THE DIAGNOSIS AND TREATMENT OF SHOULDER INJURIES IN THE THROWING ATHLETE

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ABSTRACT

Objective: To discuss the general diagnostic and therapeutic considerations involved in managing patients with shoulder injury.

Data Sources: Medline search going back 10 years, and using the key terms "throwing" and "shoulder injuries."

Data Synthesis: Papers which evaluated current treatment protocols as determined by previously published papers in peer reviewed journals or textbooks that had no confounding variables were examined.

Results: The throwing motion is a complex maneuver which requires coordination of a variety of structures. Depending upon the specific kind of injury, rehabilitation may involve numerous different approaches. A 4-phase rehabilitation program is described.

Conclusion: Synthesis of the literature regarding management of throwing injuries is described. (J Chiropr Med 2002;1:23-30)

KEY WORDS: Shoulder Injury; Athlete; Rehabilitation; Scapula; Biomechanics

INTRODUCTION

Shoulder pain and dysfunction are common complaints among overhead throwing athletes. Competitive athletes who use overhead motions, particularly baseball players, place tremendous repetitive stresses on their shoulders (1). Although overuse of the throwing shoulder can promote a significant injury, many difficulties begin with improper mechanics and poor conditioning.

Understanding the basic biomechanics of the throwing motion is vital to the determination of an accurate diagnosis and the formation of a successful treatment plan by the treating physician. The throwing motion is an extremely complex function, combining both translational and rotational movements (2). The overhand

throwing motion occurs in 6 phases. From a mechanical perspective, the goal of the motion is to sequentially develop a package of potential energy that is then converted to kinetic energy that can be conveyed to the ball in an efficient and fluid manner (3). Phase I, the wind-up, is the readying phase during which the body's overall center of gravity is raised with minimal stress placed on the shoulder. At the end of this phase, the shoulder is in minimal internal rotation and slight abduction, with minimal muscular activity occurring (3). Phase II, early cocking, is a minimal load phase. The initiation of this phase is marked by early activation of the deltoid muscles and late activation of the supraspinatus, infraspinatus, and teres minor muscles (3). Phase III, late cocking, begins with the planting of the striding leg and ends with the shoulder in a position of maximum external rotation (170° to 180°). Deltoid muscle firing decreases, and supraspinatus, infraspinatus, and teres minor muscle activity reaches its peak in the midpoint of this phase (3).

In the terminal point of this phase, the subscapularis is facilitated as the torso begins to rotate forward and there is activity of the pectoralis major, latissimus dorsi, and serratus anterior muscles in order to create maximum horizontal adduction and internal rotation of the arm (3). Foot plant is the most important motion in the cocking phase. It serves as a fulcrum to maintain body balance and maximum throwing hand acceleration (2). Phase IV, acceleration, consists of internal rotation of the humerus to the ball release point. The triceps muscle has marked activity early and the pectoralis major, latissimus dorsi, and serratus anterior muscles are facilitated late in this phase (3). Phase V, deceleration, begins at the ball release and ends with the termination of humeral rotation. It is recognized as the most violent phase of the throwing cycle. It is responsible for the dissipation of the remaining kinetic energy that is not transmitted to the ball. A violent contraction of all muscle groups occurs, with eccentric contraction essential to slow down arm rotation (3). Finally, phase VI, the follow-through, is the re-balancing phase where the body moves forward with the arm until motion stops. Muscle firing returns to resting levels, and joint loads decrease (3).

The scapula also has a major role in the throwing motion. The scapula's role in throwing involves the facilitation

tation of normal physiology and biomechanics necessary for the restoration of optimal shoulder mechanics and function (4). Normal scapular function is necessary for the throwing athlete for several reasons. First, it provides a stable base for the glenohumeral articulation, reducing the stress to the shoulder capsule. Second, it is involved in retraction and protraction motions seen throughout the throwing motion. Third, it plays a role in the acromial elevation that coincides with arm abduction. Finally, the scapula maintains the proper length-tension relationship of the glenohumeral muscles, allowing them to perform efficiently and reduce the chance of overuse (5).

Shoulder pain is a common complaint in the throwing athlete, and successful treatment can only begin with an accurate diagnosis. This, in turn, comes from a thorough understanding of the pertinent anatomy, the basic biomechanics of the throwing motion, and the correct interpretation of pathology determined through history, physical exam, and diagnostic studies (6). The goals of treatment should focus on the elimination of pain, restoration of motion, correction of strength deficits, and the restoration of normal coherent muscle activity (7). Many studies have suggested that the throwing athlete should initially be treated with a non-operative, conservative treatment approach (4–15). The objective of this literature review is to examine the proper diagnostic methods and conservative treatment protocols for shoulder injuries in the throwing athlete.

DISCUSSION

Review of the Literature

The glenohumeral joint is a multiaxial ball and socket joint that allows an extensive range of motion. The glenohumeral joint consists of the articulation of the spherical humeral head articulation with the shallow glenoid cavity of the scapula. The glenoid cavity is deepened slightly by a fibrocartilaginous structure called the glenoid labrum. The glenohumeral joint capsule begins at the border of the labrum, and is anchored onto the bone of the glenoid neck (16). The superior portion of the capsule transgresses on the base of the coracoid process so that it encloses the attachment of the long head of the biceps muscle within the joint. The capsule is attached medially to the glenoid cavity. Laterally, the fibrous capsule attaches to the anatomical neck of the humerus. The inferior portion of the capsule is its weakest area (17).

Within the glenohumeral joint, mobility is gained at the cost of stability. The strength and stability of the glenohumeral joint results mainly from the action of a group

of muscles called the rotator cuff. The rotator cuff, consisting of the supraspinatus, infraspinatus, teres minor, and subscapularis muscles, attaches the humerus to the scapula and operates as a cohesive unit in order to hold the humeral head into the glenoid cavity (17).

There are also several bursa that contain synovial fluid within the glenohumeral joint. The subscapular bursa is located between the tendon of the subscapularis muscle and the neck of the scapula. This bursa protects the subscapularis tendon at the area where it passes under the coracoid process and over the neck of the scapula. The subacromial bursa lies between the deltoid muscle, the supraspinatus tendon, and the fibrous capsule of the glenohumeral joint.

This bursa acts as a barrier between the deltoid muscle, fibrous capsule of the shoulder joint, and the supraspinatus tendon (17). The inherent ligaments of the shoulder are thick sections of the fibrous capsule and help provide stability to the glenohumeral joint. The glenohumeral ligaments are sections of the anterior portion of the fibrous capsule. The superior, middle, and inferior glenohumeral ligaments travel from the supraglenoid tubercle of the scapula to the lesser tubercle and the anatomical neck of the humerus. The transverse humeral ligament is a band of fibers that passes from the greater tubercle to the lesser tubercle of the humerus. It forms a platform over the superior end of the intertubercular groove and transforms it into a canal that holds the tendon of the long head of the biceps. The coracohumeral ligament strengthens the superior part of the glenohumeral joint capsule. It travels from the lateral side of the base of the coracoid process of the scapula to the anatomical neck of the humerus. The coracoacromial ligament is a triangular ligament that attaches to the lateral border of the coracoid process and inserts into the acromion (17).

The arteries to the glenohumeral joint consist of branches of the anterior and posterior circumflex humeral arteries that originate from the axillary artery, and branches of the suprascapular artery that originates from the subclavian artery. The nerves throughout the glenohumeral joint consist of branches of the suprascapular, axillary, and lateral pectoral nerves (17).

Shoulder injuries in the throwing athlete may result from the chronic repetitive micro-trauma associated with the throwing motion. The chronic repetitive microtrauma associated with the throwing motion may cause rotational inflexibilities, muscle strength imbalances, and changes in biomechanical function, which may predispose the throwing athlete to muscles tears, and ligamentous damage (8).

Shoulder instability is a common complaint among throwing athletes. Stability is achieved through joint compression, coordinated contraction of the rotator cuff muscles, and glenohumeral ligament integrity (18). Anterior instability of the glenohumeral joint is commonly seen in throwing athletes. Over time, secondary to poor mechanics in the late cocking phase, overthrowing, or weakness, the anterior capsule undergoes increasing loads unshielded by equal contributions of the surrounding musculature (3). The anterior capsule then fatigues and breaks down, resulting in increased anterior laxity of the glenohumeral joint. The failure of the anterior capsule may progress to induce an increased anterior translation in the most stressful phases of the throwing motion. Manifestations of this increased laxity include secondary rotator cuff tendinitis, subacromial impingement, superior labrum/anterior and posterior (SLAP) lesions, and posterior glenohumeral impingement (3). It is important to identify instability of the glenohumeral joint because the microtrauma of throwing, coupled with increased laxity, puts the throwing athlete at risk for developing damage to the intra- and periarticular structures of the glenohumeral joint (8).

Posterior instability of the shoulder may also occur in the throwing athlete. This condition results from excessive posterior humeral translation on the glenoid leading to possible dislocation or subluxation (11). Capsular ligamentous tissues, muscle forces, and the rotational position of the arm influence resistance to posterior humeral translation (11). Of interest, complete incision of the posterior capsule allows for posterior subluxation. However, dislocation does not occur until the anterior capsule is incised through the rotator interval (11).

A study performed by Paley et al (19) confirmed that impingement of the rotator cuff undersurface does indeed occur in overhand throwing athletes with shoulder pain. Of interest, the study suggested that the development of posterior internal impingement could be attributed to anterior shoulder instability. The study theorizes that the mechanism of such an injury is based on the anterior translation of the humeral head in the glenoid motion due to repetitive microtrauma to the anterior dynamic stabilizers of the shoulder during the late cocking phase of throwing. This anterior translation of the humeral head, with the shoulder abducted and maximally externally rotated, can result in impingement of the rotator cuff undersurface against the posterior glenoid rim.

Nerve entrapment may also occur in the throwing athlete. For example, the throwing athlete may develop posterior shoulder pain and isolated infraspinatus

muscle weakness secondary to entrapment of the distal suprascapular nerve. The most frequent site for nerve injury is at the suprascapular notch, as the nerve travels under the superior transverse scapular ligament (20). Possible mechanisms of injury include traction, direct trauma, or compression from a ganglion cyst. The true incidence of this injury is unknown; however, it appears to be more common in athletes who participate in sports involving overhead activities (20).

Successful treatment of a throwing athlete's shoulder is predicated on the ability to make an accurate diagnosis. Therefore, any intervention is preceded by a thorough work-up, including a complete medical history, physical examination, routine diagnostic imaging, and an isokinetic profile and evaluation of throwing mechanics (7).

The first important step involves taking the patient's clinical history. A detailed history is always essential and should include eliciting any exacerbating activities (reaching overhead, reaching behind the back, or throwing), duration of symptoms, history of trauma, and neurological complaints (6). The most common complaints associated with shoulder pathology include pain, muscle weakness, instability, stiffness, deformity, locking, and swelling (21). Pain needs to be carefully evaluated in terms of its site, radiation, quality, onset, frequency, nocturnal occurrence, aggravating factors, and relieving factors. Pain due to rotator cuff pathology and impingement is usually felt over the anterolateral aspect of the shoulder (21). Radiation of pain down the arm, aggravation by overhead activities, and associated nocturnal disturbances are also commonly reported complaints. Pain that is associated with the late cocking or acceleration phase of throwing is most likely due to mild anterior instability (22). Also, shoulder pain that is exacerbated with progressive activity is usually associated with rotator cuff tendinitis or subacromial bursitis (22). Pain due to acromioclavicular joint pathology is usually well localized to the region of the joint, and there is often associated trauma to this region (21).

The physical examination must be thorough in order to exclude other intrinsic and extrinsic causes of shoulder pain. The main focus of the physical examination should be directed toward reproducing the athlete's symptoms (11). A systemic approach to a proper shoulder examination includes inspection, palpation, range of motion, strength testing, and neurological testing. Of importance, the cervical spine should also be evaluated because cervical pathology can refer pain to the shoulder region. Functional disorders in the cervical and cervicothoracic spine can contribute to shoulder complaints by the existence of a functional relationship

between the shoulder girdle and the structures around the glenohumeral joint (23). Visual inspection should focus on shoulder asymmetry due to muscular hypertonicity or atrophy, and bone deformity. Bone deformities usually occur as a result of trauma. Muscle atrophy can be attributed to rotator cuff tears presenting as the end stage of impingement, or neurologic conditions such as suprascapular nerve entrapment or C5/C6 radiculopathy (6). However, some degree of hypertrophy is often seen in the athlete's dominant throwing arm. Deformity, swelling, and asymmetry anteriorly may represent sternoclavicular, clavicular, or acromioclavicular pathology (21). From the posterior view, the position and attitude of the scapula should be noted. Winging of the scapula usually suggests underlying scapulothoracic dysfunction and may be associated with shoulder instability, muscle imbalance, or muscle fatigue and not necessarily secondary to long thoracic nerve injury (21).

Palpation must also be systematic and focus on specific anatomical structures. Careful palpation about the shoulder not only provides additional clues to the diagnosis, but may direct therapeutic modalities to areas of injury or inflammation (22). Palpation of the shoulder should include assessment of the sternoclavicular and acromioclavicular joints, the clavicle, the acromion, the anterior and posterior joint lines, the biceps tendon, and the supraspinatus tendon. Various conditions associated with palpable tenderness include acromioclavicular joint tenderness that might indicate acromioclavicular synovitis or osteoarthritis; subacromial space tenderness that might indicate subacromial bursitis, rotator cuff impingement, or a rotator cuff tear; and intertubercular tenderness that might indicate biceps tendinitis or subluxation (22).

Range of motion should be determined both actively and passively and compared with the contralateral side. In evaluating the range of motion, it is important to note when the patient's symptoms are reproduced. For example, impingement classically causes a painful arc of elevation between 60 and 120°, as the rotator cuff tendons are compressed against the anterior acromion and coracoacromial ligament (21). Compressive forces across the acromioclavicular occur mainly in the terminal 60° of abduction, and this often causes pain during this range if pathology exists at this joint (21). Of note, an increase in external rotation and mild loss of internal rotation have been observed, particularly in overhead athletes. Bigliani, et al (1) studied 148 professional baseball players with no history of shoulder problems to assess range of motion and laxity of their dominant and non-dominant shoulders. The study showed that the average external rotation with the arm in 90° of abduc-

tion was statistically greater than the average internal rotation in the players' dominant shoulder. Thus, the dominant shoulders of overhead athletes tend to have an altered arc of glenohumeral motion in the throwing position, with relatively more external rotation and less internal rotation than their non-dominant shoulders.

Muscle testing should be performed with the aim of specifically isolating certain muscles such as the rotator cuff muscles and deltoid. Isokinetic evaluation, if it is available and if tolerated by the athlete, can be used as a routine method of strength testing (7). Observed weakness noted on selective testing of the biceps muscle, rotator cuff, or scapular rotators may be an indication of underlying tendinitis, muscle strain, tear, or even nerve impairment (22). Siorta, et al (24) compared the isokinetic eccentric muscular performance characteristics of the external and internal rotator muscles in the shoulders of 25 professional baseball pitchers. The study suggests that eccentric strength was significantly greater than concentric strength for all muscle groups tested.

Neurovascular assessment of the upper extremities includes palpation of the peripheral pulses, motor, reflex, and sensory examination of cervical roots C5-T1, auscultation for subclavian bruits, nail bed perfusion, and Roo's elevated arm stress test. Neurovascular examination of the cervical spine is also performed at this stage of the examination. This includes cervical spine ranges of motion and cervical compression testing in the most provocative position allowable by the patient's range of motion (15).

The use of diagnostic imaging may also aid in obtaining an accurate diagnosis. Initial evaluation includes radiographic studies of the involved shoulder and cervical spine, which serve to screen for osseous or calcified structures, but rarely demonstrate soft tissue pathology (25). Radiographs should be obtained in acute injuries to rule out any traumatic injury or instability and can also be considered when no progress has been made with 3–6 months of conservative care. Radiographs of the shoulder should include a true AP view (Grashey), a lateral scapular view, and an axillary lateral view (11). Additional studies such as MRI, ultrasound, arthrogram, and CT may also assist the physician in defining pathology and initiating a modified treatment plan. MRI has been shown to be an effective tool for identifying partial or full-thickness rotator cuff tears or even edema and degeneration within the tendon (26).

Many studies have suggested that the initial course of management for shoulder injury in the throwing athlete should be non-operative (4–9,11–13,22,24). With

the exception of treatment in the acute dislocation in the dominant shoulder of a throwing athlete, the initial course of treatment for shoulder injury should be conservative (7). A general rehabilitation program should be initiated with the overall progression focused on eliminating pain, restoring motion, correcting strength deficits, restoring normal synchronous muscle activity, and returning the athlete to an optimal level of function (7).

During the initial phase of rehabilitation, the main goal should be to reduce symptoms. Strategies to decrease pain and inflammation include relative rest of involved area, cryotherapy, ultrasound, electric stimulation, and phonophoresis (5). Stretching within a pain-free range may also be initiated immediately to avoid possible contracture of the posterior rotator cuff or posterior capsule (5). Examples of stretching exercises include Codman's exercises and "wall walking" exercises.

The kinetic chain needs to be initiated early in the rehabilitation process in order to restore optimal shoulder function and shoulder strength. Most of the shoulder's motions observed in the throwing action work off a kinetic chain linkage from the ground through the trunk. Inflexibilities, weaknesses, or imbalances of the hamstrings and corresponding musculature of the hip and trunk, as well as any subclinical adaptations of stance patterns or gait pattern should be corrected before starting formal strength rehabilitation (8). Examples of these exercises include use of gymballs, agility drills with running and jumping, jumping jacks, and mini-trampoline exercises for coordinating extensor activity of the hips, trunks, and shoulder. Integration of the scapular retraction muscles to the lower extremity kinetic chain via specific coordinated exercises is very important because these actions tend to be coupled in the cocking phases of throwing (8).

The next phase of rehabilitation should focus on scapular stabilization. As already stated, the scapula's motion and position create the parameters that allow normal physiology and biomechanics of the shoulder to occur. Specific scapular rehabilitation activities can be divided into scapular stability exercises, closed-chain exercises, and open chain exercises. Scapular stability exercises involve isometric exercises such as the scapular pinch and scapular shrug exercises (4). Closed chain activities are incorporated into the rehabilitation program in order to reorganize and reestablish normal muscle firing patterns for the scapula. Such exercises involve patterns of scapular retraction and protraction in single planes, followed by the progression to scapular elevation and depression (8). Open chain activities may be initiated after the athlete

has mastered the above mentioned isometric and closed chain exercises. Open chain exercises are more strenuous exercises that aid the injured muscles in returning to more normal physiologic function. Examples of open chain exercises include vigorous proprioceptive neuromuscular facilitation patterns, external rotation and retraction exercises, and plyometric exercises (4).

The next phase of rehabilitation focuses on the introduction of closed chain exercises of the rotator cuff. Closed chain activity emphasizes normal physiologic patterns of co-contractions of the scapular stabilizing muscles and the rotator cuff, and stimulates the normal proprioceptive pathways that exist in the throwing motion (8). Overall, these exercises are vital for the restoration of the stable scapular base and early rotator cuff strength that are needed for the progression to open chain activities. Examples of such exercises include the above mentioned scapular stabilization exercises, and "clock" exercises in which the hand is moved to the various positions on the clock face, which results in glenohumeral joint compression with contraction into the joint exercises (8).

Plyometric exercises are essential to any shoulder rehabilitation program. These open chain exercises develop the athlete's ability to generate power and involve a stretch-shortening cycle in which the muscle is eccentrically stretched and slowly loaded (8). It is important to note that since these exercises develop a large amount of strain on the shoulder, these exercises should be done only when complete anatomic healing has occurred. Examples of plyometric exercises include the use of rubber tubing, medicine balls, and "wall" pushup exercises (5).

Finally a sound shoulder rehabilitation program should include open chain exercises that focus on the restoration of rotator cuff strength. The rotator cuff's actions throughout the throwing motion primarily focus on maintaining the humeral head in the glenoid socket. When training these muscles, they should be rehabilitated as an integrated unit, rather than as individual muscles (8). Examples of pertinent exercises include free weight training when applicable.

Once the athlete has successfully completed their prescribed rehabilitation program, a decision to return to throwing must also be carefully evaluated. Each player should be progressed in distance and volume on an individual basis. The primary goal is to build arm strength without creating re-injury (5). It is important to note that a conservative treatment program for shoulder injuries in the overhead athlete may not al-

ways work. Specific surgical indications include a psychologically stable patient, who, after a 4–6 month period, has failed a non-operative program (11). Acute cases of instability in the dominant shoulder of a throwing athlete should be referred for surgical intervention (7). Surgical treatment, when indicated, attempts to correct the underlying instability by repairing any associated tissues. For example, surgical intervention may be used to tighten the joint capsular and ligamentous structures in order to stabilize the shoulder. Once any surgery is deemed successful, a proper shoulder rehabilitation program should be initiated. Cases of chronic instability also may be managed with the above mentioned rehabilitation program (8).

This review was accomplished by utilizing the public search engine Medline at the URL address <http://www.ncbi.nlm.nih.gov/entrez/query.fcgi>. The review search concentrated on studies performed within the last ten years. The search terms used included “throwing,” and “shoulder injuries.” The retrieved studies were investigated carefully and those that focused on the objective of this review of literature were obtained via interlibrary loans. Inclusion criteria used in this process included papers which evaluated currently accepted treatment protocols determined by previously published textbooks and papers in peer reviewed journals, and the absence of confounding variables within the studies.

Using the search term “throwing,” 257 studies were found. The addition of the search term “shoulder injuries” resulted in 488 studies. When these two search terms were combined, 210 studies were found. After reviewing the titles of the selected studies, the search was narrowed to 145 studies. The abstracts of the remaining studies were reviewed and the search was further narrowed to 87 studies. Each study was then thoroughly reviewed and the final literature count was narrowed to 34.

Competitive athletes who use overhead motions, particularly baseball players, place tremendous repetitive stresses on their shoulders. The throwing athlete, especially baseball pitchers who throw with high frequency and velocity at the extremes of motion, are prone to injury and dysfunction of the shoulder (1). Shoulder pain and dysfunction are common complaints among overhead throwing athletes. Although overuse of the throwing shoulder can contribute significantly to injury, many difficulties may also begin with improper mechanics and poor conditioning (7). Injuries from throwing can occur to any of a number of structures contributing to the dynamic or static restraint of the shoulder

(3). Accurate diagnosis and successful treatment of the various conditions that are unique to the throwing athlete requires a thorough understanding of the pertinent anatomy, the basic biomechanics of the throwing motion, and the relationship of mobility and stability of the shoulder joint.

The throwing motion is an extremely complex function. It requires coordination of the pelvis and trunk, strength and endurance of the lower extremities, and an appropriate balance of stability and flexibility of the capsular structures of the shoulder (1). The complex interaction of strength and flexibility required in the throwing motion has been demonstrated through the studies of Meister (3), Halder et al (16) and Qingyun et al (2). In addition, other studies have investigated the roles of excessive motion, capsular laxity, and limited flexibility of the shoulder as possible etiologic factors in impingement syndrome and glenohumeral instability in the throwing population (1,3,6,7,11–13,15,18,19,22,26).

Evaluation and treatment of the thrower’s pathologic shoulder has been aided by recent publications in the literature. Of importance, with the exception of treatment of an acute anterior dislocation in the dominant shoulder of a throwing athlete, the initial course of management for shoulder injury should be non-operative (4–9,11–13,22,24). For example, rehabilitation of an unstable shoulder should focus on the strengthening of the dynamic stabilizers and the periscapular musculature (1,3,6,7,11,12,18,22). Also, a rehabilitation program for impingement syndrome should focus on strengthening the humeral head depressors (subscapularis, infraspinatus, and teres minor), scapular balancing muscles (upper and lower trapezius, serratus anterior, and rhomboids), and the prime humeral positioners (deltoid, pectoralis major, and latissimus dorsi) (6,13,15,19,26). A proper non-operative management protocol should focus on eliminating pain, restoring motion, correcting strength deficits, and restoring normal muscle activity (7). Also, the success of treatment should be measured by the ability to return to pre-injury levels of function (6).

Our review performed a critical analysis of the papers that focused on diagnostic criteria and treatment protocols. This analysis revealed a discrepancy among the studies in terms of research protocols. The analysis was performed with an emphasis on the inclusion of proper randomization of the studied population, use of a control group, size of the studied population, and the use of double-blinded studies to eliminate examiner and/or patient bias.

Bigliani et al (1) studied 148 professional baseball players with no history of shoulder problems to assess range of motion and laxity of their dominant and non-dominant shoulders. This study was performed exquisitely and discussed a very important element of shoulder laxity. The study used a large population group. The examination criteria used for assessing shoulder laxity were consistent with standard medical parameters. Two surgeons specializing in shoulder surgery examined all participants. Active and passive shoulder range of motion were recorded bilaterally using the standard goniometric techniques. The study's only significant flaw was the lack of a control group. It would have been interesting to examine if the same pattern of shoulder laxity would exist in a control group consisting of a population that does not play baseball on a consistent basis. Also, the incorporation of a control group would have lessened the possibility of examiner bias. Of importance, Bigliani et al (1) discussed the role and possible value of this increased shoulder laxity in professional baseball players. The study stated that the possibility exists that the presence of increased shoulder laxity in this patient population may indicate an adaptive response to the repetitive throwing motion, allowing a greater abduction and external rotation in the cocking and early acceleration phases of throwing. The study also suggested that the pre-existing, inherent glenohumeral laxity may actually play a role in the selection of athletes who are able to succeed at such a high level of competition.

Kibler (8) reviewed the physiology and biomechanics of normal shoulder function and then described basic principals and clinical practices to restore those functions. This study should be used as a primary source of proper rehabilitation protocols for restoring normal shoulder function. Kibler (8) discussed each aspect of shoulder rehabilitation clearly and precisely by formatting his study to include the principals, practice, and goals for each part of the shoulder rehabilitation program.

Sirota et al (24) studied the isokinetic eccentric muscular performance characteristics of external and internal rotator muscles in the shoulders of 25 professional baseball players. The testing protocol was standardized for each subject. Each player was evaluated with a KinCom isokinetic dynamometer. A major flaw of this study is the lack of a control group. The study's results would be more significant if the pattern of greater eccentric strength discovered in the baseball player population was determined to be unique to the studied population only. The study did not investigate if this strength pattern is also seen in a population that does not play baseball.

Clarnette and Miniaci (21) outlined the important features of the clinical assessment of the shoulder in a systematic and thorough manner. The study highlighted the key symptoms, particularly pain and instability, and described how they may be associated with various pathologies. This study should be used as a teaching aid because it detailed the physical examination of the shoulder in order of inspection, palpation, and range of motion. The study also emphasized specific shoulder tests that may provide evidence of rotator cuff weakness, impingement, biceps pathology, and instability.

CONCLUSION

To summarize, a proper rehabilitation program of the throwing shoulder can be divided into four phases. Phase one is reduction of pain and inflammation; phase two, initiation of a progressive strengthening program; phase three, advanced strengthening; and phase four, a return to competitive throwing (22). Criteria for return to play must include a normal clinical examination, normal shoulder arthrokinetics, normal kinetic chain integration, and completed progressions in all rehabilitative exercises (8).

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