

[Sports Physical Therapy]



Current Concepts in the Evaluation and Treatment of the Shoulder in Overhead-Throwing Athletes, Part 1: Physical Characteristics and Clinical Examination

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The overhead-throwing athlete is a challenging sports medicine patient. The repetitive microtraumatic stresses imposed on the athlete's shoulder joint complex during the throwing motion constantly places the athlete at risk for injury. These stresses may effect several adaptations to normal shoulder range of motion, strength, and scapula position. The clinician should therefore appreciate the unique physical characteristics of the overhead-throwing athlete to accurately evaluate and treat throwing-related injuries.

Keywords: glenohumeral joint; scapula; baseball

The overhead-throwing athlete is a unique and complicated sports medicine patient. The repetitive microtraumatic stresses placed on the athlete's shoulder joint complex during the throwing motion challenges the physiologic limits of the surrounding tissues. During the overhead-throwing motion, the athlete places excessive stresses on the shoulder at the end range of motion, with tremendous angular velocities. Fleisig et al^{28,29} reported the angular velocity of the overhead throw reaches over 7000 degrees per second, which is the fastest recorded human movement. This motion results in high forces being generated at the shoulder joint, where the dynamic and static stabilizing structures of the shoulder are vulnerable.^{28,29} Fleisig et al²⁸ also reported anterior forces up to 1 times body weight during external rotation (ER; late cocking) and up to 1.5 times body weight during the follow-through phase (distracting the joint). These forces are likely similar for other overhead-throwing athletes, such as football quarterbacks, softball players, and tennis players.

Consequently, the preventative care and treatment of these athletes are challenging. Injury may occur because of muscle fatigue, muscle weakness, strength imbalances, loss of motion, soft tissue flexibility, alterations in throwing mechanics, and

poor static stability. Because the overhead-throwing athlete is unique, the knowledge of the normal physical characteristics, biomechanics, and pathomechanisms of throwing-related injuries is imperative to accurately assess and treat potential injuries.

CLINICAL EXAMINATION

The overhead-throwing athlete exhibits several different physical characteristics—specifically, shoulder range of motion, scapular position, laxity, strength, and proprioception (Table 1). These characteristics must be understood to accurately assess what is a normal physical adaptation rather than pathology.

History

A thorough history of the patient's complaints, mechanism of injury, and chronicity of symptoms is advantageous and can often lead the clinician to the appropriate examination process. The injured overhead-throwing athlete generally presents with pain, agitated by throwing and subsiding with inactivity; the athlete also tends to be asymptomatic during all activi-

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Table 1. The physical characteristics of the shoulder in the asymptomatic overhead-throwing athlete.^a

Examination Component	Specific Measurement	Normative Value
Range of motion	External rotation at 90° abduction Internal rotation at 90° abduction Total motion	129°-137° (7°-9° > than ND) ^{18,70,89} 54°-61° (7°-9° < than ND) ^{18,70,89} 183°-198° (bilaterally equal) ^{18,70,89}
Joint laxity	Sulcus sign Anterior translation Posterior translation	61% of pitchers, positive sulcus ¹⁰ 2.8 mm (bilaterally equal) ^{11,12} 5.4 mm (bilaterally equal) ^{11,12}
Resting scapula position	Upward rotation Anterior tilt Protraction	6° on D ^{73,79,80} 20° on D ^{73,79,80} 39° on D ^{73,79,80}
Muscular strength	External rotation Internal rotation Abduction Adduction Scapular retraction Scapular protraction Scapular elevation Scapular depression	0%-14% < on D ^{58,69,84,86} 3%-9% > on D ^{58,69,84,86} Bilaterally equal ^{58,69,84,86} 10%-30% > on D ^{58,69,84,86} 0%-3% > on D ^{58,92} 0% to -4% < on D ^{58,92} Bilaterally equal ^{58,92} 22% > on D ^{58,92}
Proprioception	Joint reposition sense	-2° error < on D ^{2,81,82,b}

^aND, nondominant extremity; D, dominant extremity.

^bJoint reposition sense decreased by 2° of error.

ties other than overhead throwing. Injuries may occur through acute mechanisms in which the athlete attributes the onset of the symptoms to a specific throw. Throwing injuries are typically the result of chronic, repetitive throwing. Patients often report a gradual onset, with no history of an acute episode of injury. It can be helpful to ask what phase of the throw elicits the most symptoms.

Symptoms may initially be subtle and may not alter the patient's performance. As the symptoms progress, the patient may complain that his or her shoulder is "difficult to warm up" or "get loose" during sport participation, with vague discomfort in the shoulder throughout the throwing motion. There is often a loss of throwing velocity and a lack of command while pitching, which becomes more notable as symptoms worsen. The chronicity of symptoms often establishes the severity of the injury, and the repetitive nature of these athletic activities often results in a gradual progression of pathology and a decline in performance. A player's injury history, pitch counts in recent games, and number of innings pitched in previous years will give an indication of recent workloads and fatigue levels.

As symptoms progress, the patient can often localize the source and timing of discomfort. However, symptoms are typically vague and diffuse, likely because of a combination of pathologies that are present in the throwing shoulder. The positions that are most provocative in overhead throwers are the fully externally rotated cocked position and the ball release

position (Figure 1). These positions correlate to phases of the throwing motion when stresses on the shoulder are highest.²⁸

Palpation of the entire shoulder girdle may also elicit symptoms and help differentiate involved structures. The postero-superior glenohumeral joint line, subacromial space, greater tuberosity, and acromioclavicular joint and tendon of the long head of the biceps should be palpated for tenderness. For acromioclavicular disorders or bicipital tendonitis, the subjective examination and palpation may be enough to diagnose the pathology.

Range of Motion

One of the most distinguishing characteristics of overhead-throwing athletes is glenohumeral range of motion. Most athletes exhibit excessive ER and decreased internal rotation (IR) at 90° of abduction in the throwing shoulder.^{10,13,43,70,89} This has been shown in baseball players^{70,89} and tennis players^{25,26} during passive motion^{70,89} and active motion.^{25,26} Meister et al⁵⁵ also found this adaptation in adolescent baseball players, noting that the loss of IR was gradual but most dramatic between the ages of 13 and 14 years old.

Wilk et al⁸⁹ reported passive range of motion characteristics of the shoulder in 372 professional baseball players: 129° ± 10° of ER and 61° ± 9° of IR in the throwing shoulder at 90° abduction. ER was an average of 7° greater, and IR an average of 7° less, in the dominant arm when compared to the nondominant

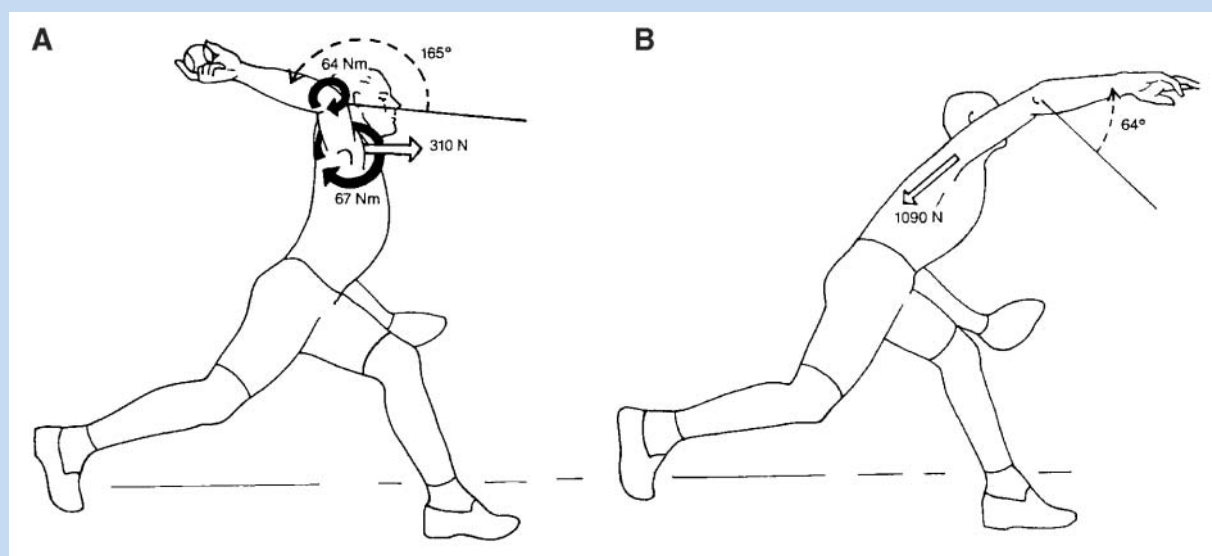


Figure 1. The 2 critical instances of potential injury during the throwing motion: A, the moment of full arm cocking when the shoulder reaches maximal external rotation. During this moment, 67 N-m of internal rotation torque and 310 N of anterior force are applied to the shoulder. B, the moment of ball release as the shoulder begins to decelerate. Forces at this moment include 1090 N of compressive force at the shoulder joint to prevent subluxation. (From Fleisig GS, Dillman CJ, Andrews JR. Kinetics of baseball pitching with implications about injury mechanisms. *Am J Sports Med.* 1995;23:233-239.)

arm. Thus, total rotation range of motion at 90° of abduction is bilaterally equal in asymptomatic overhead throwers (Figure 2).

The cause of this adaptation has not been established. Numerous theories regarding the altered range of motion pattern observed in overhead-throwing athletes have been reported.[†] Several authors have documented humeral osseous retroversion in the thrower's shoulder and attribute the altered range of motion to bony adaptations.^{18,63,67} Others have theorized that excessive ER and limited IR are due to anterior capsular laxity and posterior capsule tightness,¹⁵ although no clinical studies have confirmed these findings to date.

The theory of posterior capsular tightness has come into question from other researchers who have determined that range of motion in baseball pitchers—specifically, a loss of IR—does not correlate with an alteration in posterior glenohumeral translation.^{11,12} Borsa et al¹² studied glenohumeral translation in a series of 43 asymptomatic professional baseball pitchers. The authors reported that posterior translation was twice that of anterior translation. There was also no difference in the amount of translation between the dominant shoulder and the nondominant shoulder. The authors were unable to show a correlation between a loss of IR range of motion and posterior laxity.

Reinold et al⁷⁰ recently examined the passive range of motion of the shoulder in 31 professional baseball pitchers, before and immediately after pitching. The researchers reported that rotational range of glenohumeral motion is immediately affected by

overhead throwing. Mean IR range of motion after pitching significantly decreased ($73^\circ \pm 16^\circ$ before, $65^\circ \pm 11^\circ$ after) and total rotation motion decreased (average, 9°). Mean ER before throwing ($133^\circ \pm 11^\circ$) did not significantly change after throwing ($131^\circ \pm 10^\circ$). The researchers hypothesized that this decrease in IR range of motion is due to large eccentric forces being generated in the external rotators (particularly, the infraspinatus and teres minor) during the follow-through phase of throwing. The authors attribute the acute loss of motion to microscopic muscle damage due to eccentric contractions of the posterior shoulder musculature. Eccentric muscular contractions have been correlated to a rise in passive muscular tension and a loss of joint range of motion.⁶⁶ Anecdotally, baseball players often describe generalized tightness in the musculature of their posterior shoulder after pitching. The muscles responsible for ER of the shoulder exhibit high eccentric muscle activity^{31,32,41,42,75} during the throwing motion as the shoulder internally rotates between 6000 and 7000 degrees per second.^{23,28,64} Yanagisawa et al⁹³ showed long-lasting T2 elevations on magnetic resonance imaging of the supraspinatus, infraspinatus, and teres minor following baseball pitching. The authors attributed these findings to muscle damage that resulted from eccentric muscle contractions. Previous studies examining the effect of repetitive eccentric contractions have shown a subsequent loss of joint range of motion in the upper and lower extremities following testing.^{38,65,71}

The observed range of motion adaptations are likely due to osseous adaptations in the humeral physes of young athlete's throwing shoulder.^{55,68,70} In addition, throwing itself results in

[†]References 10-12, 15, 18, 55, 59, 63, 67, 70, 89.

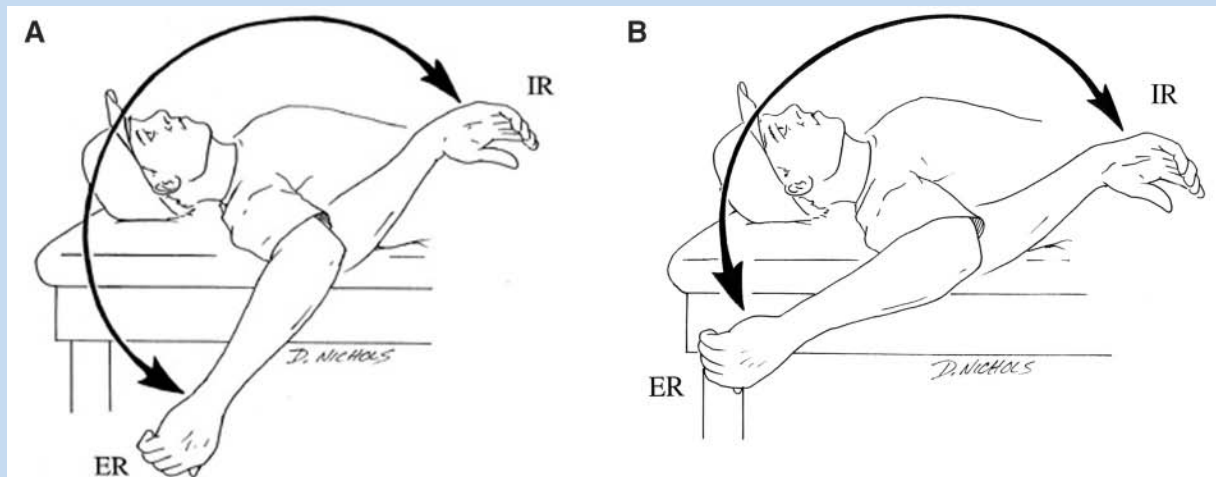


Figure 2. The total motion concept: The dominant shoulder (A) of overhead-throwing athletes exhibits a greater external rotation (ER) and lesser internal rotation (IR), compared to the nondominant shoulder (B). However, the total motion (external and internal rotation) is equal bilaterally.

an acute loss of IR motion, most likely attributed to muscular tightness of the posterior shoulder muscles from the high levels of eccentric contraction while the arm decelerates.⁷⁰

An evaluation (unpublished data, 2008) of shoulder range of motion before and after the competitive season in 20 professional baseball pitchers was conducted. The season consisted of 2 months of spring training and 6 months of the competitive season, with pitchers averaging 122 innings. Over the course of the season, these pitchers performed a daily stretching program designed to maintain their range of motion, but they avoided stretching and mobilizing their posterior capsule. The stretching program was performed daily with 3 to 5 repetitions of 10 seconds in shoulder flexion, ER and IR at 90° abduction, and cross-body horizontal adduction. At the season end, there was no change in passive IR motion. Based on these results, a loss of IR may be a consequence of the eccentric nature of throwing, and a stretching program may help prevent loss of IR. Shoulder ER increased an average of almost 5° over the course of the season, despite the avoidance of aggressive ER stretching. Total rotation motion also increased by 5° in the throwing shoulder, which may be explained by the repetitive attenuation of the anterior capsule and other structures of the shoulder over the course of a season.⁴⁰

When evaluating range of glenohumeral motion, standard goniometric measurements of active and passive motion should be performed for all planes of movement. Total rotation motion should be calculated and compared to the nondominant shoulder at 90°. Reinold et al⁷⁰ found that goniometric measurements of passive ER and IR at 90° of abduction were reliable in overhead-throwing athletes (intratester reliability intraclass correlation coefficients were .81 and .87). However, bilateral comparisons of ER and IR are not useful.

If the total rotation motion decreases on the throwing side, careful measurements of range of motion should be made to determine if IR has been lost. A loss of IR with a hard end-point may represent other pathologies, such as a thrower's exostosis²⁷ (ie, calcification of the posteroinferior glenohumeral capsular attachment due to chronic traction stress). If total motion increases, the status of the static stabilizers should be assessed.

Joint Laxity

The excessive motion observed in overhead-throwing athletes is commonly attributed to an increase in glenohumeral laxity.^{53,68,89} This increased motion may represent excessive ER due to anterior capsular laxity.⁴⁰ Excessive laxity may be the result of repetitive throwing (acquired laxity)⁶⁸ or congenital laxity.¹⁰

Bigliani et al¹⁰ reported laxity measurements in 72 professional baseball pitchers and 76 positional players. Sixty-one percent of pitchers and 47% of positional players exhibited a positive sulcus sign, indicating laxity of the superior glenohumeral ligament. This laxity was present bilaterally, suggesting a congenital origin.

Borsa et al^{11,12} recently assessed anterior and posterior capsular laxity in professional baseball pitchers using an objective mechanical translation device and reported that posterior capsular laxity was significantly greater than anterior capsular laxity despite gross limitations of passive or active IR. The participant in this study who had the least IR range of motion had the greatest amount of posterior translation. Total translation (anterior and posterior) was equal bilaterally, indicating that the throwing shoulder was not more lax than the nonthrowing shoulder.

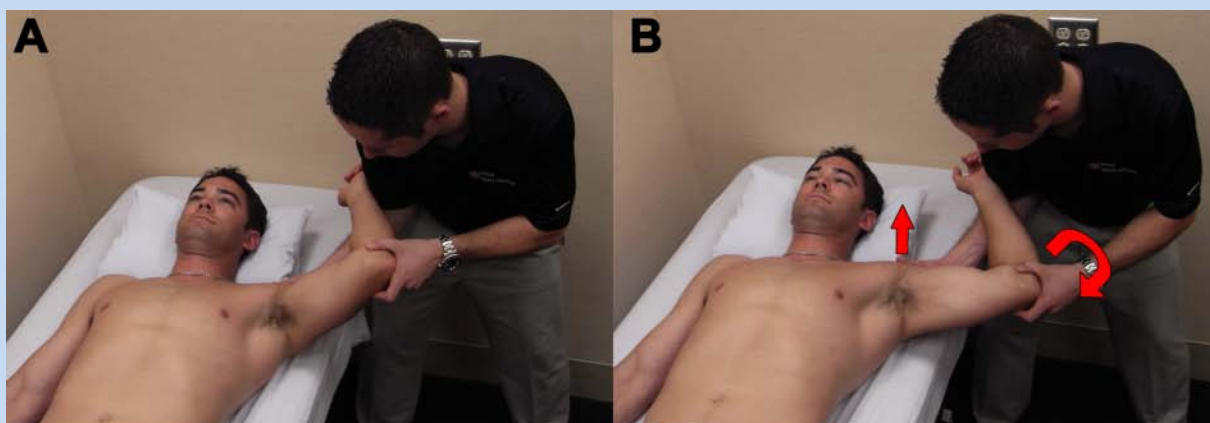


Figure 3. The anterior fulcrum test for anterior shoulder laxity and instability: A, the shoulder is positioned in approximately 90° of abduction and external rotation; B, as the arm is brought into horizontal abduction, an anterior force is applied to the glenohumeral joint in a fulcrum maneuver. The examiner notes the amount of translation and end feel in comparison to the opposite extremity.⁸⁵

Assessing Laxity

The overhead-throwing athlete has acquired laxity from throwing that is often superimposed on underlying congenital laxity.^{68,89} To assess shoulder laxity, the clinician should begin with an exam for generalized joint laxity: hyperextension of the elbow, knee, fifth finger, apposition of the thumb, and trunk flexion.⁸ For the shoulder, a sulcus test is performed at 0° of abduction. In this position, inferior translation is resisted by the superior glenohumeral ligament. Excessive mobility is thought to indicate generalized glenohumeral hypermobility.^{90,91}

Next, assessment of glenohumeral translation is performed with standard anterior drawer,³⁰ anterior fulcrum (Figure 3),⁸⁵ posterior drawer,³⁰ and posterior fulcrums⁸⁵ at 0°, 45°, and 90° of abduction to assess all aspects of the glenohumeral ligament complex. Another important test to perform is the Lachman test of the shoulder (Figure 4).⁵ The shoulder is abducted overhead to approximately 120° to 135° of abduction and full ER and then translated anteriorly. The examiner notes the amount of humeral translation as well as the end-point of translation, in comparison to the nondominant shoulder. In this position, the integrity of the inferior glenohumeral ligament and anterior-inferior capsule is tested. The anterior drawer and fulcrum maneuvers can be repeated at 45° of abduction (to test the middle glenohumeral ligament) and in adduction (to assess the superior glenohumeral ligament). Special tests for gross instability, such as the apprehension/relocation sign,³⁹ should be performed to assess the integrity of the static stabilizing structures. It is not uncommon for an overhead-throwing athlete to have a capsulolabral defect from chronic microtrauma.

The anterior Lachman and anterior fulcrum tests are 2 of the most important tests to perform because they assess the anterior stabilizing structures of the shoulder in the full ER position,

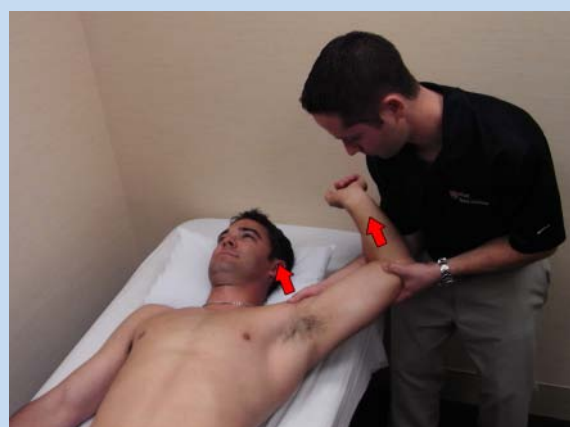


Figure 4. The anterior Lachman test for anterior shoulder laxity and instability: The shoulder is positioned in approximately 120° to 135° of abduction and external rotation. The proximal and distal aspects of the shoulder are translated anteriorly. The examiner notes the amount of translation and end feel in comparison to the opposite extremity.⁵

similar to the vulnerable maximal arm-cocking position during throwing. The apprehension test is an essential part of the anterior stability examination.

Scapular Position

Evaluation of scapular position is an important component of the clinical examination of the overhead-throwing athlete. Past reports have documented alterations in resting scapula position



Figure 5. Clinical measurements of anterior/posterior tilt (A) and upward/downward rotation (B) of the scapula using a digital inclinometer, which is placed along the medial border (to measure tilt) and along the spine of the scapula (to measure rotation).

in symptomatic patients, which may contribute to some shoulder pathologies.¹⁶ The combination of scapular depression, anterior tilt, and protraction may contribute to shoulder pathology.¹⁶

Bastan et al⁷ reported that the asymptomatic thrower's scapula is more protracted and anteriorly tilted at rest, compared to the nonthrowing side. Seitz et al⁷³ confirmed these findings in a study using an electromagnetic tracking system that measured scapular position in 41 asymptomatic professional baseball pitchers. Results indicated that in asymptomatic pitchers, the scapula rests in 6° of superior rotation, 20° of anterior tilting, and 39° of protraction.

These studies dispute the clinical impression that a protracted and anteriorly tilted scapular position is indicative of pathology. Macrina et al⁵⁰ noted that the scapular is more protracted after throwing than before. A protracted scapular position may be a normal adaptation to throwing, which, if untreated, may progressively increase over the course of a season. This scapular positioning may be similar to the humeral adaption of IR.

This adaptive scapular position may alter scapular and glenohumeral range of motion and strength. An increase in anterior tilt of the scapula correlated with an increase in glenohumeral IR in the dominant shoulder of 98 asymptomatic professional baseball pitchers.⁸⁰ A protracted, anterior-tilted scapula also correlated to a significant decrease in serratus anterior and lower trapezius strength in asymptomatic baseball pitchers.⁷⁹

Just as overhead-throwing athletes have adaptations in glenohumeral motion, asymptomatic baseball pitchers have an adaptive depressed, anteriorly tilted, and protracted scapula (Tables 1 and 2).^{71,75-77} Measuring scapular position using a digital inclinometer (Figure 5) allows comparisons to normative data.^{73,78-}

⁸⁰ Testing can be performed with the arm in various degrees of shoulder abduction and rotation to assess scapular position. The superomedial border of the scapula should be palpated

during abduction to detect "snapping scapular syndrome" associated with scapulothoracic bursitis.⁵¹

Muscular Strength

Several investigators have examined muscle strength parameters in the overhead-throwing athlete.[‡] Isokinetic testing on professional baseball pitchers' throwing shoulders during spring training showed ER peak torque at an average of 6% lower ($P < .05$) than that of the nonthrowing shoulders at 90° of abduction.^{84,86} IR peak torque of the throwing shoulder was 3% higher on average ($P < .05$) than that of the nonthrowing shoulder. The mean optimal ratio between ER and IR peak torque at 90° of abduction during isokinetic testing was between 66% and 75%. Adduction torque of the throwing shoulder was 14% greater than that of the nonthrowing shoulder.

The muscle strength profiles of professional baseball pitchers using a handheld dynamometer have been studied (unpublished data, 2009). A 7% dominant-side increase in IR force and a slight decrease in ER and abduction force (1% to 2% each) was seen before the competitive baseball season.⁸⁶ Over the course of the 8-month season (2 months of preseason and 6 months of competition), a 3% to 4% decrease in force in all planes of motion was seen. Abduction force decreased by 16% at the midpoint of the season and 21% by the end of the season. All players participated in a shoulder injury prevention program designed to minimize loss of strength over the course of a season. These results suggest that although testing of the rotator cuff did not significantly change, the loss of abduction strength may be related to rotator cuff fatigue. Fatigue may result in an inability of the rotator cuff to center and stabilize the glenohumeral joint, potentially resulting in subacromial impingement.

[‡]References 1, 6, 13, 17, 19, 36, 84, 88.

Table 2. The effects of acute and chronic throwing on the physical characteristics of the shoulder in the asymptomatic overhead-throwing athlete.^a

Examination Component: Measurement	Normative Value		
	Before Throwing	Immediately After Throwing	Over the Course of a Season
Range of motion			
External rotation	137° ⁷⁰	No change ⁷⁰	Increase of 5° ⁷⁰
Internal rotation	54° ⁷⁰	45° ⁷⁰	No change ⁷⁰
Total motion	191° ⁷⁰	180° ⁷⁰	Increase of 5° ⁷⁰
Muscular strength			
External rotation	0%-14% < on D ^{58,69,84,86}	-11% ⁴⁴	-3% to -4%
Internal rotation	3%-9% > on D ^{58,69,84,86}	-18% ⁴⁴	-3% to -4%
Full can	Bilaterally equal ^{58,69,84,86}	-6% ⁴⁴	-3% to -4%
Abduction	Bilaterally equal ^{58,69,84,86}	-12% ⁴⁴	-16% to -21%
Adduction	10%-30% > on D ^{58,69,84,86}	-11% ⁴⁴	-3% to -4%
Scapular retraction	0%-3% > on D ⁹²	-4% ⁴⁴	
Scapular posterior tilt	0%-3% > on D ⁹²	-4% ⁴⁴	
Resting scapular position			
Upward rotation	6° ^{73,79,80}	No change ⁵⁰	
Anterior tilt	20° ^{73,79,80}	No change ⁵⁰	
Protraction	39° ^{73,79,80}	8% ⁵⁰	
Proprioception			
Joint reposition sense	-2° error ^{2,81,82,b}	-4° error ^{82,c}	

^aD, dominant extremity.

^bJoint reposition sense decreased by 2° of error.

^cJoint reposition sense decreased by 4° of error.

In another study, ER and IR force at 0° and 90° of abduction was compared in 23 professional baseball pitchers using a handheld dynamometer.⁶⁹ A decrease in ER and IR force of approximately 20% was noted at 90° of abduction, indicating that the 90° abducted position may be better suited for manual strength testing.

Strength of the scapular muscles also plays a vital role during overhead throwing.²² When compared to positional players, professional pitchers and catchers have exhibited significantly greater force during scapular protraction and elevation.⁹²

Manual muscle testing with a handheld dynamometer is used for ER and IR at 0° and 90° of coronal plane abduction and scapular plane elevation (full can) for the shoulder. Elevation, posterior tilt, protraction, and retraction are tested for the scapula. A handheld dynamometer is valuable for detecting subtle differences that are often present in overhead-throwing athletes and that may be missed with manual muscle testing. The adaptations that occur from repetitive throwing preclude the meaningful use of bilateral comparisons (Table 2).

The timing of the strength examination must be considered when assessing results. Pitchers often have profound weakness on manual strength testing for 2 days following a start, as well as at the end of the season, presumably due to cuff fatigue.

Proprioception

The overhead thrower relies on enhanced proprioception to dynamically stabilize the glenohumeral joint in the presence of capsular laxity and excessive range of motion.^{20,24,29,68,87,89}

One study tested shoulder proprioception in 20 healthy overhead-throwing athletes by joint repositioning.² The dominant shoulder exhibited diminished proprioception and improved proprioception toward end range of motion.⁷² Proprioception significantly decreased after throwing to fatigue, although deficits returned to normal within 10 minutes after throwing.⁸¹

To assess proprioception one can use repositioning in several patterns of movement (Figure 6). For example, ER can be tested with the athlete's eyes closed. The athlete assumes the supine position, and the shoulder is abducted to 90°. The athlete's shoulder is passively rotated to a point within his or her ER range, and it is held for 3 to 5 seconds before returning to the starting position. The athlete is then instructed to reproduce the previous position, and the difference between the 2 angles is calculated as the error. This measurement is repeated at various points within the range of motion, with an emphasis toward end range, where

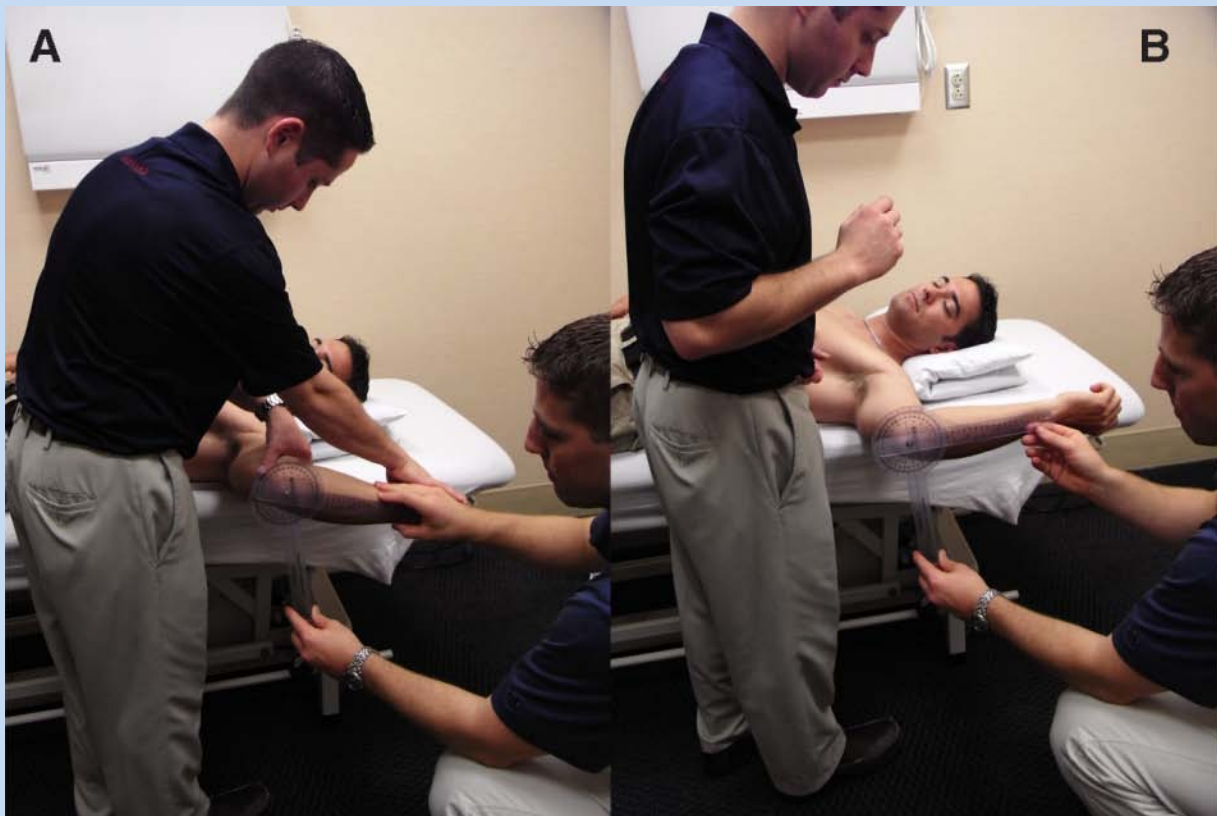


Figure 6. Clinical assessment of joint repositioning skill: A, with the patient's eyes closed, the examiner passively brings the joint to a point within the patient's available range of motion. This position is measured and documented, and the joint is brought back to the starting position. B, the patient is instructed to attempt to reproduce the precise position. Measurements are taken and compared to the original measurement to determine the degree of error.

proprioception is arguably most important. This measurement technique can also be used for shoulder flexion, abduction, proprioceptive neuromuscular facilitation diagonal patterns, and scapula position.

Testing for Rotator Cuff Injuries

Injuries to the rotator cuff can range from tendonitis to a full-thickness tear. Progressive degeneration can occur in athletes with poor strength and poor injury prevention. Young athletes often present with inflammation from overuse, with poor muscle strength, and with a stability imbalance between the rotator cuff and scapula. Experience suggests that over the course of a season or career, this degeneration may result in partial-thickness undersurface tearing. If untreated, full-thickness rotator cuff tears can develop.³ Internal impingement of the supraspinatus and infraspinatus on the posterosuperior aspect of the glenoid rim during abduction and ER may cause pain in the thrower.⁸³ The rotator cuff is active in resisting glenohumeral subluxation and decelerating the arm. Patients with internal impingement often respond to

conservative treatment. If the pathology progresses, vague discomfort along the deltoid insertion is common, especially in older athletes.

Examination should include the Neer⁶¹ and Hawkins³⁴ impingement tests to detect subacromial inflammation. The empty can test can be used to evaluate the athlete's tolerance of overload to the supraspinatus.

Meister et al⁵⁴ described an internal impingement sign. With the athlete supine, the arm is abducted to 90° and maximally externally rotated. This maneuver compresses the posterosuperior rotator cuff tendons against the posterosuperior glenoid rim. The athlete will often report a vague "deep discomfort"; the test is considered positive if posterior humeral translation causes a decrease in symptoms (Figure 7). The fact that this relocation test is indicative of internal impingement lends credibility to the theory that anterior capsular laxity/microinstability is a likely contributing factor to internal impingement. In a series of 69 athletes, Meister et al⁵⁴ reported a sensitivity of 95% and a specificity of 100% in detecting articular-side rotator cuff pathology using an apprehension-relocation test.

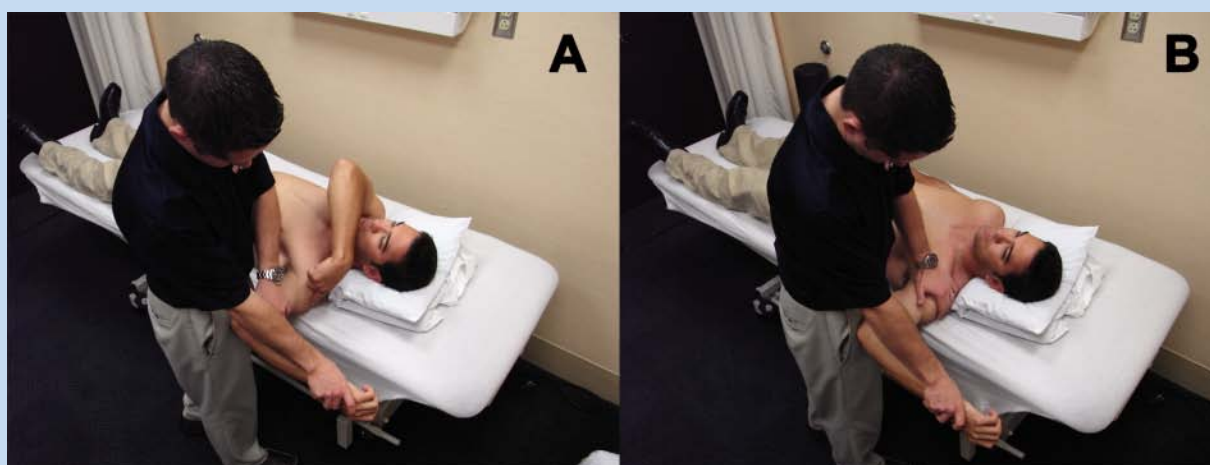


Figure 7. The internal impingement sign: A, the shoulder is positioned in 90° of abduction and full external rotation. In this position, a patient with internal impingement will complain of posterosuperior shoulder pain. B, the examiner may then place a posteriorly directed force on the anterior aspect of the glenohumeral joint to relocate the humeral head within the glenoid fossa. The patient will report a reduction of symptoms in this position.⁵⁴

Detecting full-thickness rotator cuff tears based on the athlete's strength alone is difficult. The majority of overhead-throwing athletes with full-thickness rotator cuff tears will present with pain in the lateral aspect of their shoulders, weakness in empty can testing, and positive impingement signs. They usually do not present with drop arm³⁷ or lag signs.³⁵

Superior Labral Injuries

Superior labral (SLAP) lesions can be difficult to detect because of the presence of concomitant pathology. Andrews et al⁴ reported that 45% of patients (73% of baseball pitchers) with SLAP lesions had concomitant partial-thickness tears of the supraspinatus. Mileski and Snyder⁵⁶ reported that 29% of their patients with SLAP lesions exhibited partial-thickness tears, 11% had complete cuff tears, and 22% had Bankart lesions. Kim et al⁴⁸ prospectively analyzed SLAP lesions in 139 cases and found that type I is typically associated with rotator cuff pathology whereas type III and IV are associated with traumatic instability. With type II SLAP lesions, older patients tend to have associated rotator cuff pathology, and younger patients are more likely to have instability. Labral pathologies may result from repetitive overuse but can also result from a single traumatic event, such as a fall onto the outstretched arm, sudden traction, or a blow to the shoulder.

Special tests have been described to detect labral pathology, including active compression,⁶² compression-rotation (or grind),⁷⁶ Speed's,⁷⁶ dynamic Speed's,⁹¹ clunk,⁴ crank,⁴⁹ anterior slide,⁴⁵ biceps load,⁴⁷ biceps load II,⁴⁶ pronated load,⁹¹ pain provocation,⁵⁷ and resisted supination ER.⁶⁰

Dessaur and Magarey²¹ and Jones and Galluch⁴⁴ reviewed and noted that the majority of studies reporting highly accurate

tests for SLAP lesions were of low quality and were not supported by other researchers.^{52,77}

The discrepancy in accurately testing for SLAP lesions may be due to the difficulty in comparing patient populations. The testing for SLAP lesions in the overhead-throwing athlete should attempt to reproduce the peel-back mechanism.⁹¹ As the shoulder externally rotates in the abducted position, torsion occurs at the insertion of the long head of the biceps into the labrum—peeling back the superior portion.¹⁴ Tests that mimic the peel-back mechanism^{14,74} include biceps load,⁴⁷ biceps load II,⁴⁶ pronated load,⁹¹ pain provocation,⁵⁷ and resisted supination ER.⁶⁰ Tests that do not re-create this mechanism may produce false negatives.⁶² The presence of deep and diffuse glenohumeral joint pain is most indicative of the presence of a SLAP lesion. Posterior symptoms may be indicative of rotator cuff strain. The active compression test is useful to localize pain and to establish a starting point for specific SLAP testing.

Two new tests to detect SLAP lesions include the pronated load⁹¹ test and the resisted supination ER test.⁶⁰ For the pronated load test, the athlete assumes the supine position with the shoulder abducted to 90° and externally rotated. The forearm is then fully pronated to increase tension on the biceps and the labral attachment. When maximal ER is achieved, a resisted isometric contraction of the biceps is used to simulate the peel-back mechanism (Figure 8). This test combines active biceps contraction^{46,47,57} with the passive ER in the pronated position.

For the resisted supination ER test (Figure 9), the patient is positioned in 90° of shoulder abduction, 65° to 70° of elbow flexion, and neutral forearm rotation.⁶⁰ Maximal active supination is resisted while passively externally rotating the

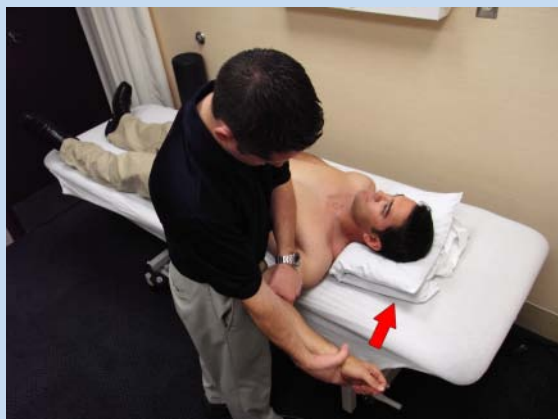


Figure 8. The pronated load test for superior labral lesions: The shoulder is positioned in 90° of abduction and full external rotation while the forearm is placed in full pronation. Once full passive external rotation is achieved, the patient is instructed to begin an active isometric contraction of his or her biceps, in an attempt to simulate a peel-back superior labral lesion.⁹¹

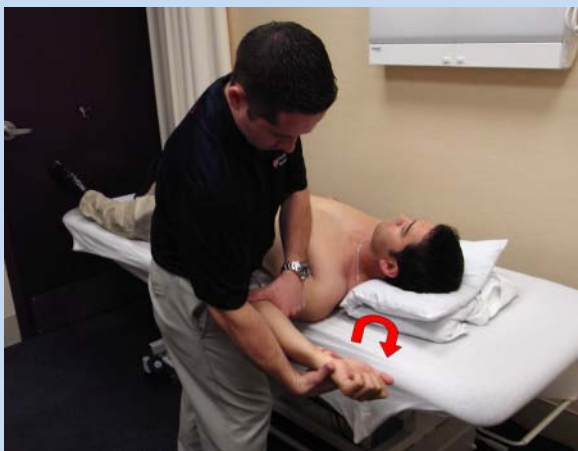


Figure 9. The resisted supination external rotation test for superior labral lesions: The shoulder is placed in 90° abduction and full passive external rotation. The elbow is flexed to approximately 65°. As the shoulder reaches full passive external rotation, the patient is instructed to begin an active contraction against resistance into forearm supination, in an attempt to simulate a peel-back superior labral lesion.⁶⁰

shoulder. This test simulates the peel-back mechanism of SLAP injuries by placing maximal tension on the long head of the biceps.⁶⁰ A preliminary study of 40 patients revealed sensitivity (82.8%), specificity (81.8%), positive predictive

value (92.3%), negative predictive value (64.3%), and diagnostic accuracy (82.5%).⁶⁰

IMAGING

Basic examination includes standard radiographs for the overhead-throwing athlete: the West Point, axillary, Stryker notch, and IR/ER views in the true anteroposterior plane of the shoulder (Grashey views).

Magnetic resonance arthrography may also be performed to provide further detail of the soft tissue structures; it is the imaging technique of choice for suspected rotator cuff tears, SLAP lesions, and capsular disruptions.

The diagnostic accuracy of magnetic resonance imaging for SLAP lesions is unclear,^{33,72} and definitive diagnosis may require arthroscopy. Bencardino et al⁹ retrospectively reviewed preoperative magnetic resonance arthrography following shoulder arthroscopy, reporting sensitivity (89%), specificity (91%), and accuracy (90%; 47 of 52 patients) in detecting SLAP lesions.

CLINICAL IMPLICATIONS

The physical characteristics (Table 1) of the overhead-throwing athlete are important factors to consider during a physical examination. Acute and chronic adaptations may occur following throwing and over the course of a competitive season (Table 2) that are not necessarily pathologic.

CONCLUSION

The overhead-throwing athlete presents with several normal anatomical adaptations that make the physical examination challenging. Adaptations of range of motion, strength, and scapular position are common and not necessarily pathologic.

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