EDITORIAL

The Shoulder: Embracing the Clinical Challenge of Its Complexity

GUY G. SIMONEAU, *PT, PhD, ATC*
Editor in Chief

KEVIN E. WILK, *PT, DPT*[1]
Special Issue Guest Editor

J Orthop Sports Phys Ther 2009;39(2):37. doi:10.2519/jospt.2009.0109

The shoulder, by combining the actions across the glenohumeral, scapulothoracic, acromioclavicular, and sternoclavicular joints, provides an extraordinarily wide range of functional versatility to the upper extremity. Such versatility is apparent when considering the large amplitude of movement required to reach with the hand far overhead or behind the back. Seldom mentioned is the amazing potential of the shoulder, contingent on proper training, to combine this amplitude of movement with sufficient strength, speed, and coordination to precisely throw a baseball at 150 km per hour (95 miles per hour) to a defined target, or to propel Olympic swimmers through the pool at incredible speeds. Equally impressive is the ability of the shoulder not only to move the arm in space and against resistance but to move the body when the arm is held firmly fixed to an external object, as seen in many of the routines performed in gymnastics (eg, pommel horse, still rings, floor exercise). While few aspire to such prowess, we all require various combinations of shoulder mobility, strength, and dexterity to attend to our daily work and leisure activities.

As physical therapists, we marvel at the complexity, strength, and agility of movements performed by the healthy shoulder. At the same time, however, we are called upon to treat a large number of patients with shoulder pain and dysfunction. These patients are remarkably diverse, including older individuals requiring shoulder function to attend to casual daily activities, recreational or elite athletes participating in a variety of sports, and persons across the full range of occupations demanding repetitive or occasional use of their upper extremities. As reflected by the enormous volume of published literature devoted to the topic, the evaluation and treatment of shoulder pain or dysfunction represents a source of both excitement and challenge. Our excitement is fueled by the new knowledge acquired over the past few years that has led to better clinical outcomes. But, given the anatomic and biomechanical complexity of the shoulder region, we continue to be challenged to further refine our diagnostic and intervention techniques.

In this special issue of the *Journal*, we have assembled some of the leading clinical and research authorities on the rehabilitation of the shoulder to share their expertise, insights, and clinical pearls. Specific topics include the full range of shoulder mobility dysfunctions from frozen shoulder to congenital instability. There are also papers on a trio of subacromial pathologies often difficult to differentiate, which often coexist with abnormal shoulder mobility: long head of the biceps, rotator cuff, and SLAP lesions. An additional 2 manuscripts provide an update on our current understanding of strengthening exercises for the shoulder musculature and of the scapulothoracic joint as it relates to shoulder function and pathologies. Information shared in this special issue should be relevant to the full spectrum of patients with shoulder pathologies, and we express our sincere appreciation to all the contributors.

We hope you enjoy this special issue on the shoulder.

[1]Vice President of Education, Physiotherapy Associates, Exton, PA; Associate Clinical Director, Champion Sports Medicine, A Physiotherapy Associates Clinic, Birmingham, AL; Director of Rehabilitation Research, American Sports Medicine Institute, Birmingham, AL; Rehabilitation Consultant, Tampa Bay Rays Baseball Organization, Tampa Bay, FL.

Current Concepts: The Stabilizing Structures of the Glenohumeral Joint

Kevin E. Wilk, PT[1]
Christopher A. Arrigo, MS, PT, ATC[2]
James R. Andrews, MD[3]

Significant contemporary advances have permitted a more comprehensive understanding and development of some interesting concepts about the glenohumeral joint. The purpose of this review paper was to discuss current concepts related to the anatomic stabilizing structures of the shoulder joint complex and their clinical relevance to shoulder instability. The clinical syndrome of shoulder instability represents a wide spectrum of symptoms and signs which may produce various levels of dysfunction, from subtle subluxations to gross joint instability. The glenohumeral joint attains functional stability through a delicate and intricate interaction between the passive and active stabilizing structures. The passive constraints include the bony geometry, glenoid labrum, and the glenohumeral joint capsuloligamentous structures. Conversely, the active constraints, also referred to as the active mechanisms, include the shoulder complex musculature, the proprioceptive system, and the musculoligamentous relationship. The interaction of the active and passive mechanisms which provide passive and active glenohumeral joint stability will be thoroughly discussed in this paper.

Key Words: *glenohumeral joint, anatomy, instability*

[1] National Director, Research and Clinical Education, HealthSouth Rehabilitation Corporation, Birmingham, AL; Associate Clinical Director, HealthSouth Sports Medicine and Rehabilitation Center, Birmingham, AL; Director, Rehabilitative Research, American Sports Medicine Institute, 1313 13th Street South, Birmingham, AL 35205
[2] Physical Therapy Coordinator, HealthSouth Sports Medicine and Rehabilitation Center, Birmingham, AL; Coordinator of Rehabilitation, Texas Rangers Baseball Club, Arlington, TX
[3] Clinical Professor, Orthopaedics and Sports Medicine, University of Virginia Medical School, Charlottesville, VA; Medical Director, American Sports Medicine Institute, Birmingham, AL; Orthopaedic Surgeon, Alabama Sports Medicine and Orthopaedic Center, Birmingham, AL

Shoulder instability is a vague, nonspecific term which actually represents a wide spectrum of clinical pathologies, ranging from gross instability to subtle subluxation. Patients exhibiting shoulder instability are commonly encountered by therapists, athletic trainers, and physicians in both the general orthopaedic and sports medicine population. Often, an appropriate clinical diagnosis is difficult due to the excessive amount of capsular laxity normally seen and appreciated during clinical examination of the glenohumeral joint. Clinicians may become perplexed when attempting to determine the amount of normal acceptable laxity vs. pathological ligamentous laxity. The purpose of this paper is to discuss current concepts related to the anatomic stabilizing structures of the glenohumeral joint.

The glenohumeral joint is inherently unstable and exhibits the greatest amount of motion found in any joint in the human body (116). Additionally, the glenohumeral joint is the most commonly dislocated major joint in the human body (20,47). Thus, the shoulder joint sacrifices stability for mobility. Although the glenohumeral joint exhibits significant physiologic motion, only a few millimeters of humeral head displacement occur during these movements in the normal individual (1,35,36,40, 75,76,103). Conversely, on clinical examination, Matsen et al (55) have demonstrated excessive passive displacement (10 mm inferiorly and 8 mm anteriorly) in normal asymptomatic shoulders. Therefore, stabilization of the humeral head within the glenoid is accomplished through the combined efforts of the ligamentous structures and the surrounding shoulder musculature.

Matsen et al have defined instability as a clinical condition in which unwanted translation of the humeral head on the glenoid compromises the comfort and function of the shoulder (55). Conversely, laxity refers to the ability of the humeral head to be passively translated on the glenoid fossa (55). The amount of translation that is "normal" for any given individual varies (35,37). Relative laxity may exist without the accompanying symptoms of instability. Harryman et al, in an *in vivo* assessment of glenohumeral translation, noted wide variations in anterior, posterior, and inferior translation among normal individuals (35). These findings were reconfirmed recently by Wuelker et al (117), who also reported wide variations in translations in cadaveric shoulders.

Despite the individual differences noted in passive translation, the pathomechanical condition that uni-

INVITED CLINICAL COMMENTARY

NON-OPERATIVE REHABILITATION FOR TRAUMATIC AND ATRAUMATIC GLENOHUMERAL INSTABILITY

Kevin E. Wilk, PT, DPT[a]
Leonard C. Macrina, MSPT[a]
Michael M. Reinold, PT, DPT, ATC[a]

ABSTRACT

Glenohumeral joint instability is a common pathology encountered in the orthopaedic and sports medicine setting. A wide range of symptomatic shoulder instabilities exist ranging from subtle subluxations due to contributing congenital factors to dislocations as a result of a traumatic episode. Non-operative rehabilitation is utilized in patients diagnosed with shoulder instability to regain their previous functional activities through specific strengthening exercises, dynamic stabilization drills, neuromuscular training, proprioception drills, scapular muscle strengthening program and a gradual return to their desired activities. The specific rehabilitation program should be varied based on the type and degree of shoulder instability present and desired level of function. The purpose of this paper is to outline the specific principles associated with non-operative rehabilitation for each of the various types of shoulder instability and to discuss the specific rehabilitation program for each pathology type.

Keywords: Dynamic stabilization, neuromuscular control, shoulder joint

a Champion Sports Medicine
American Sports Medicine Institute
Birmingham, AL

INTRODUCTION

Shoulder instability is a common pathology often seen in the orthopaedic and sports medicine setting. The glenohumeral joint allows tremendous amounts of joint mobility to function, thus, making the joint inherently unstable and the most frequently dislocated joint in the body.[1] Due to the joint's poor osseous congruency and capsular laxity, it greatly relies on the dynamic stabilizers and neuromuscular system to provide functional stability.[2] Therefore, differentiation between normal translation and pathological instability is often difficult to determine. A wide range of shoulder instabilities exist from subtle subluxations to gross instability. Often the success of the rehabilitation program is based on the recognition and treatment program designed to treat the specific type of instability present.

TABLE. Seven key factors to consider in the rehabilitation of the unstable shoulder

1. Onset of the pathology
2. Degree of instability – subluxation vs. dislocation
3. Frequency of dislocation – chronic vs. acute
4. Direction of instability – anterior, posterior, multidirectional
5. Concomitant pathologies
6. End range neuromuscular control
7. Premorbid activity level

Non-operative rehabilitation is often implemented in patients diagnosed with a variety of shoulder instabilities. These instability patterns can range from congenital multidirectional instabilities to traumatic unidirectional dislocations. We have classified glenohumeral joint instabilities into two broad categories: traumatic and atraumatic. Based on the classification system of glenohumeral instability, as well as several other factors, a non-operative rehabilitation program may be developed. The purpose of this paper is to discuss and overview these factors along with the non-operative rehabilitation programs for the various types of shoulder instability in order to return the patient to their previous level of function.

The Physical Examination of the Glenohumeral Joint: Emphasis on the Stabilizing Structures

Kevin E. Wilk, PT[1]
James R. Andrews, MD[2]
Christopher A. Arrigo, MS, PT, ATC[3]

Thorough descriptions of specific physical examination tests used to determine glenohumeral instability are lacking in the scientific literature. The purpose of this paper was to discuss the importance of the subjective history and illustrate the physical examination of the glenohumeral joint. Additionally, the authors will illustrate specific stability assessment tests for the glenohumeral joint based on current basic science and clinical research. The physical examination of a patient whose history suggests subtle glenohumeral joint instability may be extremely difficult for the clinician due to the normal amount of capsular laxity commonly present in most individuals. An essential component of the physical examination is a thorough and meticulous subjective history which includes the mechanisms of injury and/or dysfunction, chief complaint, level of disability, and aggravating movements. The physical examination must include an assessment of motion, static stability testing, muscle testing, and a neurologic assessment. A comprehensive understanding of various stability testing maneuvers is important for the clinician to appreciate. The evaluation techniques discussed in this paper should assist the clinician in determining the passive stability of the glenohumeral joint.

Key Words: glenohumeral joint, instability, assessment

[1] National Director, Research and Clinical Education, HealthSouth Rehabilitation Corporation, Birmingham, AL; Associate Clinical Director, HealthSouth Sports Medicine and Rehabilitation Center, Birmingham, AL; Director, Rehabilitative Research, American Sports Medicine Institute, 1313 13th Street South, Birmingham, AL 35205
[2] Clinical Professor, Orthopaedics and Sports Medicine, University of Virginia Medical School, Charlottesville, VA; Medical Director, American Sports Medicine Institute, Birmingham, AL; Orthopaedic Surgeon, Alabama Sports Medicine and Orthopaedic Center, Birmingham, AL
[3] Physical Therapy Coordinator, HealthSouth Sports Medicine and Rehabilitation Center, Birmingham, AL; Coordinator of Rehabilitation, Texas Rangers Baseball Club, Arlington, TX

The physical examination of patients whose complaints suggest subtle to moderate shoulder instability can be extremely difficult. Often, the clinical diagnosis of instability is difficult because of the normal amount of capsular laxity appreciated during clinical examination. Clinicians may be challenged when attempting to determine the amount of normal acceptable ligamentous laxity compared with pathologic excessive laxity. Additionally, there are few published papers in which specific physical examination tests used to determine glenohumeral instability are thoroughly described. The purpose of this paper is to discuss and illustrate the subjective history and physical examination of the glenohumeral joint. An additional purpose is to present specific stability assessment tests to evaluate the glenohumeral joint and identify the specific anatomic structures injured.

The stability assessment maneuvers discussed in this paper have been developed and based on recent research in the area of arthrokinematic motions (5,13,16,34) and selected ligamentous cutting studies which determined the primary and secondary restraints to directional translations of the glenohumeral joint (5,6,9,11,24,25,27,28,39,40). Before discussing the physical examination and assessment of static stability, we will discuss the importance and clinical relevance of a thorough subjective history.

SUBJECTIVE HISTORY

Before any clinical physical examination can be performed, a thorough and meticulous subjective history must be obtained. Several key facts play a major role in establishing a diagnosis of shoulder instability. One of the first questions asked is the patient's age and activity level. Age is important because it suggests the type of pathology present. In most cases, shoulder instability patients will be younger than 30 years of age (15). Conversely, patients in or above their fourth or fifth decade of life most often exhibit rotator cuff pathology (15). The patient should be questioned in regard to how this condition has affected their daily activities and sports. In addition, the patient's general health, occupation, hand dominance, sports, and leisure activities should all be documented. Next, establish the patient's chief complaint (Why is he/she here today?). Additionally, when and how

Rehabilitation Following Thermal-Assisted Capsular Shrinkage of the Glenohumeral Joint: Current Concepts

Kevin E. Wilk, PT[1,2,3]
Michael M. Reinold, PT[1,2]
Jeffrey R. Dugas, MD[4]
James R. Andrews, MD[4,5]

Glenohumeral joint instability is a common pathology observed in the orthopedic and sports medicine settings. Overhead athletes often exhibit a certain degree of acquired laxity that can lead to various pathologies. Unfavorable results often observed with traditional open procedures to correct instability in the overhead athlete have led to the development of arthroscopic thermal-assisted capsular shrinkage (TACS). TACS is not commonly used as an isolated procedure in overhead athletes; various procedures are often performed concomitantly. The overall outcome greatly depends on a postoperative rehabilitation program that must be assessed and adjusted frequently based on several factors. Knowledge of the basic science of TACS as well as emphasis on dynamic stabilization, proprioception, and neuromuscular control are vital to the rehabilitation program for overhead athletes. The purpose of this paper is to discuss the basic science and clinical application of thermal-assisted capsular shrinkage of the glenohumeral joint as well as the postoperative rehabilitation for the overhead athlete and the patient with congenital laxity and related multidirectional instability. *J Orthop Sports Phys Ther.* 2002;32:268–292.

Key Words: *dynamic stabilization, glenohumeral instability, neuromuscular control, overhead athlete, SLAP lesions*

Instability of the glenohumeral joint is a common pathology observed by clinicians in the orthopaedic and sports medicine settings. Shoulder instability encompasses a wide spectrum of conditions ranging from subtle subluxations to gross instability. Some individuals appear to have congenitally increased elasticity of the glenohumeral joint capsule, often presenting with instability in more than one direction (ie, multidirectional instability). In contrast, overhead athletes tend to exhibit acquired laxity of the shoulder joint capsule due to the repetitive stresses and excessive motions necessary to perform their overhead sport, which may be superimposed upon a small degree of congenital laxity. In particular, high-level overhead throwers often present with tremendous amounts of shoulder motion, in particular external rotation.[2,7,59,62,69] Crockett et al[10] observed that overhead athletes exhibit increased humeral retroversion of the dominant shoulder as compared to the nondominant shoulder. Therefore, acquired laxity in the overhead athlete may be the result of the combination of soft tissue changes (capsular) and osseous adaptation.[10] This acquired laxity can often lead to a variety of symptoms, such as internal impingement, labral lesions, rotator cuff lesions, and instability.[1,8,24,34,58]

Traditional open procedures to correct acquired laxity in the overhead athlete often result in unfavorable failure rates due to overconstraint (tightness) of the glenohumeral joint capsule.[3,26,31,42] Also, the consequent postoperative loss of motion may not allow the athlete's shoulder to generate the rotational torque required to throw at a high level. Recent technological advances have led to the development of a procedure to arthroscopically apply thermal energy to the joint capsule, selectively shrinking the capsular tissue. Thus, the glenohumeral joint capsule may be shrunk in one isolated region, such as the anterior band of the anterior-inferior glenohumeral joint capsule, or shrinking the entire capsule can be done. Despite

[1] *Physical therapist, HealthSouth Rehabilitation, Birmingham, AL.*
[2] *Physical therapist, American Sports Medicine Institute, Birmingham, AL.*
[3] *Rehabilitation consultant, Tampa Bay Devil Rays Baseball Organization, Tampa Bay, FL.*
[4] *Orthopaedic surgeon, Alabama Sports Medicine and Orthopedic Center, Birmingham, AL.*
[5] *Medical director, Tampa Bay Devil Rays Baseball Organization, Tampa Bay, FL.*
Send correspondence to Kevin E. Wilk, HealthSouth Rehabilitation, 1201 11th Avenue South, Suite 100, Birmingham, AL 35205. E-mail: kevin.wilk@healthsouth.com

MICHAEL M. REINOLD, PT, DPT, ATC, CSCS[1] • RAFAEL ESCAMILLA, PT, PhD, CSCS, FACSM[2] • KEVIN E. WILK, PT, DPT[3]

Current Concepts in the Scientific and Clinical Rationale Behind Exercises for Glenohumeral and Scapulothoracic Musculature

The biomechanical analysis of rehabilitation exercises has gained recent attention. As our knowledge of specific muscle biomechanics and function has increased, we have seen a gradual progression towards more scientifically based rehabilitation exercises. Several investigators have sought to describe common rehabilitation exercises using kinematics, kinetics, and electromyographic (EMG) data in an attempt to better understand the implications of each exercise on the soft tissues of the glenohumeral and scapulothoracic joints. Advances in the understanding of the biomechanical factors of rehabilitation have led to the enhancement of rehabilitation programs that seek to facilitate recovery, while placing minimal strain on specific healing structures.

Though the fields of orthopedics and sports medicine have evolved to emphasize the necessity of evidence-based practice, few studies have been conducted to determine the efficacy of specific shoulder rehabilitation exercises. Thus, knowledge of anatomy, biomechanics, and function of specific musculature is critical in an attempt to develop the most advantageous rehabilitation programs.

The purpose of this paper is to provide an overview of the biomechanical and clinical implications associated with the rehabilitation of the glenohumeral and scapulothoracic joints. We will review the function and biomechanics of each muscle, with specific emphasis on many commonly performed rehabilitation exercises. The goal of this is to provide the clinician with a thorough overview of the available information to develop safe, potentially effective, and appropriate exercise programs for injury rehabilitation and prevention.

• SYNOPSIS: The biomechanical analysis of rehabilitation exercises has led to more scientifically based rehabilitation programs. Several investigators have sought to quantify the biomechanics and electromyographic data of common rehabilitation exercises in an attempt to fully understand their clinical indications and usefulness. Furthermore, the effect of pathology on normal shoulder biomechanics has been documented. It is important to consider the anatomical, biomechanical, and clinical implications when designing exercise programs. The purpose of this paper is to provide the clinician with a thorough overview of the available literature relevant to develop safe, effective, and appropriate exercise programs for injury rehabilitation and prevention of the glenohumeral and scapulothoracic joints.

• LEVEL OF EVIDENCE: Level 5. *J Orthop Sports Phys Ther 2009; 39(2):105-117. doi:10.2519/jospt.2009.2835*

• KEY WORDS: *electromyography, infraspinatus, serratus anterior, supraspinatus, trapezius*

ROTATOR CUFF MUSCLES

The rotator cuff has been shown to be a substantial dynamic stabilizer of the glenohumeral joint in multiple shoulder positions.[49,66] Appropriate rehabilitation progression and strengthening of the rotator cuff muscles are important to provide appropriate force to help elevate and move the arm, compress and center the humeral head within the glenoid fossa during shoulder movements (providing dynamic stability), and provide a counterforce to humeral head superior translation resulting from del-

[1]Coordinator of Rehabilitation Research and Education, Department of Orthopedic Surgery, Division of Sports Medicine, Massachusetts General Hospital, Boston, MA; Rehabilitation Coordinator/Assistant Athletic Trainer, Boston Red Sox Baseball Club, Boston, MA. [2]Professor, Department of Physical Therapy, California State University, Sacramento, Sacramento, CA. [3]Clinical Director, Champion Sports Medicine, Director of Rehabilitative Research, American Sports Medicine Institute, Birmingham, AL. Address correspondence to Dr Michael M. Reinold, Rehabilitation Coordinator/Assistant Athletic Trainer, Boston Red Sox Baseball Club, Fenway Park, 4 Yawkey Way, Boston, MA 02215. Email: mreinold@redsox.com

Techniques in Shoulder & Elbow Surgery 1(2):128–144, 2000

TECHNIQUE

Rehabilitation After Rotator Cuff Surgery

KEVIN E. WILK, P.T.
HEALTHSOUTH Rehabilitation Corporation
Birmingham, Alabama, U.S.A.

HEBER C. CROCKETT, M.D.
Trails West Orthopaedic & Sports Medicine Center
Kearney, Nebraska, U.S.A.

JAMES R. ANDREWS, M.D.
Department of Orthopaedic Surgery
University of Alabama at Birmingham
Birmingham, Alabama, U.S.A.

The surgical repair of a torn rotator cuff is performed to decrease pain, increase function, and improve range of motion (27). Postoperative rehabilitation after rotator cuff repair appears to play a significant role in the ultimate outcome. Postsurgical care should strike a balance among restrictions to allow for tissue healing, activities to restore motion, and gradual restoration of muscular strength and function. Often residual postoperative pain and stiffness remain despite an adequate surgical repair (17). Frequently, shoulder surgeons are concerned about initiating voluntary shoulder muscle contractions for fear of deleterious effects at the repair site. Because of these concerns, a common postoperative rehabilitation regimen has been advocated that allows only passive range of motion for the first 6 to 8 weeks, then gradually allows active motions, with full active motion at 12 weeks after surgery (30). In our opinion, a conservative, patient-directed rehabilitation approach often leads to joint stiffness, muscular weakness, and prolonged rehabilitation. Gore et al (17) noted that residual postoperative pain and stiffness may exist despite an adequate repair. Warner and Greis (48) reported that a loss of passive motion is not uncommon after rotator cuff repair.

The surgical treatment of rotator cuff tears has evolved in the past decade. With the advent of the arthroscopically assisted "mini-open" approach to treat small- to large-sized rotator cuff tears, the shoulder surgeon is able to treat most rotator cuff tears with an arthroscopic assessment of the glenohumeral joint, followed by an arthroscopic subacromial decompression and a rotator cuff repair through a limited deltoid-splitting approach (1,6,25,26,42,50). This type of surgical intervention has allowed a slightly more aggressive rehabilitation approach. Furthermore, some shoulder arthroscopists have performed arthroscopic rotator cuff repairs for small- to medium-sized tears (16,43,45). Other shoulder surgeons, however, prefer the traditional open rotator repair with acromioplasty described by Neer (30). Rehabilitation after rotator cuff repair must be based on several factors, one of which is the surgical approach. Thus, all three surgical techniques dictate a dramatically different postsurgery program.

The postsurgery rehabilitation program should vary based on the surgical intervention. The primary goal of the surgery and rehabilitation program is to restore the patient's shoulder function and to decrease pain. In this paper, we will discuss the postoperative rehabilitation programs followed after various rotator cuff repair surgeries.

FACTORS AFFECTING THE REHABILITATION PROGRAM

Eight factors that significantly affect the postoperative rehabilitation program are listed in Table 1. The first factor concerns the type of surgical approach. In particular, patients who have deltoid muscle detachment or release from the acromion or clavicle or both, as in a traditional open rotator cuff repair, may not be able to perform any active muscular contractions involving the deltoid for 6 to 8 weeks. This is done to prevent the avulsion of the deltoid muscle. Conversely, if a mini-open procedure is performed, in which the deltoid muscle is split vertically with the orientation of the deltoid muscle fibers, we will allow mild deltoid muscular

Address correspondence and reprint requests to Kevin Wilk, PT, HealthSouth Sports Medicine and Rehabilitation Center, 1201 11th Avenue, Suite 100, Birmingham, AL 35205.

[CLINICAL COMMENTARY]

NEIL S. GHODADRA, MD[1] • MATTHEW T. PROVENCHER, MD, LCDR[2] • NIKHIL N. VERMA, MD[1]
KEVIN E. WILK, PT, DPT[3] • ANTHONY A. ROMEO, MD[1]

Open, Mini-open, and All-Arthroscopic Rotator Cuff Repair Surgery: Indications and Implications for Rehabilitation

Rotator cuff tears can lead to a variety of clinical manifestations, including debilitating shoulder dysfunction and impairment. The goal of rotator cuff repair is to eliminate pain and improve function with increased shoulder strength and range of motion (ROM). Optimal repair of the rotator cuff includes achievement of high fixation strength, minimal gap formation and maintenance of mechanical stability under cyclic loading, and proper healing of tendon to bone. In addition to adequate surgical repair, outcomes are dependent on appropriate rehabilitation. Successful postoperative management following rotator cuff repair is dependent on several variables, including surgical intervention method, patient age, activity level, chronicity of tear, and tear size. With rapidly advancing surgical techniques and modes of fixation, optimal rehabilitation following rotator cuff surgical repair has become increasingly important and challenging for the orthopedic surgeon and physical therapist. This article will address the current trends in rotator cuff repair and discuss the important postoperative implications of open, mini-open, and all-arthroscopic cuff repair techniques.

SUPPLEMENTAL VIDEO ONLINE

• SYNOPSIS: Rotator cuff tears lead to debilitating shoulder dysfunction and impairment. The goal of rotator cuff repair is to eliminate pain and improve function with increased shoulder strength and range of motion. The clinical outcomes of the surgical methods of rotator cuff repair (open, mini-open, and all-arthroscopic cuff repair) vary, as each method provides an array of advantages and disadvantages. Although the open surgical technique has long been considered the gold standard of rotator cuff repair, surgeons are becoming more adept at decreasing patient morbidity through decreased surgical trauma from an all-arthroscopic approach. In addition to a surgery-specific rotator cuff rehabilitation program, effective communication, and coordination of care by the physical therapist and surgeon are essential in optimal patient education and outcomes. In the ideal situation, a very well-educated therapist who has great communication with the treating surgeon can mobilize the shoulder early, re-establish scapulothoracic function safely and minimize the risk of stiffness and retear, while facilitating return to function. Treatment options can be individualized according to patient age, size and chronicity of tear, surgical approach, and fixation method. We recommend that patients who have undergone an all-arthroscopic rotator cuff repair undergo an accelerated postoperative rehabilitation program. A rational approach to therapy involves early, safe motion to allow optimal tendon healing, yet maintenance of joint mobility with minimal stress. As the field of orthopedics and, particularly, rotator cuff repair continues to develop with new technologies, the patient, physical therapist, and doctor need to work together to ensure optimal outcomes and patient satisfaction.

• LEVEL OF EVIDENCE: Therapy, Level 5.
J Orthop Sports Phys Ther 2009; 39(2):81-89. doi:10.2519/jospt.2009.2918

• KEY WORDS: *arthroscopy, rotator cuff tear, shoulder, supraspinatus*

OPEN ROTATOR CUFF REPAIR

THE FIRST ROTATOR CUFF REPAIR was performed by Dr Codman in 1911, utilizing an open technique.[77] Further modifications were later proposed by Neer in 1972 and included a description of 5 fundamentals of open rotator cuff repair techniques: (1) meticulous repair of the deltoid origin, (2) subacromial decompression, (3) surgical releases as necessary to obtain freely mobile muscle-tendon units, (4) secure transosseus fixation of the tendon to the tuberosity, and (5) closely supervised rehabilitation with early passive motion.[77] Outcome studies of individuals who were treated with an open rotator cuff repair have revealed good to excellent results in both functional improvement (75%-

[1]Orthopaedic Surgeon, Rush University, Department of Orthopaedic Surgery, Chicago, IL. [2]Orthopaedic Surgeon, Naval Medical Center, Department of Orthopaedic Surgery, San Diego, CA. [3]Associate Clinical Director, Champion Sports Medicine, A Physiotherapy Associates Clinic, Birmingham, Al; Rehabilitation Consultant, Tampa Bay Rays Baseball Team, Tampa Bay, FL. Address correspondence to Dr Neil S. Ghodadra, 1653 West Congress Pkwy, 1471 Jelke Bldg, Chicago, IL 60612. Email: neil_ghodadra@rush.edu

Supplemental Video Available at www.jospt.org

Current Concepts in the Recognition and Treatment of Superior Labral (SLAP) Lesions

Kevin E. Wilk, DPT[1]
Michael M. Reinold, DPT, ATC, CSCS[2]
Jeffrey R. Dugas, MD[3]
Christopher A. Arrigo, PT, MS[4]
Michael W. Moser, MD[5]
James R. Andrews, MD[6]

CLINICAL COMMENTARY

Pathology of the superior aspect of the glenoid labrum (SLAP lesion) poses a significant challenge to the rehabilitation specialist due to the complex nature and wide variety of etiological factors associated with these lesions. A thorough clinical evaluation and proper identification of the extent of labral injury is important to determine the most appropriate nonoperative and/or surgical management. Postoperative rehabilitation is based on the specific surgical procedure as well as the extent, location, and mechanism of labral pathology and associated lesions. Emphasis is placed on protecting the healing labrum, while gradually restoring range of motion, strength, and dynamic stability of the glenohumeral joint. The purpose of this paper is to provide an overview of the anatomy and pathomechanics of SLAP lesions and review specific clinical examination techniques used to identify these lesions, including 3 newly described tests. Furthermore, a review of the current surgical management and postoperative rehabilitation guidelines is provided. *J Orthop Sports Phys Ther 2005;35:273-291.*

Key Words: *dynamic stability, glenohumeral, rehabilitation, shoulder*

The inherently complicated nature of injuries involving the superior aspect of the glenoid labrum can present a substantial clinical challenge. Successful return to unrestricted function requires integrating the appropriate diagnosis, surgical management, and rehabilitation in a coordinated effort. The advent of new arthroscopic techniques has helped to provide a better understanding of normal labral anatomy, capsulolabral anomalies, and the pathomechanics of conditions involving this structure. Likewise these techniques have also drastically improved the surgical treatment options available to successfully address these pathologies. Andrews et al[3] originally described the detachment of the superior labrum in a subset of throwing athletes in 1985. Later Snyder et al[49] introduced the term SLAP lesion, indicating an injury located within the superior labrum extending anterior to posterior. They originally classified these lesions into 4 distinct categories based on the type of lesion present, emphasizing that this lesion may disrupt the origin of the long head of the biceps brachii[49] (Figure 1). Subsequent authors have added additional classification categories and specific subtypes, further expanding on the 4 originally described categories.[15,29,33] Based on these subtle differences in labral pathology an appropriate treatment plan may be developed to adequately address the specific pathology present.

In recent years it has become clear that symptomatic superior labral lesions and detachments can be treated effectively with either arthroscopic debridement or repair, depending on the specific type of pathology present.[14,39,45,51,65] We believe that it is critical to carefully follow a postoperative rehabilitation program that has been based on an accurate diagnosis that specifies extent of superior labral pathology to ensure a successful outcome. The purpose of this paper is to

[1] Co-Founder and Co-Director, Champion Sports Medicine, American Sports Medicine Institute, Birmingham, AL.
[2] Coordinator of Rehabilitative Research and Clinical Education, Champion Sports Medicine, American Sports Medicine Institute, Birmingham, AL.
[3] Orthopedic Surgeon, Alabama Sports Medicine & Orthopedic Center, American Sports Medicine Institute, Birmingham, AL.
[4] President and Clinical Director, Advanced Rehabilitation, Tampa, FL.
[5] Orthopedic Surgeon, Tampa Orthopedic and Sports Medicine, Tampa, FL.
[6] Medical Director, Alabama Sports Medicine & Orthopedic Center, American Sports Medicine Institute, Birmingham, AL.
Address correspondence to Michael M. Reinold, Coordinator of Rehabilitative Research and Clinical Education, Champion Sports Medicine, 1621 11th Avenue South, Suite 205, Birmingham, AL 35205. E-mail: mike.reinold@championsportsmedicine.com

Electromyographic Analysis of the Rotator Cuff and Deltoid Musculature During Common Shoulder External Rotation Exercises

Michael M. Reinold, DPT, ATC[1]
Kevin E. Wilk, PT[2]
Glenn S. Fleisig, PhD[3]
Nigel Zheng, PhD[4]
Steven W. Barrentine, MS[5]
Terri Chmielewski, PT, PhD[6]
Rayden C. Cody, MD[7]
Gene G. Jameson, MA[5]
James R. Andrews, MD[8]

RESEARCH REPORT

Study Design: Prospective single-group repeated-measures design.

Objectives: To quantify electromyographic (EMG) muscle activity of the infraspinatus, teres minor, supraspinatus, posterior deltoid, and middle deltoid during exercises commonly used to strengthen the shoulder external rotators.

Background: Exercises to strengthen the external rotators are commonly prescribed in rehabilitation, but the amount of EMG activity of the infraspinatus, teres minor, supraspinatus, and deltoid during these exercises has not been thoroughly studied to determine which exercises would be most effective to achieve strength gains.

Methods and Measures: EMG measured using intramuscular electrodes were analyzed in 10 healthy subjects during 7 shoulder exercises: prone horizontal abduction at 100° of abduction and full external rotation (ER), prone ER at 90° of abduction, standing ER at 90° of abduction, standing ER in the scapular plane (45° abduction, 30° horizontal adduction), standing ER at 0° of abduction, standing ER at 0° of abduction with a towel roll, and sidelying ER at 0° of abduction. The peak percentage of maximal voluntary isometric contraction (MVIC) for each muscle was compared among exercises using a 1-way repeated-measures analysis of variance ($P<.05$).

Results: EMG activity varied significantly among the 7 exercises. Sidelying ER produced the greatest amount of EMG activity for the infraspinatus (62% MVIC) and teres minor (67% MVIC). The greatest amount of activity of the supraspinatus (82% MVIC), middle deltoid (87% MVIC), and posterior deltoid (88% MVIC) was observed during prone horizontal abduction at 100° with full ER.

Conclusions: Results from this study provide initial information to develop rehabilitation programs. It also provides information helpful for the design and conduct of future studies. *J Orthop Sports Phys Ther 2004;34:385-394.*

Key Words: *dynamic stabilization, infraspinatus, supraspinatus, teres minor*

[1] *Coordinator of Rehabilitative Research and Clinical Education, Healthsouth Rehabilitation, American Sports Medicine Institute, Birmingham, AL.*
[2] *National Director of Research and Education, Healthsouth Rehabilitation, American Sports Medicine Institute, Birmingham, AL.*
[3] *Smith and Nephew Chair of Research, American Sports Medicine Institute, Birmingham, AL.*
[4] *Coordinator of Joint Biomechanics Research, American Sports Medicine Institute, Birmingham, AL.*
[5] *Biomechanist, American Sports Medicine Institute, Birmingham, AL.*
[6] *Assistant Research Professor, Department of Physical Therapy, University of Florida, Gainesville, FL.*
[7] *Assistant Professor, Department of Orthopedics and Rehabilitation, University of Vermont, Burlington, VT.*
[8] *Medical Director, American Sports Medicine Institute, Alabama Sports Medicine and Orthopedic Center, Birmingham, AL.*
This study was approved by the American Sports Medicine Institute Institutional Review Board, Birmingham, AL.
Address correspondence to Michael M. Reinold, Coordinator of Rehabilitative Research and Clinical Education, Healthsouth Sports Medicine and Rehabilitation Center, American Sports Medicine Institute, 1201 11th Avenue South, Suite 100, Birmingham, AL 35205. E-mail: michael.reinold@healthsouth.com

The glenohumeral joint exhibits the greatest amount of motion of any articulation in the human body, consequently little inherent stability is provided by its osseous configuration.[42] Functional stability of the

Journal of Athletic Training 2007;42(4):464–469

www.journalofathletictraining.org

Electromyographic Analysis of the Supraspinatus and Deltoid Muscles During 3 Common Rehabilitation Exercises

Michael M. Reinold, DPT, PT, ATC, CSCS*; Leonard C. Macrina, MSPT, CSCS†; Kevin E. Wilk, DPT, PT†‡; Glenn S. Fleisig, PhD‡; Shouchen Dun, MS‡; Steven W. Barrentine, MS‡; Michael T. Ellerbusch, MD§; James R. Andrews, MD‡||

*Boston Red Sox Baseball Club, Massachusetts General Hospital, and Northeastern University, Boston, MA; †Champion Sports Medicine, Birmingham, AL; ‡American Sports Medicine Institute, Birmingham, AL; §Alabama Orthopedic and Spine Center, Tuscaloosa, AL; ||Alabama Sports Medicine and Orthopaedic Center, Birmingham, AL

Context: Investigators have observed electromyographic (EMG) activity of the supraspinatus muscle and reported conflicting results.

Objective: To quantify EMG activity of the supraspinatus, middle deltoid, and posterior deltoid muscles during exercises commonly used in rehabilitation.

Design: One-factor, repeated-measures design.

Setting: Controlled laboratory.

Patients or Other Participants: Twenty-two asymptomatic subjects (15 men, 7 women) with no history of shoulder injury participated.

Main Outcomes Measure(s): The dominant shoulder was tested. Fine-wire EMG electrodes were inserted into the supraspinatus, middle deltoid, and posterior deltoid muscles. The EMG data were collected at 960 Hz for analysis during maximal voluntary isometric contraction (MVIC) and 5 repetitions of 3 exercises: standing elevation in the scapular plane ("full can"), standing elevation in the scapular plane with glenohumeral internal rotation ("empty can"), and prone horizontal abduction at 100° with glenohumeral external rotation ("prone full can"). We calculated 1-way repeated-measures analysis of variance ($P < .05$) and post hoc 2-tailed, paired t tests to detect significant differences in muscle activity among exercises.

Results: No statistical difference existed among the exercises for the supraspinatus. The middle deltoid showed significantly greater activity during the empty-can exercise (77 ± 44% MVIC) and prone full-can exercise (63 ± 31% MVIC) than during the full-can exercise (52 ± 27% MVIC) ($P = .001$ and .017, respectively). The posterior deltoid showed significantly greater activity during the prone full-can exercise (87 ± 53% MVIC) than during the full-can ($P = .001$) and the empty-can ($P = .005$) exercises and significantly greater activity during the empty-can exercise (54 ± 24% MVIC) than during the full-can exercise (38 ± 32% MVIC) ($P = .012$).

Conclusions: While all 3 exercises produced similar amounts of supraspinatus activity, the full-can exercise produced significantly less activity of the deltoid muscles and may be the optimal position to recruit the supraspinatus muscle for rehabilitation and testing. The empty-can exercise may be a good exercise to recruit the middle deltoid muscle, and the prone full-can exercise may be a good exercise to recruit the posterior deltoid muscle.

Key Words: shoulder, dynamic stabilization, empty-can exercises, full-can exercises, prone full-can exercises, rotator cuff, scaption

Key Points

- The full-can exercise may be the safest and most effective exercise to strengthen the supraspinatus muscle in patients with shoulder lesions.
- Compared with the empty-can and prone full-can exercises, the full-can exercise elicited the same amount of supraspinatus activity with the least amount of middle and posterior deltoid muscle activity.
- The full-can exercise also may be the best exercise for manual muscle testing of the supraspinatus.

The glenohumeral joint exhibits the greatest amount of motion of any joint in the human body.[1] The rotator cuff provides dynamic stability by compressing the humeral head within the concave glenoid fossa during upper extremity motion, which is critical to normal functional activities.[2] This synergistic compressive force is necessary to efficiently counteract the superiorly oriented force produced by the larger muscle groups of the shoulder, such as the deltoid, and maintain the centralized position of the humeral head within the glenoid fossa during upper extremity movements.[3–5] Pathologic lesions of the rotator cuff, particularly of the supraspinatus muscle, often develop because of an overuse or traumatic injury. Any pathologic condition of the rotator cuff may affect the ability of the rotator cuff to provide this com-

0363-5465/102/3030-0136$02.00/0
THE AMERICAN JOURNAL OF SPORTS MEDICINE, Vol. 30, No. 1

Current Concepts

Current Concepts in the Rehabilitation of the Overhead Throwing Athlete

Kevin E. Wilk,*† PT, Keith Meister,‡ MD, and James R. Andrews,§|| MD

*From *HealthSouth Rehabilitation Corporation and American Sports Medicine Institute, Birmingham, Alabama, ||Tampa Bay Devil Rays Baseball Team, Tampa Bay, Florida, ‡Department of Orthopaedics, Division of Sports Medicine, University of Florida, Gainesville, Florida, and §Alabama Sports Medicine and Orthopaedic Center, Birmingham, Alabama*

ABSTRACT

The overhead throwing motion is an extremely skillful and intricate movement that is very stressful on the shoulder joint complex. The overhead throwing athlete places extraordinary demands on this complex. Excessively high stresses are applied to the shoulder joint because of the tremendous forces generated by the thrower. The thrower's shoulder must be lax enough to allow excessive external rotation, but stable enough to prevent symptomatic humeral head subluxations, thus requiring a delicate balance between mobility and functional stability. We refer to this as the "thrower's paradox." This balance is frequently compromised, which leads to injury. Numerous types of injuries may occur to the surrounding tissues during overhead throwing. Frequently, injuries can be successfully treated with a well-structured and carefully implemented nonoperative rehabilitation program. The key to successful nonoperative treatment is a thorough clinical examination and accurate diagnosis. Athletes often exhibit numerous adaptive changes that develop from the repetitive microtraumatic stresses observed during overhead throwing. Treatment should focus on the restoration of these adaptations during the rehabilitation program. In this article, the typical musculoskeletal profile of the overhead thrower and various rehabilitation programs for specific injuries are discussed. Rehabilitation follows a structured, multiphase approach with emphasis on controlling inflammation, restoring muscle balance, improving soft tissue flexibility, enhancing proprioception and neuromuscular control, and efficiently returning the athlete to competitive throwing.

The repetitive microtraumatic stresses placed on the athlete's shoulder joint complex during the throwing motion challenge the physiologic limits of the surrounding tissues. Frequently, alterations in throwing mechanics, muscle fatigue, muscle weakness or imbalance, and excessive capsular laxity may lead to tissue breakdown and injury. These injuries frequently involve the glenohumeral capsule, glenoid labrum, and the rotator cuff musculature.

It has been our experience that most injuries to the thrower's shoulder can be effectively treated with a proper nonoperative rehabilitation program. Generally, the rehabilitation program consists of activity modification, flexibility exercises, strengthening exercises, and a gradual return to throwing activities. In part one of his "Current Concepts" series, Meister [64] described a four-group classification system to categorize shoulder injuries in the overhead throwing athlete. We will discuss the rehabilitation program for each of the classifications. Bison and Andrews[10] have also offered a classification system for injuries to the thrower's shoulder. Each of these abnormalities develops because of unique etiologic factors. On the basis of these etiologic factors and the clinical examination, a proper rehabilitation program can be developed for each category. The key to effective treatment is a thorough clinical examination and appropriate differential diagnosis. In this article, we will discuss a typical nonoperative rehabilitation program for various shoulder injuries that have been discussed in the previous two articles.

REHABILITATION OVERVIEW

Before the specifics of the rehabilitation program can be discussed, a thorough understanding of the clinical exam-

† Address correspondence and reprint requests to Kevin E. Wilk, PT, HealthSouth Rehabilitation Corporation, 1201 11th Avenue South, Suite 100, Birmingham, AL 35202.

No author or related institution has received financial benefit from research in this study.

0363-5465/102/3030-0020$02.00/0
THE AMERICAN JOURNAL OF SPORTS MEDICINE, Vol. 30, No. 1

Osseous Adaptation and Range of Motion at the Glenohumeral Joint in Professional Baseball Pitchers*

Heber C. Crockett,†‡ MD, Lyndon B. Gross,§ MD, PhD, Kevin E. Wilk,§ PT, Martin L. Schwartz,§ MD, Jamie Reed,|| ATC, Jay O'Mara,§ MD, Michael T. Reilly,|| MD, Jeffery R. Dugas,§ MD, Keith Meister,[a] MD, Stephen Lyman,|| PhD, and James R. Andrews,§ MD

From †Trailswest Sportsmedicine, Kearney, Nebraska, §American Sports Medicine Institute, Birmingham, Alabama, ||Tampa Bay Devil Rays Baseball Club, Tampa Bay, Florida, and [a]University of Florida Shands Clinic, Gainesville, Florida

ABSTRACT

The throwing shoulder in pitchers frequently exhibits a paradox of glenohumeral joint motion, in which excessive external rotation is present at the expense of decreased internal rotation. The object of this study was to determine the role of humeral head retroversion in relation to increased glenohumeral external rotation. Glenohumeral joint range of motion and laxity along with humeral head and glenoid version of the dominant versus nondominant shoulders were studied in 25 professional pitchers and 25 nonthrowing subjects. Each subject underwent a computed tomography scan to determine bilateral humeral head and glenoid version. The throwing group demonstrated a significant increase in the dominant shoulder versus the nondominant shoulder in humeral head retroversion, glenoid retroversion, external rotation at 90°, and external rotation in the scapular plane. Internal rotation was decreased in the dominant shoulder. Total range of motion, anterior glenohumeral laxity, and posterior glenohumeral laxity were found to be equal bilaterally. The nonthrowing group demonstrated no significant difference in humeral head retroversion, glenoid retroversion, external rotation at 90° or external rotation in the scapular plane between shoulders, and no difference in internal rotation at 90°, total motion, or laxity. A comparison of the dominant shoulders of the two groups indicated that both external rotation at 90° and humeral head retroversion were significantly greater in the throwing group.

In the throwing athlete, a delicate balance of mobility and dynamic stability is required for the shoulder. Dynamic stabilization of the glenohumeral joint is accomplished through coordinated muscular activities coupled with ligament and capsular restraints. Competitive overhead throwing athletes perform at the extremes of glenohumeral motion and place tremendous repetitive stresses on their shoulders. These stresses generate humeral angular velocities of up to 7550 deg/sec and rotational torques of up to 67 N·m.[11] The importance of this delicate balance is apparent when considering that the shoulder joint must withstand these forces over the course of a season or a career. When this balance is disrupted, shoulder instability and secondary impingement may result.

Most of the interest in shoulder instability and secondary impingement has focused on the static stabilizers of the shoulder, specifically the soft tissues. Many researchers have investigated the role of excessive motion, capsular laxity, and limited shoulder flexibility as possible etiologic factors in instability and impingement.[1,3,6,14,15,22,23,30] Evidence exists that the dominant shoulder in throwing athletes exhibits a unique and paradoxical glenohumeral range of motion. Specifically, there is greater external rotation and a loss of internal rotation when the dominant shoulder is compared with the nondominant shoulder.[3,14,15,22,28] The implication of this altered arc of motion is that a physiologic adaptation of the dominant shoulder through repetitive microtrauma leads to selective stretching of the anterior capsule and tightening of the posterior capsule,

*Presented at the 26th annual meeting of the AOSSM, Sun Valley, Idaho, June 2000.

‡ Address correspondence and reprint requests to Heber C. Crockett, MD, 2 Rolling Hills Road, Kearney, NE 68845.

No author or related institution has received any financial benefit from research in this study. See "Acknowledgments" for funding information.

Correlation of Range of Motion and Glenohumeral Translation in Professional Baseball Pitchers

Paul A. Borsa,*† PhD, ATC, Kevin E. Wilk,‡ DPT, Jon A. Jacobson,§ MD, Jason S. Scibek,|| MA, ATC, CSCS, Geoffrey C. Dover,† MS, CAT(c), ATC, Michael M. Reinold,‡ DPT, ATC, CSCS, and James R. Andrews,¶ MD

From the †Sports Medicine Research Laboratory, University of Florida, Gainesville, Florida, the ‡Champion Sports Medicine, Birmingham, Alabama, the §Department of Radiology and the ||Division of Kinesiology, University of Michigan, Ann Arbor, Michigan, and the ¶Alabama Sports Medicine and Orthopedic Center, Birmingham, Alabama

Background: Altered mobility patterns in the throwing shoulders of professional baseball pitchers have been reported. Most published reports examining glenohumeral laxity have not used an objective testing device.

Objective: Quantify and compare glenohumeral translation and rotational range of motion between the throwing and non-throwing shoulders in professional baseball pitchers.

Study Design: Descriptive laboratory study.

Methods: Force-displacement and range of motion measures were performed bilaterally on 43 asymptomatic professional baseball pitchers. Ultrasound imaging was used to measure glenohumeral translations under stressed and unstressed conditions.

Results: No significant difference in translation was found between the throwing and nonthrowing shoulders. For both shoulders, posterior translation (5.38 ± 2.7 mm) was significantly greater ($P < .001$) than was anterior translation (2.81 ± 1.6 mm). External rotation in the throwing shoulder was significantly greater than that in the nonthrowing shoulder ($P < .001$), whereas internal rotation in the throwing shoulder was significantly less than that in the nonthrowing shoulder ($P < .001$). The total arc of rotation for the throwing shoulder was not significantly different than that for the nonthrowing shoulder, and correlation coefficients were poor between rotational and translational range of motion in the throwing shoulder, ranging from $r = 0.232$ to 0.209 between variables.

Conclusion: No significant difference in glenohumeral translation exists between the throwing and nonthrowing shoulders in asymptomatic professional baseball pitchers, posterior translation is significantly greater than anterior translation in the throwing shoulders of professional baseball pitchers, and glenohumeral translation is not related to rotational range of motion in the throwing shoulders of professional baseball pitchers.

Clinical Relevance: Altered mobility patterns in asymptomatic professional baseball pitchers may be due to factors other than capsular adaptive changes.

Keywords: shoulder; force displacement; sonography; joint laxity; ligament

The throwing shoulder in the overhead-throwing athlete has received considerable attention from individuals in the sports medicine and orthopaedic communities. Numerous studies have examined and compared bilaterally humeral range of motion,[4,7,10,11,26,30] muscular strength,[4,21,34,35] EMG activity,[13] and biomechanics[8,12] in overhead-throwing athletes. Several authors have documented that the throwing shoulder exhibits significantly more external rotation and significantly reduced internal rotation when compared to the nonthrowing shoulder.[2,4,7,10,11,19,26,30] These same studies also note that even though the range of motion in the throwing shoulder is

*Address correspondence to Paul A. Borsa, PhD, ATC, University of Florida, 149 Florida Gymnasium, PO Box 118205, Gainesville, FL 32611-8205 (e-mail: pborsa@hhp.ufl.edu).

No potential conflict of interest declared.

The American Journal of Sports Medicine, Vol. 33, No. 9
DOI: 10.1177/0363546504273490

Sports Medicine and Arthroscopy Review
9:69–95

Postoperative Treatment Principles in the Throwing Athlete

Kevin E. Wilk, P.T.,*†‡ Michael M. Reinold, P.T.,‡ and James R. Andrews, M.D.†§

Summary: Rehabilitation plays a vital role in the ultimate functional outcome after surgery in the overhead-throwing athlete. The ultimate goal of the postoperative rehabilitation program is to return the athlete to unrestricted sport specific activities as expeditiously and safely as possible while minimizing postsurgical complications. Rehabilitation after surgical procedures to stabilize the throwing shoulder must allow adequate healing time without allowing significant loss of motion to occur. Emphasis is placed on immediate but restricted and controlled motion, as well as the development of proprioception, neuromuscular control, and dynamic stabilization of the glenohumeral and scapulothoracic joint. The rehabilitation program will vary based on the unique characteristics and pathology of each patient, the specific surgical procedure performed, and the healing rate of the soft tissues involved. All of these factors must be considered when designing a postsurgical rehabilitation program for the overhead-throwing athlete. This article discusses the postoperative rehabilitation principles for the overhead athlete as well as specific programs used following thermal-assisted capsular shrinkage, arthroscopic Bankart repairs, open anterior capsular shift procedures, and glenoid labrum procedures. **Key Words:** Rehabilitation—Stabilization—Thermal.

Rehabilitation plays a vital role in the ultimate functional outcome after shoulder stabilization surgery in the overhead-throwing athlete. The most significant challenge facing the clinician is the achievement of a delicate balance between mobility and stability. The overhead-throwing athlete must exhibit considerable glenohumeral joint mobility and laxity to allow the extreme motions necessary to throw effectively and without pain. The rehabilitation specialist must restore enough motion to allow functional throwing drills but not excessive motion, which may lead to a recurrence of instability.

The ultimate goal of the postoperative rehabilitation program is to return the athlete to unrestricted sport-specific activities. The process is gradual and requires adjustments along the way. After shoulder stabilization surgery, the emphasis is early guarded and restricted motion, protected strengthening, and a functional rehabilitation program. There are several surgical procedures to stabilize the thrower's shoulder joint, and there are significant differences among the rehabilitation programs that follow each of these procedures. We discuss specific rehabilitation programs for several of the most common surgical procedures.

Rehabilitation following shoulder stabilization surgery should proceed in a progressive and sequential fashion, organized in multiple phases with each phase comprising specific goals. The ultimate goal of the process is to return the athlete to throwing activities as expeditiously and safely as possible without complications. Probably the most common complication following shoulder stabilization surgery is loss of motion, particularly external rotation (ER) after anterior stabilization.[1] This can result in disastrous consequences for the overhead thrower.

The rehabilitation programs we discuss are based on several factors, including the type and classification of the instability exhibited by the athlete (Table 1) and the unique characteristics of the patient (Table 2). Thus, classifying the patients into specific pathologic and tissue categories may prevent some postoperative complications. Rehabilitation should be tailored to the indi-

From *Marquette University, Milwaukee, Wisconsin; and the †American Sports Medicine Institute, ‡HEALTHSOUTH Sports Medicine and Rehabilitation Center, and the §Alabama Sports Medicine and Orthopaedic Center, Birmingham, Alabama.

Send correspondence to Michael Reinold, P.T., Healthsouth Sports Medicine and Rehabilitation Center, 1201 11th Avenue South, Suite 100, Birmingham, AL 35205. E-mail: miker@asmi.org

Recipient of the 2002 Sports Physical Therapy Section Excellence in Research Award

Thermal-Assisted Capsular Shrinkage of the Glenohumeral Joint in Overhead Athletes: A 15- to 47-Month Follow-up

Michael M. Reinold, PT, ATC[1]
Kevin E. Wilk, PT[2]
Todd R. Hooks, PT[3]
Jeffrey R. Dugas, MD[4]
James R. Andrews, MD[5]

Study Design: Descriptive postoperative follow-up research.

Objectives: The purpose of this investigation was to describe the return-to-competition rate and functional outcome of overhead athletes following arthroscopic thermal-assisted capsular shrinkage (TACS).

Background: Traditional open procedures to correct instability in overhead athletes, such as capsulolabral repairs and capsular shifts, have produced less-than-favorable results, which have led to the development of TACS. Currently there are no long-term follow-up studies documenting the efficacy of this procedure in groups greater than 31 subjects or for a time period greater than 27 months.

Methods and Measures: Two hundred thirty-one consecutive overhead athletes who due to symptoms of hyperlaxity had previously undergone a TACS procedure from 1997 to 1999 were selected for inclusion in the study. During a 1-month period, 130 of these athletes (mean age ± SD, 24 ± 6 years; 113 male, 17 female) were contacted by phone for follow-up at a mean of 29.3 months postoperatively (range, 15.4-46.6 months). Of the 130, 105 participated in baseball (80 pitchers), 14 in softball, 4 in football (quarterbacks), 4 in tennis, and 3 in swimming. Fifty-four (42%) subjects were professional, 49 (38%) collegiate, 16 (12%) high school, and 11 (8%) recreational athletes. One hundred twenty-three of the 130 (95%) underwent 1 or more concomitant procedure(s) at the time of TACS. Most commonly performed were labral debridements (69%), rotator cuff debridements (65%), and superior labral repairs (35%). Subjects who returned to competition were retrospectively evaluated using a modified Athletic Shoulder Outcome Rating Scale to subjectively assess pain, strength and endurance, stability, intensity, and performance. Overall results were based on a 90-point scale with scores of 80 to 90 representing excellent, 60 to 79 good, 40 to 59 fair, and less than 40 poor results.

Results: One hundred thirteen out of 130 subjects (87%) returned to competition. Mean (±SD) time from surgery to return to competition was 8.4 ± 4.6 months. Mean outcome score for all subjects was 79/90; 75 (66%) subjects had excellent, 24 (21%) good, 11 (10%) fair, and 3 (3%) poor result. The mean outcome score for males was 80/90 and for females was 70/90.

Conclusions: The majority of overhead athletes (87%) successfully returned to competition following a TACS procedure with good-to-excellent long-term outcomes (88%). Based on the results of this study, TACS of the glenohumeral joint is a viable option for overhead athletes with pathological instability. *J Orthop Sports Phys Ther 2003;33:455–467.*

Key Words: *acquired laxity, baseball, rehabilitation, shoulder, shoulder instability*

[1] *Coordinator of Rehabilitative Research and Clinical Education, Healthsouth Rehabilitation, American Sports Medicine Institute, Birmingham, AL.*
[2] *National Director of Research and Clinical Education, Healthsouth Corporation, American Sports Medicine Institute, Birmingham, AL.*
[3] *Physical Therapist, Healthsouth Rehabilitation, Birmingham, AL.*
[4] *Orthopedic Surgeon, Alabama Sports Medicine and Orthopedic Center, American Sports Medicine Institute, Birmingham, AL.*
[5] *Orthopedic Surgeon, Alabama Sports Medicine and Orthopedic Center, Medical Director, American Sports Medicine Institute, Birmingham, AL.*
This study received the 2002 Sport Physical Therapy Section Excellence in Research Award and was approved by the American Sports Medicine Institute Institutional Review Board.
Send correspondences to Michael M. Reinold, Healthsouth Rehabilitation, 1201 11th Avenue South, Suite 100, Birmingham, AL 35205. E-mail: michael.reinold@healthsouth.com

The overhead athlete applies large forces upon the shoulder during the act of throwing and various other overhead sports. These high forces occur at angular velocities up to 7200°/s.[5] In addition, the overhead thrower exhibits excessive shoulder range of motion and soft tissue flexibility. In this population, Wilk et al[32] reported the average (±SD) shoulder external rotation at 90° of shoulder abduction to be 129° ± 9°. As a result of the excessive joint forces, angular velocities, and range of motion, shoulder injuries are common in the overhead athlete.

One of the most common pathologies treated by the sports medicine team in the overhead athlete is anterior microinstability.

KEVIN E. WILK, PT, DPT[1] • PADRAIC OBMA, MD[2] • CHARLES D. SIMPSON II, DPT[3]
E. LYLE CAIN, MD[4] • JEFFREY DUGAS, MD[4] • JAMES R. ANDREWS, MD[5]

Shoulder Injuries in the Overhead Athlete

The overhead throwing motion is a highly skilled movement performed at extremely high velocity, which requires flexibility, muscular strength, coordination, synchronicity, and neuromuscular control. The throwing motion generates extraordinary demands on the shoulder joint. It is because of these high forces, which are repetitively applied, that the shoulder is the most commonly injured joint in professional baseball pitchers.[27]

During the throwing movement, tremendous forces are placed on the shoulder joint at extremely high angular velocities. The acceleration phase of the pitch is the fastest movement recorded and reaches a peak angular velocity of 7250°/s.[41,43] It has been estimated that the anterior translation forces generated when pitching are equal to one-half body weight (BW) during the late cocking phase, and there is a distraction force equal to BW during the deceleration phase.[43] Consequently, throwing requires a high level of muscle activation, as indicated by the electromyographic signal of the shoulder musculature, which can exceed 80% to 100% of the signal measured during a maximum voluntary isometric contraction (MVIC).[54] Lastly, the thrower's shoulder often exhibits excessive motion and laxity. Wilk et al[112] stated that the thrower's shoulder must be "loose enough to throw but stable enough to prevent symptoms." Whether the typical injury sustained to the thrower's shoulder is due to hyperlaxity or capsular tightness is currently a controversial topic of discussion. Shoulder pathology can manifest as pain, diminished performance (velocity and accuracy), or a decrease in strength or range of motion. The challenge for medical practitioners is to determine the accurate differential diagnosis, the cause of the injury, and the most effective treatment plan based on the identified pathology.

In this manuscript, we will discuss the physical characteristic of the overhead athlete, common pathologies seen, and the nonoperative, surgical, and postoperative treatment.

• SYNOPSIS: The overhead throwing motion is an extremely skillful and intricate movement. When pitching, the overhead throwing athlete places extraordinary demands on the shoulder complex subsequent to the tremendous forces that are generated. The thrower's shoulder must be lax enough to allow excessive external rotation but stable enough to prevent symptomatic humeral head subluxations, thus requiring a delicate balance between mobility and functional stability. We refer to this as the "thrower's paradox." This balance is frequently compromised and believed to lead to various types of injuries to the surrounding tissues. Frequently, injuries can be successfully treated with a well-structured and carefully implemented nonoperative rehabilitation program. The key to successful nonoperative treatment is a thorough clinical examination and accurate diagnosis. Rehabilitation follows a structured, multiphase approach, with emphasis on controlling inflammation, restoring muscles' balance, improving soft tissue flexibility, enhancing proprioception and neuromuscular control, and efficiently returning the athlete to competitive throwing. Athletes often exhibit numerous adaptive changes that develop from the repetitive microtraumatic stresses occurring during overhead throwing. Treatment should include the restoration of these adaptations.

• LEVEL OF EVIDENCE: Level 5. *J Orthop Sports Phys Ther 2009;39(2):38-54. doi:10.2519/jospt.2009.2929*

• KEYWORDS: *baseball, glenohumeral joint, labral lesions, pitching, rotator cuff*

PHYSICAL CHARACTERISTICS

IT IS IMPORTANT FOR THE CLINICIAN to realize and appreciate the "typical" physical characteristics of the overhead thrower.

Range of Motion

Most throwers exhibit an obvious motion disparity, whereby shoulder external rotation (ER) is excessive and internal rotation (IR) is limited when measured at 90°

[1]Vice President of Education, Physiotherapy Associates, Exton, PA; Associate Clinical Director, Champion Sports Medicine, A Physiotherapy Associates Clinic, Birmingham, AL; Director of Rehabilitation Research, American Sports Medicine Institute, Birmingham, AL; Rehabilitation Consultant, Tampa Bay Rays Baseball Organization, Tampa Bay, FL. [2] Orthopaedic Sports Medicine Fellow, Andrews Sports Medicine, Birmingham, AL. [3] Physical Therapy Fellow, Champion Sports Medicine, Birmingham, AL. [4]Orthopaedic Surgeon, Andrews Sports Medicine Center, Birmingham, AL. [5]Orthopaedic Surgeon, Andrews Sports Medicine Center, Birmingham, AL; Medical Director, Tampa Bay Rays Baseball Organization, Tampa Bay, FL. Address correspondence to Dr Kevin E. Wilk, Champion Sports Medicine, 805 St Vincent's Drive, Suite C100, Birmingham, AL 35205. E-mail: kwilkpt@hotmail.com

Sports Medicine and Arthroscopy Review
8:124–134 © 2000 Lippincott Williams & Wilkins, Inc., Philadelphia

Biomechanics of the Overhead Throwing Motion

Kevin E. Wilk, P.T.,*‡ Keith Meister, M.D.,† Glenn Fleisig, Ph.D.,‡ and James R. Andrews, M.D.‡§

Summary: The throwing motion is a complex movement pattern that requires flexibility, muscular strength, coordination, synchronicity of muscular firing, and neuromuscular efficiency. During the act of throwing, excessively high stresses are generated at the shoulder joint because of the unnatural movements frequently performed by the throwing. The thrower's shoulder must be flexible enough to allow the excessive external rotation required to throw a baseball. The overhead throwing motion places tremendous demands on the shoulder joint complex musculature to produce functional stability. The surrounding musculature must be strong enough to assist in arm acceleration but must exhibit neuromuscular efficiency to produce dynamic functional stability. During the act of pitching, the angular velocity at the shoulder joint exceeds 7,000° per second and has been referred to as the fastest human movement. Tremendous forces are generated at the shoulder joint, at times up to one times body weight. Because of these tremendous demands, at incredible angular velocities, various shoulder injuries may occur. An understanding of the biomechanics of throwing will assist the clinician in the recognition of various injuries and their specific treatment approaches. In this paper, we discuss the biomechanics of the overhead throwing motion for baseball as well as football. **Key Words:** Baseball—Biomechanics—Throwing—Motion analysis.

The throwing motion is a complex movement pattern that requires flexibility, muscular strength, coordination, synchronicity of muscular firing, and neuromuscular efficiency. The overhead throwing athlete is a highly skilled individual. During the act of throwing, excessively high stresses are generated at the shoulder joint because of the unnatural movements frequently performed by the throwing. The thrower's shoulder must be flexible enough to allow the excessive external rotation required to throw a baseball. However, the thrower's shoulder must be stable enough to prevent symptomatic subluxations in the shoulder joint. Therefore, there appears to exist a paradox when describing the thrower's shoulder. The thrower's shoulder must be loose enough to throw, but stable enough to prevent humeral head subluxation. Hence the thrower's shoulder is in delicate balance between mobility and stability.

The overhead throwing motion places tremendous demands on the shoulder joint complex musculature to produce functional stability. The surrounding musculature must be strong enough to assist in arm acceleration but must exhibit neuromuscular efficiency to produce dynamic functional stability. During the act of pitching, the angular velocity at the shoulder joint exceeds 7,000° per second and has been referred to as the fastest human movement.[1] Furthermore, tremendous forces are generated at the shoulder joint, at times up to one times body weight. Because of these tremendous demands, at incredible angular velocities, various shoulder injuries may occur. An understanding of the biomechanics of throwing will assist the clinician in the recognition of various injuries and their specific treatment approaches. In this paper, we discuss the biomechanics of the overhead throwing motion for baseball as well as football.

From *HEALTHSOUTH Sports Medicine and Rehabilitation Center, Birmingham, Alabama, and Physical Therapy Programs, Marquette University, Milwaukee, Wisconsin; †Department of Orthopedics, University of Florida, Gainesville, Florida; ‡American Sports Medicine Institute, Birmingham, Alabama; and §Alabama Sports Medicine and Orthopedic Center, Birmingham, Alabama.

K.E. Wilk is Rehabilitation Consultant for the Tampa Bay Devil Rays, Tampa Bay, Florida.

Send correspondence to Kevin E. Wilk, P.T., Birmingham Sports Medicine, 1201 11th Avenue South, #200, Birmingham, AL 35205.

AJSM PreView, published on November 8, 2007 as doi:10.1177/0363546507308935

Changes in Shoulder and Elbow Passive Range of Motion After Pitching in Professional Baseball Players

Michael M. Reinold,*†‡ PT, DPT, ATC, CSCS, Kevin E. Wilk,§‖ PT, DPT, Leonard C. Macrina,§ MSPT, CSCS, Chris Sheheane,§ ATC, Shouchen Dun,‖ MS, Glenn S. Fleisig,‖ PhD, Ken Crenshaw,¶ ATC, CSCS, and James R. Andrews,‖# MD
From the †Boston Red Sox Baseball Club, Boston, Massachusetts, ‡Massachusetts General Hospital, Department of Orthopedics, Sports Medicine Division, Boston, Massachusetts, §Champion Sports Medicine, Birmingham, Alabama, ‖American Sports Medicine Institute, Birmingham, Alabama, ¶Arizona Diamondbacks Baseball Club, Phoenix, Arizona, and #Alabama Sports Medicine and Orthopedic Center, Birmingham, Alabama

Background: The overhead throwing athlete has unique range of motion characteristics of the shoulder and elbow. Numerous theories exist to explain these characteristics; however, the precise cause is not known. Although it is accepted that range of motion is altered, the acute effect of baseball pitching on shoulder and elbow range of motion has not been established.

Hypothesis: There will be a reduction in passive range of motion immediately after baseball pitching.

Study Design: Controlled laboratory study.

Methods: Sixty-seven asymptomatic male professional baseball pitchers participated in the study. Passive range of motion measurements were recorded using a customized bubble goniometer for shoulder external rotation, shoulder internal rotation, total shoulder rotational motion, elbow flexion, and elbow extension on the dominant and nondominant arms. Testing was performed on the first day of spring training. Measurements were taken before, immediately after, and 24 hours after pitching.

Results: A significant decrease in shoulder internal rotation (–9.5°), total motion (–10.7°), and elbow extension (–3.2°) occurred immediately after baseball pitching in the dominant shoulder ($P < .001$). These changes continued to exist 24 hours after pitching. No differences were noted on the nondominant side.

Conclusion: Passive range of motion is significantly decreased immediately after baseball pitching. This decrease in range of motion continues to be present 24 hours after throwing. High levels of eccentric muscle activity have previously been observed in the shoulder external rotators and elbow flexors during pitching. These eccentric muscle contractions may contribute to acute musculotendinous adaptations and altered range of motion. The results of this study may suggest a newly defined mechanism to range of motion adaptations in the overhead throwing athlete resulting from acute musculoskeletal adaptations, in addition to potential osseous and capsular adaptations.

Keywords: overhead throwing athlete; glenohumeral joint; capsule; internal impingement

The unique range of motion (ROM) characteristics of the shoulder in overhead throwing athletes have been well defined.[1-4,6,8,16,18,25,31] These studies have shown increased external rotation (ER) and decreased internal rotation (IR) at 90° of abduction in the throwing shoulder.[1-4,6,8,16,18,25,31] Wright et al[32] have documented a decrease in elbow extension and flexion ROM in throwing athletes.

Wilk et al[31] reported the shoulder passive ROM characteristics in 372 professional baseball players. The authors reported a mean of 129° ± 10° of ER and 61° ± 9° of IR in the throwing shoulder at 90° of abduction. The authors noted that ER was 7° greater and IR was 7° less in the dominant arm when compared with the nondominant arm. The concept of "total motion" was introduced in this article. Total motion is the total value of ER plus IR ROM (at 90° of abduction). The authors noted that there was not a significant difference in total motion bilaterally, despite alterations in ER and IR.

*Address correspondences to Michael M. Reinold, PT, DPT, ATC, CSCS, Coordinator of Rehabilitation Research & Education, MGH Sports Medicine Center, Fenway Park, 4 Yawkey Way, Boston, MA 02215 (e-mail: mreinold@redsox.com).

No potential conflict of interest declared.

The American Journal of Sports Medicine, Vol. X, No. X
DOI: 10.1177/0363546507308935

0363-5465/93/2101-0061$02.00/0
THE AMERICAN JOURNAL OF SPORTS MEDICINE, Vol. 21, No. 1

The strength characteristics of internal and external rotator muscles in professional baseball pitchers

KEVIN E. WILK,*†‡ PT, JAMES R. ANDREWS,† MD, CHRISTOPHER A. ARRIGO,* MS, PT, ATC, MICHAEL A. KEIRNS, MA, PT, ATC, AND DONNA J. ERBER,* MA

*From *HEALTHSOUTH Sports Medicine & Rehabilitation and the †American Sports Medicine Institute, Birmingham, Alabama*

ABSTRACT

The purpose of this study was to establish a data base regarding the isokinetic muscular performance characteristics of the external/internal rotator muscles of professional baseball pitchers. One hundred fifty healthy professional baseball pitchers were evaluated by use of a Biodex isokinetic dynamometer. The subjects tested had a mean age of 23.4 years and a mean body weight of 199 pounds. Isokinetic tests were performed concentrically at 180 and 300 deg/sec for both the throwing and nonthrowing shoulders. Testing procedures regarding positioning and stabilization followed established guidelines. The testing protocol and actual test repetitions were standardized for each subject. Statistical analysis was performed using the Pearson Product Moment Correlation and paired *t*-tests. Determination of the correlation coefficient was made at the $P < 0.05$ level of significance.

Test results for bilateral comparison of mean peak torque for the throwing and nonthrowing shoulders indicated no statistically significant difference between the internal rotators at both test speeds, or for the external rotators at 300 deg/sec. There was a significant statistical difference at the 180 deg/sec test speed for the external rotators. The external/internal rotator strength ratio indicated a 65% ratio at 180 deg/sec and a 61% ratio at 300 deg/sec. Data were also collected for mean peak torque/body weight ratios of the throwing shoulder to establish a data base in professional throwers.

This study offers clinical relevance in establishing a muscle performance profile for the professional thrower. This data base can therefore be used as criteria that should be met before an injured pitcher can be returned to throwing at the professional baseball level.

The dynamic stabilizers of the shoulder complex play an important role in glenohumeral stabilization during the throwing motion.[13,14] These stabilizers include the rotator cuff musculature (supraspinatus, infraspinatus, teres minor, and subscapularis), the deltoid, and the long head of the biceps brachii muscles.[2,7,14]

Statically, the glenohumeral joint is inherently unstable because of the normal configuration and composition of the geometry and ligamentous restraints of the joint.[3,4,16,18] The geometry of the joint, which is composed of the large humeral head in the relatively smaller glenoid fossa, affords the shoulder tremendous mobility at the expense of osseous stability. Additionally, the ligamentous restraints (the glenohumeral joint capsule and the bands of the anterior glenohumeral ligament) normally provide a moderate degree of static stability. However, in the thrower, these restraints are compromised because of the tremendous forces placed across the joint and the excessive motions required during throwing. Thus, in the throwing athlete, static glenohumeral stabilization is inadequate and the thrower must rely on the neuromuscular components of the shoulder to provide dynamic stability during throwing.

Biomechanically, the distraction forces at the glenohumeral joint during the acceleration to ball release phase of throwing are 1 to 1.5 times that of body weight (unpublished data, 1990), while the angular velocities produced by professional baseball pitchers range from 6500 to 7200 deg/sec.[6]

‡ Address correspondence and reprint requests to: Kevin E. Wilk, PT, Clinical Director, HEALTHSOUTH Sports Medicine & Rehabilitation, 1201 Eleventh Avenue South, Suite 100, Birmingham, AL 35205.

0363-5465/95/2303-0307$02.00/0
THE AMERICAN JOURNAL OF SPORTS MEDICINE, Vol. 23, No. 3

The Abductor and Adductor Strength Characteristics of Professional Baseball Pitchers

Kevin E. Wilk,*† PT, James R. Andrews,‡ MD, and Christopher A. Arrigo,* MS, PT, ATC

*From *HEALTHSOUTH Sports Medicine & Rehabilitation Center and ‡Alabama Sports Medicine & Orthopaedic Center, Birmingham, Alabama*

ABSTRACT

The purpose of this investigation was to establish a data base regarding the isokinetic muscular performance characteristics of the abductor and adductor muscles of professional baseball pitchers. Eighty-three healthy professional baseball pitchers (mean age, 22.6 years; mean weight, 199 pounds) were evaluated by use of a Biodex isokinetic dynamometer. Isokinetic tests were performed concentrically at 180 and 300 deg/sec for both the throwing and nonthrowing shoulders. The testing protocol and test repetitions were standardized for each subject. Statistical analysis was performed using a paired *t*-test. Determination of the correlation coefficient was made at the $P < 0.05$ level of significance. Test results for bilateral comparisons of mean peak torque for the throwing and nonthrowing shoulders demonstrated a significant difference in adductor values between the dominant and nondominant shoulders at both test speeds. There were no significant differences between extremities for the shoulder abductor muscles. The abductor-to-adductor muscle ratios between the throwing and nonthrowing shoulders were also statistically significant at both test speeds. Throwing arm values were 82.5% at 180 deg/sec and 93.8% at 300 deg/sec compared with only 66.0% and 70.3%, respectively, for the nonthrowing shoulders.

The overhead baseball throw is an explosive, high-velocity athletic movement that requires muscular strength and power, coordination, and synchronicity of muscular contraction. During the four phases of throwing (windup, cocking, acceleration, and follow-through) the shoulder complex moves through consistent planes of motion with specific muscular groups responsible for these movements.[9,14,15]

The shoulder abductor and adductor muscles play a significant role in the overhead throwing motion. The shoulder abductors are considered the deltoid and supraspinatus muscles, whereas, the adductors are the latissimus dorsi, pectoralis major, teres major, coracobrachialis and long head of the triceps brachii muscles. The abductor muscles have been found to be responsible for humeral elevation during the early cocking phase of throwing.[17] In contrast, the adductor muscles act to forcefully create internal rotation and adduction during the acceleration phase of throwing.[26] In addition, the shoulder adductor muscles contribute to dynamic glenohumeral stability by centering the humeral head within the glenoid fossa when they contract as the joint surfaces contact.[5]

Several investigators have examined isokinetic muscular performance of the shoulders' abductor and adductor muscles in baseball pitchers.[1,3,16] Alderink and Kuck[1] tested 26 high school and college baseball pitchers. The investigators reported no significant difference between the throwing shoulders' abductor muscles and those of the nonthrowing shoulder, whereas the throwing shoulders' adductor muscles were 50% stronger when compared with the contralateral limb. Bartlett et al.[3] examined the relationship of shoulder strength and throwing speed in 11 professional baseball pitchers and reported a positive statistical relationship between shoulder adductor strength and throwing speed. Pedegana et al.,[16] in a similar research design of eight professional baseball pitchers, found no direct relationship between adductor muscle isokinetic torque and throwing speed.

The purpose of this study was to study and quantify the isokinetic muscular performance test results of the shoulder adductor and abductor muscle groups in uninjured professional baseball pitchers. The goals of this study were to 1) compare the dominant throwing arm to the nondominant arm and establish a bilateral comparison ratio for the abductor and adductor muscles, 2) examine abductor-to-

† Address correspondence and reprint requests to: Kevin E. Wilk, PT, Director of Research and Clinical Education, HEALTHSOUTH Sports Medicine & Rehabilitation Center, 1201 Eleventh Avenue South, Suite 100, Birmingham, AL 35205.

No author or related institution has received financial benefit from this study.