • Non-inflammatory
    • Recovery time: 6-10 weeks
    • Likelihood for full recovery: ~80%
Articular-sided partial thickness rotator cuff tears

- Success rates are better with better vascularity=bursal tear
- Tension on tear with movement=more difficult to heal
- Partial tears are more difficult to reliably detect on MRI than full thickness tears (Ellman 1987)
Lesions in the posterior superior labrum

SLAP-lesions (superior labrum from anterior to posterior)

- Early surgical intervention
• Evaluation of the Shoulder
  – Evaluate ROM, palpation, joint mobility, etc.
  – Special testing
  – Functional testing
  – Identifying a RTC tear

• 12 Essential Evaluation Elements
  – Subjective History
  – Inspection/observation
  – Palpation
  – Clearing Tests (cervical, thoracic, scapula)
  – ROM
  – Accessory joint motion
  – Laxity assessment
  – Muscle strength testing
  – Special Tests
  – Neurovascular assessment
  – Imaging
  – Functional assessment
• Subjective
  – “loss of velocity”
  – “loss of control”
  – “difficulty warming up”
  – “pain during late cocking phase”

• Research Statistical Terms
  – Sensitivity: (the *true positive rate*) measures the proportion of actual positives which are correctly identified as positive
  – Specificity: (the *true negative rate*) measures the proportion of negatives which are correctly identified as negative
  – Intertester reliability: degree which different testers can reach same result with test
  – Intratester reliability: degree which same tester can reach same result with test
Normal shoulder ROM ranges in overhead athletes (Reinold et al., 2010)

<table>
<thead>
<tr>
<th>Motion</th>
<th>ROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>ER</td>
<td>129° to 137°</td>
</tr>
<tr>
<td>IR</td>
<td>54° to 61°</td>
</tr>
<tr>
<td>total ER-IR</td>
<td>183° to 198°</td>
</tr>
<tr>
<td>dominant</td>
<td>&gt;ER, less IR</td>
</tr>
<tr>
<td>Combined total motion</td>
<td>Equal bilaterally</td>
</tr>
</tbody>
</table>

 Exists if total arc of motion=25°× contralateral shoulder
 “Total Motion Concept”=ER+IR

GIRD=Post-Inf Capsule Contracture
 “Total Motion Concept”=ER+IR

Wilk et al, AJSM 2002
Ellenbecker et al, MSSE 2002
Wilk et al, JOSPT 2009
In this author's opinion, an important finding is GIRD.

In addition, scapular dyskinesis:
- Characteristic features include a prominent inferior medial border of the scapula and the appearance of an inferiorly dropped throwing shoulder compared to the non-throwing side (Kibler, 2006).

Scapula Evaluation:
- Observe
  - During AROM abduction and flexion ~5 repetitions
- Load
  - Add 3-5 pound weight to hand and perform AROM
- Maximum Force output
  - MMT middle, lower trap, rhomboids
- Endurance
  - Wall push up
• Lateral Scapular Glide Test
  – Scapulohumeral Motion (Kibler, 1991: Contemp Orthop)
  – Quantify bilateral scapular motion
  – > 1.5cm asymmetry correlated to impingement
  – Glenoid faces up=increased movement humeral head

• Lateral Scapular Glide Test
  – Semi-dynamic test to evaluate scapular position and scapular stabilizer strength
  – 3 positions measure (cm) from inferior angle to spinous process in direct horizontal line
    • Arms at side, hands-on-hips, 90° GH abd with full IR
  – (+) greater that 1.5cm difference between sides
  – Indicates a deficit in dynamic stabilization or postural adaptations
  – Test-retest reliability (Kibler, 1998)
    • ICC=0.84 intra-tester to 0.88 inter-tester
• Supraspinatus test

• Evaluate Strength and Integrity
  – Supraspinatus
    • Empty Can and Full can
  – Infraspinatus and Teres Minor
    • Infraspinatus Muscle Test at 0 and at 90/90 Teres Minor
• During shoulder examination perform and observe:
  – Relative hypertrophy of the dominant arm versus areas of atrophy
  – Bilateral AROM and PROM
  – Test for SLAP lesions
  – Test impingement signs
    • Neer and Hawkins tests, cross-body adduction tests
  – Assessment of laxity and instability
    • The sulcus sign
  – Beighton score should be analyzed.
  – Evaluate antero-posterior translation of the humeral head the “anterior-and-posterior-drawer-test” as well as the “load-and-shift-test”
• Beighton Hypermobility Score is a simple system to quantify joint laxity and hypermobility.
  – 9 point system, higher the score = higher the laxity
  – Threshold for joint laxity in a young adult is 4-6. Score above 6 = hypermobility, but not necessarily true BENIGN JOINT HYPERMOBILITY SYNDROME (BHJS)

<table>
<thead>
<tr>
<th>Joint</th>
<th>Finding</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>left little (fifth) finger</td>
<td>passive dorsiflexion beyond 90°</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>passive dorsiflexion &lt;= 90°</td>
<td>0</td>
</tr>
<tr>
<td>right little (fifth) finger</td>
<td>passive dorsiflexion beyond 90°</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>passive dorsiflexion &lt;= 90°</td>
<td>0</td>
</tr>
<tr>
<td>left thumb</td>
<td>passive dorsiflexion to the flexor aspect of the forearm</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>cannot passively dorsiflex thumb to flexor aspect of the forearm</td>
<td>0</td>
</tr>
<tr>
<td>right thumb</td>
<td>passive dorsiflexion to the flexor aspect of the forearm</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>cannot passively dorsiflex thumb to flexor aspect of the forearm</td>
<td>0</td>
</tr>
<tr>
<td>left elbow</td>
<td>hyperextends beyond 10°</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>extends &lt;= 10</td>
<td>0</td>
</tr>
<tr>
<td>right elbow</td>
<td>hyperextends beyond 10°</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>extends &lt;= 10</td>
<td>0</td>
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<tr>
<td>left knee</td>
<td>hyperextends beyond 10°</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>extends &lt;= 10</td>
<td>0</td>
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<tr>
<td>right knee</td>
<td>hyperextends beyond 10°</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>extends &lt;= 10</td>
<td>0</td>
</tr>
<tr>
<td>forward flexion of trunk with knees full extended</td>
<td>palms and hands can rest flat on the floor</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>palms and hands cannot rest flat on the floor</td>
<td>0</td>
</tr>
</tbody>
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• DIAGNOSTIC CRITERIA FOR THE BENIGN JOINT HYPERMOBILITY SYNDROME (BJHS)

• Major Criteria
  – A Beighton score of 4/9 or greater (either currently or historically)
  – Arthralgia for longer than 3 months in 4 or more joints

• Minor Criteria
  – A Beighton score of 1, 2 or 3/9 (0, 1, 2 or 3 if aged 50+)
  – Arthralgia (> 3 months) in one to three joints or back pain (> 3 months), spondylosis, spondylolysis/spondylolisthesis.
  – Dislocation/subluxation in more than one joint, or in one joint on more than one occasion.
  – Soft tissue rheumatism. > 3 lesions (e.g. epicondylitis, tenosynovitis, bursitis).
  – Marfanoid habitus (tall, slim, span/height ratio >1.03, upper: lower segment ratio less than 0.89, arachnodactyly [positive Steinberg/wrist signs].
  – Abnormal skin: striae, hyperextensibility, thin skin, paperyaceous scarring.
  – Eye signs: drooping eyelids or myopia or antimongoloid slant.
  – Varicose veins or hernia or uterine/rectal prolapse.

• The BJHS is diagnosed in the presence two major criteria, or one major and two minor criteria, or four minor criteria. Two minor criteria will suffice where there is an unequivocally affected first-degree relative.

• BJHS is excluded by presence of Marfan or Ehlers-Danlos syndromes
During shoulder examination

- Significant controversy regarding the validity of tests for detecting SLAP tears
- Better to perform a combination of these tests
- O’Brien test,
  - Author reported 100% sensitivity, 98.5% specificity for the active compression test
    - Performed with the arm positioned in 90° forward flexion, 20° adduction, and in maximal internal rotation. Resistance creates pain in the anterior superior shoulder being relieved by resistance with maximal external rotation or supination of the forearm.
- Reproduce the throwing motion and peel-back mechanism
  - Biceps load test
  - Supinated external rotation
  - Pronated load
- 0-25% will have positive Neer or Hawkins sign (Mithöfer et al., 2004; Kirchhoff & Imhoff, 2010)
• O’Brien test: Author reported 100% sensitivity, 98.5% specificity for the active compression test
  • Performed with the arm positioned in 90° forward flexion, 20° adduction, and in maximal internal rotation. Resistance creates pain in the anterior superior shoulder being relieved by resistance with maximal external rotation or supination of the forearm.
  • (+)=pain
  • Repeat with max supination if painfree = labral pathology

• Biceps load test\(^{37}\)
  – Loads superior labrum through biceps tendon resisting flexion
  – (+) = painful = labrum tear
  – I: 90°/90° position:
    • Sensitivity 91%, specificity 97%
  – II: 120°/90° position:
    • Sensitivity 90%, specificity 97%
• Supinated external rotation\textsuperscript{36}
  – Patient supine examiner supports limb in 90° abduction, elbow flexed 60°-70°, forearm in neutral
  – Patient attempts to supinate, as examiner resists and slowly externally rotates to maximal ROM
  – (+)= anterior/deep pain, clicking, or reproduction of symptoms
  – Sensitivity 83%, specificity 82%

• Pronated load\textsuperscript{38}
  • positioned in 90° of abduction and full external rotation while the forearm is placed in full pronation
  • Once full passive external rotation is achieved
    – patient instructed to begin an active isometric contraction of his or her biceps,
    • (+) pain
      – simulate a peel-back superior labral lesion
  • sensitivity (82.8%)
  • specificity (81.8%)
• Differential Diagnosis
  – Excessive ER, Loss of IR (GIRD)
  – Look for posterior shoulder tightness
  – (+) internal impingement sign (Meister, 2000:AJSM)
    • Deep posterior shoulder pain with 90°-110° abduction, 10°-15° extension, and max ER
    • Sensitivity=75.5%; Specificity=85%
  – Posterior pain with palpation
• Focus on:
  – Proprioception in functional planes
  – Normalize ROM, strength, endurance

• Internal Impingement Sign
Radiographic evaluation of patients with internal impingement

- Include true AP, IR and ER, West Point, subacromial outlet, and Y-view radiographs of shoulder (Ferrari et al., 2004)
- Minimal findings are usually present
- Typical signs include
  - An exostosis of the posteroinferior glenoid rim (Bennett lesion)

MRI is considered the gold standard in the work-up of any young patient presenting with shoulder pain

True AP

- Humeral head position relative to glenoid; AC joint position/arthritis; RTC calcifications, acromial spurring
• West point
  – Best for osseous Bankart Lesion
  – Shoulder Instability, Glenoid Fracture

• IR
  – Visualize humeral head, better view to detect a Hill-Sachs lesion
  – Hill-Sachs lesions, Glenohumeral Arthritis, Coracoid Process Fracture, Glenoid Fracture, Proximal Humerus Fracture.
• ER
  – Glenohumeral Arthritis, Coracoid Process Fracture, Glenoid Fracture, Proximal Humerus Fracture, compression fracture of humeral head.
  – Greater tubercle of the humerus is seen

• Subacromial outlet
  – Evaluate the subacromial space and the supraspinatus outlet from lateral view
  – Assessing Subacromial Morphology, unfused acromial epiphysis
• Y-view
  – Will confirm posterior shoulder dislocation & in anterior dislocations
  – Proximal Humerus Fracture
  – Scapula Fracture

• What about MRI?
  – Used for diagnostics
  – Correlated with experience of radiologist reading the results as well as the examination quality
- **Arthroscopy - 1999**
  10 college baseball players (20 shoulders)
  - All completely Asymptomatic; No previous injury/problem; No steroid etc.
  - Thorough physical exam
  - Throwing/Non-throwing compared
  - ABER view

- **Arthroscopy – 1999**
  - 100% throwing shoulders: Internal impingement
  - 40% partial cuff pathology
  - 30% Labral Pathology
  - None of the Non-throwing shoulders had ANY signs of internal impingement
  - Significant pathology in throwing shoulder!
  - Difference!
WHAT HAPPENS TO ASYMPTOMATIC MRI FINDINGS OVER TIME?

- AJSM: 2003
- 12 pitchers + 8 tennis players (40 shoulders)
- Mean age 26 (16 y of athletic activities)
- Throwing/Non-throwing compared
- All Asymptomatic; No previous injury/problem

<table>
<thead>
<tr>
<th>5 Year F.U.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO symptoms</td>
</tr>
<tr>
<td>Same competitive level (3* professional)</td>
</tr>
</tbody>
</table>
• Take Home Message From Studies:
  – The symptomatic, non-traumatic athlete’s shoulder should be regarded primarily as a functional problem irrespective of any structural changes on MRI!
  – Use MRI as a primary indication for surgery?
  – Operate just because ”it’s possible”?

• Most Common Physical Findings:
  – Posterior glenohumeral joint line tenderness
  – AROM: Increased external rotation and decreased internal rotation
• Early treatment with mild symptoms
  – Active rest (complete break from throwing)
  – Physical therapy or rehabilitation
  – Propose a two days off-period for every day symptoms have been present (maximum break of 12 weeks) (Axe, 1987)
  – Anti-inflammatory measures
    • “Cool down” the irritated shoulder can be beneficial in accelerating the rehabilitation
    • Nonsteroidal anti-inflammatory drugs (NSAIDs)
    • Occasionally a corticosteroid injection
    • Iontophoresis
• Biomechanics after a Cuff Tear
  – Loss of Dynamic stability
    • Compress and centers humeral head
  – Increased sheer force on humeral head
  – Increased humeral head migration

• Should we rush to “Fix” the Problem:
  – The symptomatic, non-traumatic athlete’s shoulder should be regarded primarily as a functional problem irrespective of any structural changes on MRI!
  – Use MRI as a primary indication for surgery?
  – Operate just because ”it’s possible”?
• A phased progression rehabilitation program should focus on rotator cuff strengthening and scapular stabilization while emphasizing dynamic stability
  – Phase I: Acute phase
  – Phase II: Subacute phase
  – Phase III: Advanced strengthening phase
  – Phase IV: Return-to-throwing phase

• Primary goal of the rehabilitation
  – Enhance dynamic stabilization to control anterior humeral head translation
  – Restore flexibility to the posterior rotator cuff muscles
    • Careful approach warranted = aggressive stretching of the anterior and inferior glenohumeral structures may result in increased anterior translation
  – Middle trapezius and lower trapezius
  – Thrower begin the interval throwing program
• Goal of the rehabilitation = address scapula stabilizers
  – Kibler et al. presented an excellent characterization of the scapular dynamics
    • Only ½ of kinetic energy imparted to ball results from the arm and shoulder action
    • Remaining 1/2 generated by lower-limb and trunk rotation and is transferred to the upper limb through the scapulo-thoracic joint
    • This makes this articulation an important part of the kinetic chain

• Phase I: Acute phase: allow tissue to heal
  – Behavior and activity modification
    • Painfree activities only
  – ↓ pain and inflammation
    • Local therapeutic modalities
      – Ice, ultrasound, and electrical stimulation
    • Iontophoresis patch
    • Phonophoresis
    • NSAIDs
• Phase I: Acute phase
  – Restore baseline dynamic stability
  – Correct muscle imbalances
  – Restore proprioception of the shoulder
  – Correct GIRD
    • Active-assisted motion
  – Maintain or restore flexibility of internal rotation, horizontal adduction and posterior rotator cuff musculature

• Rhythmic neuromuscular training
  3 elements of this training
  • Quick
  • Rapid
  • Unpredictable
• Modified sleeper stretch
• Phase II: Intermediate phase (athlete has no pain or inflammation)
  – Intensify the strengthening program
    • isotonic strengthening to restore of the muscle balance and symmetry
  – Continue to improve flexibility
  – Facilitate neuromuscular control.
  – Stretch contributors to GIRD
    • Posterior structures, the pectoralis minor muscle, and the short head of the biceps
• Phase II: Intermediate phase (athlete has no pain or inflammation)
  – Stretching of pectoralis minor muscle, posterior inferior capsule, posterior cuff
    • McClure et al. 2007\textsuperscript{39} use of the crossbody stretch for posterior shoulder tightness
      – significantly greater increase of the internal rotation
      – compared to a control group
    • sleeper stretch
  – Strengthening of shoulder external rotator muscles, scapular retractor muscles, and protractor and depressor muscles
    • Isotonic exercise techniques are used to strengthen the scapular muscles
  – Neuromuscular control

• Phase II: Intermediate phase (athlete has no pain or inflammation)
  – Perform core-strengthening exercises
    • Abdominal and lower back musculature
  – Lower extremity strengthening
  – Running program
    • jogging and sprints
• Research has demonstrated exercises which may be more beneficial than others
• Stage of rehabilitation may contraindicate the specific exercise
  – Strengthening Progression RTC IR/ER
• Remember Progression of reps, sets, and exercises!

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• Maximally activate the supraspinatus
  – Push-up plus (99%MVIC)
  – Prone horizontal abduction at 100° abduction with ER (82%MVIC)
    • Prone full can
  – Prone ER at 90° abduction (68%MVIC)
  – Military press (80%MVIC)
  – Standing Full Can

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• Reinold, Macrina, Wilk, 2007: J Athl Train
  – EMG of supraspinatus and deltoid during 3 exercises (n=22 asymptomatic)
    • Full can, Empty can, Prone full can
  – No significant difference in supraspinatus EMG
  – Posterior Deltoid: EMG greater in prone and standing full can
    Avoid Empty Can

• Maximally activate the infraspinatus
  – SL ER at 0° abduction (85%MVIC)
  – Prone horizontal abduction at 90° abduction with ER (88%MVIC)
  – Prone horizontal abduction at 90° abduction with IR (74%MVIC)
  – Abduction above 120° with ER (74%MVIC)
  – Flexion above 120° with ER (66%MVIC)
• Maximally activate infraspinatus

• Maximally activate Supraspinatus
• Pectoral minor stretch

• Maximally activate Lower Trap
• Maximally activate Middle trap

• Maximally activate Serratus Anterior
• Phase III: Advanced strengthening phase
  – Initiate aggressive strengthening drills
  – Enhance power and endurance
    • The “thrower’s ten”
    • Perform functional drills
  – Gradually initiate throwing activities
  – Manual resistance stabilization drills
  – Plyometric drills
  – Interval throwing program

– Incorporate Functional positions
• Phase III: Advanced strengthening phase
  – Dynamic stabilization drills
    • Enhance proprioception and neuromuscular control
      – Include rhythmic stabilization exercise drills

• Phase III: Advanced strengthening phase
  – Plyometric training
    • Enhance dynamic stability, proprioception, and gradually increase functional stress on the shoulder joint
    • Plyometric exercises entail rapid transfer of eccentric to concentric contraction
      – Allows for stimulation of muscle spindles, which facilitates a recruitment of muscle fibers
• Phase III: Advanced strengthening phase
  – Interval throwing program may be initiated in this phase of rehabilitation
    • Begins with short, flat ground throwing at variable distances
    • When the throwing program
      – Start a less-intensive, high-repetition, low-weight program to avoid overtraining
        » Replaces intensive strengthening

• Phase IV: Return-to-throwing phase
  – Progression of the interval throwing program
    • neuromuscular maintenance
    • carefully monitor the thrower’s mechanics and throwing intensity
  – Position specific throwing (asymptomatic)
    • return to the full throwing velocity over the course of three months
• Phase IV: Return-to-throwing phase
  – A lack of improvement after three months or inability to return to competition within six months constitutes failure of the non-operative conservative management
    • Results in an additional diagnostic testing and, if necessary, operative intervention

• Return to sports:
  – A formal throwing mechanics evaluation may be helpful, particularly in the younger athlete with less specialized training.
  – The mature athlete with altered or poor throwing mechanics may also benefit from biomechanical and professional evaluation.
  – Once an appropriate rest period has passed and symptoms are relieved, throwing is resumed with an interval throwing program; however, the shoulder should be completely free of pain prior to resuming any throwing activities. Intensity is advanced based on symptoms, or the lack thereof, with the goal of returning to effective throwing.
• Return to sports Non-operative Treatment
  – No throwing 2-6 weeks
    • Severity/chronicity dependent

• Surgical Interventions
  – Debridement
  – Capsular Plication
  – Thermal capsular shrinkage
  – Anterior capsular shift
  – Labrum
    • I or III SLAP
    • II
• Scope Debridement of Partial thickness tear of the Infraspinatus
  – Debrided if tear less that 25%-50% depth
  – Decreases pain and mechanical symptoms
    • Fukuda, 2003, JBJS
• Considerations: Articular Surface is slow healing

• Capsular Plication
  – Used for laxity in the glenohumeral capsule
    • Can improve joint proprioception
  – Capsule is tightened using a suture then tied off at the desired tightness
Capsular Plication Rehab Considerations

- Weeks 0-2
  - Restrictive PROM
  - No excessive ER, elevation, extension
  - Submax isometrics 7-10 days (post op, NO PAIN)
  - Isotonic ER and scapular stabilizers (wk 2)
- Week 3-4
  - Stretch IR/ER at 45° abduction
    - ER to 30°, IR to touch side, AAROM flexion to 90° (>90° wk 4)
- Week 5-8
  - Stretch IR/ER at 45°/90° abduction
    - 75° ER at wk 6, 90° ER at 90° by wk 8
    - 170-180° flexion week 6-8
  - Throwers exercises (wk 5)
  - Plyometrics (wk 8)

Capsular Plication Rehab Considerations

- Weeks 12-16
  - Initiate aggressive strengthening
  - With pitcher: ER ~115°, gradual achievement
  - Throwing program (wk 16)
- Return to Contact Sports (6-8 months)
- Return to Overhead Sports (9-12 Months)
Thermal capsular shrinkage

- Arthroscopic procedure where a radiofrequency heating probe is applied to the loose ligaments and capsule of the joint
  - This will physiologically burn and tighten the tissue due to promoting scar formation
  - Capsule shrinks approximately 10% of its length

Thermal capsular shrinkage Rehab Considerations

- 4-6 weeks no stretching excessively
- 6-8 weeks no overaggressive ROM exercises
  - ↑ resting length of tissue
• Anterior capsular shift
  – Addresses instability

Illustration of the humeral-based capsular shift described by Neer and Foster. A, The capsular incision is made between the middle and inferior glenohumeral ligaments, creating superior (A) and inferior (B) capsular leaflets. B, The capsular flaps are elevated and each flap is advanced in the appropriate direction (arrows). The inferior flap is shifted first. C, The inferior (A) and superior (B) flaps are then sutured.

• Anterior capsular shift Rehab Considerations
  – Week 1-3
    • AAROM for ER/IR @ 30° abduction to tolerance
  – Week 2-4
    • AAROM ER/IR @ 45° abduction
    • Goal 45° ER/IR week 4
    • Initiate tubing IR/ER
    • Rhythmic stabilization drills
• Anterior capsular shift Rehab Considerations
  – Week 4
    • Athlete ER/IR @ 90° abduction (ortho patient wk 6)
  – Week 8
    • Full motion athlete, progressing to full throwers motion week 8-12
    • General ortho 80%-90% motion week 10
  – Return to sports
    • Week 6-9 months

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• Labrum Repairs
  – Goal in rehab is to restore/enhance dynamic stability
  – MUST know mechanism of injury
    • Compressive: fall on an outstretched arm
      – Avoid weightbearing exercises to decrease compression and shear
    • Traction injuries
      – Avoid heavy resisted or eccentric biceps contractions
    • Peel-back lesions (overhead athletes)
      – Avoid excessive shoulder external rotation

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### Labrum Tear Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Location (clock face)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>11-1</td>
<td>Labrum</td>
</tr>
<tr>
<td>II</td>
<td>11-1</td>
<td>Tear with biceps instability</td>
</tr>
<tr>
<td>IIIA</td>
<td>11-3</td>
<td>Tear with biceps instability - associated with overhead motion - similar to Type X</td>
</tr>
<tr>
<td>IIIB</td>
<td>9-11</td>
<td>Tear with biceps instability - associated with infraspinatus tear</td>
</tr>
<tr>
<td>IIIC</td>
<td>9-3</td>
<td>Tear with biceps instability - associated with infraspinatus tear</td>
</tr>
<tr>
<td>III</td>
<td>11-1</td>
<td>Bucket-handle tear with intact biceps</td>
</tr>
<tr>
<td>IV</td>
<td>11-1</td>
<td>Bucket-handle tear with biceps extension</td>
</tr>
<tr>
<td>V</td>
<td>11-5</td>
<td>Bankart lesion with superior extension, or SLAP with anterior inferior extension</td>
</tr>
<tr>
<td>VI</td>
<td>11-1</td>
<td>Anterior or posterior flap tear with tear of the bucket-handle component</td>
</tr>
<tr>
<td>VII</td>
<td>11-3</td>
<td>Middle glenohumeral ligament extension</td>
</tr>
<tr>
<td>VIII</td>
<td>7-1</td>
<td>Similar to IIIB, but more extensive - associated with acute posterior dislocation</td>
</tr>
<tr>
<td>IX</td>
<td>7-5</td>
<td>Globally abnormal labrum - likely post traumatic</td>
</tr>
<tr>
<td>X</td>
<td>11-1+</td>
<td>Rotator interval extension</td>
</tr>
</tbody>
</table>

### Labrum Repair (I or III)

- Labrum Repair (I or III)
• Labrum Repair (I or III)
  – Debridement, more aggressive rehab program due to stable biceps anchor
    • Concomitant injuries will play a role
  – Sling 3-4 days
  – AAROM/PROM immediately post op; Full ROM 10-14 days post-op
  – 1 week
    • Submax isometrics
  – 2 week
    • Light isotonics shoulder and scapula
    • Light biceps (too heavy will cause debridement irritation)

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• Labrum Repair (II)
  – More anchors means a larger repair
  – Protect biceps anchor and no biceps isotonics for 8 weeks
  – No aggressive strengthening 12 wk
  – No weight bearing 8 wk
    • Helps avoid compression/shearing

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• Labrum Repair (II) Rehab Considerations
  – Shoulder immobilized first 4 weeks
  – Gradual ROM in protective range for 4 weeks below 90° to avoid labrum stress
  – Submax isometrics immediately post-op
  – Week 1-2
    • IR/ER ROM scapular plane to 10°-15° ER and 45° IR
      – Cautious ER to ↓ labral stress through peel-back mechanism
  – Week 4
    • IR/ER at 90° abduction and flexion above 90°
    • IR/ER tubing

• Labrum Repair (II) Rehab Considerations
  – Week 8-12
    • Full ROM
    • Full can, prone row, prone horizontal abduction
    • Full isotonic program
    • Plyometrics week 10-12
  – Week 12
    • Can begin aggressive strengthening of biceps
  – Return to play 9-12 months
• Return to throwing
  – Variations
    • Mirror throwing
    • Frequency
    • Count throws
    • Intervals
    • Adapt to other sports

• Return to Play Throwing Program
  – Rate of Progression
    • Close supervision is essential & each athlete will progress at his own rate.
    • If any pain felt in shoulder or elbow=throwing should be stopped until pain free
      – Not allowed to progress to the next phase unless complete the previous phase pain free
  – Warm Up and Stretching
    • Begin each session with jogging followed by stretching for full body
  – Mechanics
    • ball thrown just hard enough to reach the target
• Return to Play Throwing Program
• Sample Progression
  – Begin with warm up and stretching
  – 5 minutes of easy warm up throwing at 30 feet
  – gradually move back to the prescribed distance (1 throw every 10 feet)
  – throw 2 days in a row or every other day
  – Rest any day persistent soreness or pain in shoulder or elbow
  – Once at >90 ft return to 60 ft
    • last 5 minutes of throwing (pitcher)
    • (extra practice at locating your throws and hitting targets)

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17 Day Return to Play Throwing Program Flat ground

<table>
<thead>
<tr>
<th>DAY</th>
<th>DISTANCE</th>
<th>TIME</th>
<th>THROWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>Throw 45 ft</td>
<td>10 minutes</td>
<td>35</td>
</tr>
<tr>
<td>Day 3</td>
<td>Throw 45 ft</td>
<td>15 minutes</td>
<td>45</td>
</tr>
<tr>
<td>Day 5</td>
<td>Throw 60 ft</td>
<td>15 minutes</td>
<td>35</td>
</tr>
<tr>
<td>Day 7</td>
<td>Throw 60 ft</td>
<td>15-20 minutes</td>
<td>45</td>
</tr>
<tr>
<td>Day 9</td>
<td>Throw 90 ft</td>
<td>15 minutes</td>
<td>35</td>
</tr>
<tr>
<td>Day 11</td>
<td>Throw 90 ft</td>
<td>15-20 minutes</td>
<td>35</td>
</tr>
<tr>
<td>Day 13</td>
<td>Throw 120 ft</td>
<td>15 minutes</td>
<td>45</td>
</tr>
<tr>
<td>Day 15</td>
<td>Throw 120 ft</td>
<td>15-20 minutes</td>
<td>35</td>
</tr>
<tr>
<td>Day 17</td>
<td>Begin making throws from position or begin mound routine (next page) at 50% effort.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Even Days REST!

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• Mound Progression or position specific position drills (After able to throw 120 feet for 15-20 minutes without pain)
  • Pitchers begin throwing fastballs only at 50% effort from the mound
  • If not old enough to throw curve then substitute with change up
  • Position players may throw in drills starting at 50% effort.
  • Use interval throwing to 120 feet as warm up

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<table>
<thead>
<tr>
<th>DAY</th>
<th>DISTANCE</th>
<th>THROWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>Interval throwing to 120 feet as warm up</td>
<td>50% FB only – 25 throws</td>
</tr>
<tr>
<td>Day 3</td>
<td>Interval throwing to 120 feet as warm up</td>
<td>50% FB only – 35 throws</td>
</tr>
<tr>
<td>Day 5</td>
<td>Interval throwing to 120 feet as warm up</td>
<td>75% FB only – 35 throws</td>
</tr>
<tr>
<td>Day 7</td>
<td>Interval throwing to 120 feet as warm up</td>
<td>75% FB only – 50 throws</td>
</tr>
<tr>
<td>Day 9</td>
<td>Interval throwing to 120 feet as warm up</td>
<td>75% FB – 40 throws; 50% BB – 20 throws</td>
</tr>
<tr>
<td>Day 11</td>
<td>Interval throwing to 120 feet as warm up</td>
<td>90% FB – 30 throws; 75% BB – 20 throws</td>
</tr>
<tr>
<td>Day 13</td>
<td>Interval throwing to 120 feet as warm up</td>
<td>95% FB – 30 throws; 95% BB – 20 throws</td>
</tr>
<tr>
<td>Day 15 &amp; 16</td>
<td>Simulated Game – 2-3 innings (10 minutes interval throwing to 90 feet)</td>
<td></td>
</tr>
<tr>
<td>Day 17 &amp; 18</td>
<td>Simulated Game – 2-3 innings (5-10 minutes interval throwing to 90 feet)</td>
<td></td>
</tr>
<tr>
<td>Day 20 &amp; 21</td>
<td>Live scrimmage (5-10 minutes interval throwing to 90 feet)</td>
<td></td>
</tr>
<tr>
<td>Day 23</td>
<td>Released for competition</td>
<td></td>
</tr>
</tbody>
</table>