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Doctors Woods and Burnett have reported no relationships with proprietary entities producing health care goods or services. Dr. Chimes is a patent holder and part-owner for ActivAided Orthotics.

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Comprehensive Approach to the Management of Scapular Dyskinesia in the Overhead Throwing Athlete

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Clinical Vignette

SM is a 16-year-old right-handed female volleyball player with no significant medical history who presents with progressively worsening right shoulder pain localized to the right periscapular region. There is no associated trauma or inciting event and pain is exacerbated when she serves or spikes the ball, and typically alleviated with rest. She denies any neck pain, radicular symptoms in the arm, or focal weakness, but her right arm just feels weaker, with less velocity on her serve. Treatment has included rotator cuff strengthening exercises and modalities under the supervision of her athletic trainer, but no physical therapy or injections. She was evaluated by her PCP, who ordered routine x-rays of the right shoulder that were normal. She also states that her PCP noticed her right shoulder blade was sticking out a little, so she underwent an electrodiagnostic evaluation that was negative.



FIGURE 1



FIGURE 2a



FIGURE 2b



FIGURE 2c

Upon examination at the UPMC Sports and Spine Clinic, she demonstrates slightly increased cervical flexion and forward rounded shoulders. The right scapula is malpositioned with increased prominence of the infero-medial angle (see Figure 1 on Page 1). She has full active shoulder range of motion with the exception of pain-limited abduction to 130 degrees and flexion to 150 degrees (see Figures 2a, 2b, 2c, above). She is tender to palpation along the medial border of the coracoid process, but otherwise there is no tenderness in the shoulder or cervical spine. Her neurologic and musculoskeletal examination is otherwise unremarkable, with the exception of decreased right hip internal ROM. She is frustrated because she doesn't know what is wrong and all tests to date have been normal. Now with the volleyball season over, she is looking forward to playing spring softball as an outfielder and is asking for recommendations.

Defining the Problem

Normal movement of the shoulder requires a fluid coordination of the scapula and the glenohumeral joint that allows the hand to achieve any position for specific sport-related activities. As forces are transmitted upward from the lower body through a kinetic chain, the scapula must allow the glenoid to be positioned at the appropriate angle for the glenohumeral joint to transfer energy from the lower body to the hand.¹ Alteration in the normal

kinematics of the scapula during scapulohumeral movements has been termed scapular dyskinesis.²

The overhead athlete requires full, unrestricted range of motion of the shoulder and arm to be able to perform the specific skill set essential to his or her sport. The shoulder has the greatest range of motion of any joint and transfers energy generated from the lower limbs into ballistic forces of the upper limb. With overhead athletes, shoulder injuries, such as subacromial impingement syndrome, rotator cuff tendonitis, glenohumeral instability, and labral injuries are common. An epidemiological study of 372 competitive professional and recreational athletes who performed overhead movements found that 44% experienced shoulder problems and 29% experienced shoulder pain at some point during their careers.³

Warner et al. described alterations in the normal static position and motion of the scapula in more than 68% of patients with a history of shoulder injuries.⁴ Although there are multiple studies linking scapular dyskinesis to almost all of the most common pathologic shoulder conditions,^{1,5,4,6} it appears that scapular dyskinesis is a non-specific response to a painful shoulder rather than a specific response to certain glenohumeral pathology.¹

For the scapula and shoulder to function properly, there needs to be a balance between flexibility and stability – often

termed the “thrower’s paradox.”⁷ Anything that upsets this balance can result in an array of altered kinematics of the scapulohumeral rhythm and lead to scapular dyskinesia. The disruption can be seen in numerous ways in competitive athletes as repetitive forces challenge the physiologic limits of the joint tissue. For example, elite volleyball players are estimated to perform as many as 40,000 spikes per season.⁸ With this volume of action and amount of force generated in these high-powered ballistic actions, it is easy to see how the flexibility/stability balance might be disrupted, causing shoulder pathology.

Given its variable presentation, the prevalence of scapular dyskinesia is often hard to quantify in specific sports. Review of the literature suggests that scapular dyskinesia appears to be most prevalent in overhead athletes, such as pitchers, swimmers, volleyball, water polo players, and athletes of racquet sports. There is however, a theoretical risk of developing this from any sport that requires repetitive scapulothoracic or scapulohumeral movement. There are no definitive studies of which we are aware that denote gender or age as risk factors for the development of scapular dyskinesia.

Scapular dyskinesia and its associated pathology have considerable impact on athletes, ranging from significant reduction in playing time (which may affect eligibility for college athletes), to chronic shoulder instability or degeneration over time. If dyskinesia can be diagnosed and treated early, then the athlete may potentially avoid lost playing time or more consequential shoulder injuries.

Pathophysiology of Scapular Dyskinesia

In an opinion paper, Kibler described the pivotal role of the scapula as a link in the kinetic chain that distributes high-energy forces generated in the legs, hips, trunk, and back to the arm and hand.⁹ An acquired dysfunction in any segment of this kinetic chain has to be compensated

for by another part in order to produce the same amount of force. Often in overhead throwing athletes, this dysfunctional adaptation occurs at the scapula.

Normal scapular motion is a combination of three movements: (1) upward/downward rotation of the glenoid through a horizontal axis perpendicular to the plane of the scapula; (2) internal/external rotation in a vertical axis through the plane of the scapula; and (3) anterior/posterior tilt in a horizontal axis in the plane of the scapula. In addition, the scapula can retract/protract around the rounded thorax.¹⁰ Studies designed to collect data on the 3D motion of the scapula have been conducted using electromagnetic surface sensors during both controlled humeral elevation and low-velocity throwing.^{10,11}

Overhand pitching is often used as the model for discussing the biomechanics for the overhead athlete, and therefore it is useful to think about how the scapula moves during the six phases of the throwing motion: wind-up, stride, arm-cocking, acceleration, deceleration, and follow-through. The cocking phase, specifically the late cocking phase, results in a maximally retracted, externally and upwardly rotated scapula in posterior tilt. The follow-through produces a protracted, internally and downward rotated scapula in anterior tilt. Although it is easy to get bogged down in the milieu of potentially abnormal scapular 3D kinematics resulting in scapular dyskinesia, it is simplified when thought about in terms of the kinetic chain: Abnormal positioning or motion in one portion of the kinetic chain has to be compensated by other portions of the kinetic chain.⁹ The most common pattern is that the athlete has abnormal motion in the proximal portions of the kinetic chain, such as insufficient rotation of the hips, which leads to an abnormal motion pattern upward into the upper limb. The potential causes of scapular dyskinesia can be summarized in several categories:

Postural or Anatomical Abnormalities

Stabilization of the scapula in a position of retraction, external rotation, and posterior tilt during arm elevation is required to maintain the optimal length-tension relationship and force generation of all muscles originating from it.^{6, 1, 12} The most common anatomical causes of scapular dyskinesis are excessive cervical lordosis or thoracic kyphosis, acromioclavicular subluxations or dislocations, and clavicular fractures. Excessive cervical lordosis or thoracic kyphosis can result in a more protracted and depressed scapula at rest. Ideally, the trapezius, serratus anterior, and rhomboids retract and upwardly rotate the scapula to place the glenoid in a more optimal position for proper glenohumeral motion.² As the main attachment to the axial skeleton, the scapula relies on an uncompromised acromioclavicular joint (AC) and clavicle to maintain its integrity. AC-joint subluxation or dislocations result in a separation from the clavicle and a downward, protracted scapula. It is estimated that 70% of patients with chronic type III AC dislocations will develop scapular dyskinesis from either the loss of function of this stable fulcrum of the shoulder girdle, or from the pain caused by the dislocation.¹³ Clavicle fractures that result in non-union or mal-union directly disrupt the only static restraint of the scapula, leading to instability.¹

Muscular/Capsule Inflexibility or Contracture

Anteriorly, via the attachment to the coracoid process, a tight pectoralis minor or short head of the biceps can create a forward pull, resulting in a more protracted, anteriorly tilted scapula.¹⁴ The coracoid process will often be quite tender because of the constant traction from the tight tendon, and is an important sign of scapular dysfunction. Additionally, the posterior capsule is often tight, possibly from repetitive injury as a restraint

during the follow-through and deceleration phases of overhead activities.^{15, 16, 17} This also can result in scapular protraction and anterior tilt through its soft tissue attachments to the scapula at the posterior glenoid rim and labral extension.¹⁸ Both of these will result in an anteriorly tilted and protracted scapula.

Deficits in Core Stability/ROM

Inflexibility or asymmetry in hip and trunk rotation, as well as relative weakness of the hip abductors/extensors and trunk flexors, negatively impact the kinetic chain by limiting proximal force generation.¹⁹ The lower limbs and trunk are responsible for generating just over half of the total kinetic energy for overhead activities.¹⁰ Consequently, even minor limitations in the pattern for normal force generation can have detrimental effects in more distal parts of the kinetic chain that need to compensate for the deficit. In a study by Reeser et al., consisting of 276 male and female collegiate intramural volleyball players, there was a correlation between core instability, as noted by the lack of trunk control over the planted leg and subsequent loss of balance while performing single leg stance, and a history of past or present shoulder problems. This highlights the potential impact that core weakness and trunk instability might have in producing shoulder dysfunction and scapular dyskinesis.²⁰

Scapular Muscle Fatigue and Pain Inhibition

Although there are 17 muscles that attach to the scapula, the fibers of the lower trapezius (LT) and serratus anterior (SA) have been shown by electromyography (EMG) to play the major role in stabilizing the scapula during arm motion.¹ Scapular motion results from patterned muscle activation and synchronized force coupling of these stabilizers.²¹ Whether it is from blunt trauma to the muscle itself, a summation of microtrauma resulting in weakness, overuse fatigue without the proper rest, or

inhibition by painful conditions around the shoulder, dysfunction of either of these two muscles alters dynamic stability, resulting in abnormal scapular kinematics.² Muscles around the shoulder are commonly inhibited by painful conditions. While the mechanism is not entirely clear, it is related to disorganization in the normal muscle activation patterns, leading to a decreased ability for the muscles to exert torque.² This is a common pattern in glenohumeral pathology, such as labral lesions.^{4, 22, 23, 24, 25, 26, 2, 27, 19, 18, 28} Muscles, such as the lower trapezius and the serratus anterior that are responsible for scapular stabilization, are perhaps the most susceptible to the effects of pain inhibition.²⁹ It has been demonstrated by EMG in individuals with shoulder pain that both the serratus anterior and lower trapezius show a delayed onset latency and decreased activity during the throwing motion.³⁰ This alteration in normal patterned muscle activation from pain inhibition leads to scapular dyskinesia.¹ For example, Tsai et al. assessed scapular kinematics before and after humeral external rotation fatiguing tasks, equal to five innings of pitching or one competitive swim practice. They found that normal scapular upward and external rotation and posterior tipping were all decreased after fatigue.³¹

Madsen et al. also showed an increased prevalence of scapular dyskinesia throughout the course of a single 100-minute training session in noninjured competitive swimmers. At the end of the training session, 82% showed signs of dyskinesia, as either scapular winging or dysrhythmia, leading the authors to assume that in the face of insufficient rest, dyskinesia might lead to shoulder pain and further inhibition of the scapular stabilizers.⁵

Nerve Injuries

In approximately 5% of cases, the etiology of scapular dyskinesia could be attributed to injury involving the

spinal accessory, long thoracic and/or suprascapular nerve.² The spinal accessory nerve is susceptible to blunt trauma at its superficial course in the posterior triangle of the neck, as well as from traction injury resulting in separation of head and shoulder, producing scapular winging from the loss of innervation to the trapezius.^{32, 33} The long thoracic nerve is tethered at both the middle scalene muscle and at its entry point on the serratus anterior. The nerve can be injured by traction with the arm in the overhead position with the head facing the contralateral side, as in a pitch in baseball, overhead spike in volleyball, or when taking a breath in freestyle swimming. The long thoracic nerve also is at risk to direct trauma along the lateral thoracic cage, especially with a maximally protracted scapula, as in the aforementioned motions producing scapular winging.³² Injury to the suprascapular nerve can lead to more of an indirect cause of scapular dyskinesia. In addition to the supraspinatus and infraspinatus muscles, the suprascapular nerve also innervates the glenohumeral joint, acromioclavicular joint, and the coracoacromial ligament. These are all potential sources of pain leading to inhibition, and thus improper biomechanics at the shoulder.³⁴ The suprascapular nerve can be entrapped across the transverse scapular ligament or spinoglenoid notch from a space-occupying lesion in this area,³⁴ but it is well acknowledged that in overhead athletes, suprascapular nerve injury is a result of traction neuropathy from repetitive hitting/pitching motions. In a study of 84 professional beach volleyball players, 30% were thought to have suprascapular neuropathy by clinical measures, but no evidence of entrapment.³⁵ A study conducted by Ringel found slowing of suprascapular nerve conduction velocities as the season progressed in baseball pitchers.³⁶

TABLE 1:
Differential Diagnosis of Shoulder Pain

Brachial plexopathy
Brachial neuritis or radiculitis
Thoracic outlet syndrome
Suprascapular nerve entrapment
Biceps tendinopathy
Calcific tendonitis
Labral pathology (SLAP lesion)
Rotator cuff pathology
Glenohumeral instability (anterior, posterior, multidirectional)
Impingement syndrome
Acromioclavicular sprain/injury
Scapular fracture
Degenerative osteoarthritis
Avascular necrosis of the humeral head

“SICK” Scapula Syndrome

“SICK” scapula syndrome is a term used to describe a constellation of findings seen in scapular dyskinesia, with four components: **S**capular malposition, **I**nferior medial border prominence, **C**oracoid pain and malposition, and **dysK**inesis of scapular movement.¹⁹ Recognized as an overuse syndrome, the SICK scapula protracted and anteriorly tilted position is a result, in part, from an overly tight pectoralis minor or short head of the biceps at the insertion to the coracoid process. This typically results in the appearance of an asymmetric, lowered throwing shoulder on static examination and in radically altered kinematics of the more distal glenohumeral and acromioclavicular joint.¹⁹

The diagnosis of scapular dyskinesia is made clinically and is based on a combination of shoulder pain with limitations of proper shoulder function. The differential diagnosis is listed in Table 1. Although there is a role for diagnostic imaging and electrodiagnosis in excluding other potential causes, the diagnosis relies heavily on a thorough history. Equally important, is a thorough shoulder examination assessing for asymmetry and muscle imbalance.

Specific history should include:

- Onset of symptoms, and whether they are related to participation in an overhead sporting activity.
- Location of pain, with specific attention to the posterior inferior scapular region.
- Specific training regimen, with emphasis on any changes in frequency, duration, or intensity.
- Prior history of any injuries intrinsic to the shoulder, as well as the proximal and distal to the shoulder involving the spine, upper, and lower limbs.

PHYSICAL EXAMINATION TO DIAGNOSE

SCAPULAR DYSKINESIS

Diagnosis of scapular dyskinesia should include examination of the scapula, both at rest and with movement, and performance of two scapular corrective maneuvers to see if either relieves pain or increases strength of the rotator cuff muscles.

Static Position of the Scapula

With the patient seated/standing, assess for evidence of asymmetry, particularly at the medial border and inferior angle. Keep in mind that asymmetric scapular/shoulder posture does not necessarily reflect pathology in unilateral overhead athletes who have more protracted, internally rotated and anteriorly tilted scapula in the dominant shoulder.³⁷ Although asymmetries do exist in asymptomatic shoulders, when accompanied by pain, it should be considered a likely contributing factor in scapular dyskinesia.³⁸ The coracoid process will often be quite tender because of the constant traction from tightness at the tendon's insertion, and is an important sign of scapular dysfunction.

Active Scapular ROM

With the patient seated/standing facing away from the examiner, assess humeral elevation looking for abnormal scapular kinematics and evidence of a painful arc. Normal scapular motion is demonstrated by a stable scapula with minimal motion during the initial 30 to 60 degrees of humeral elevation, then smooth and continuous rotation upward during further elevation without evidence of winging.³⁹ Until 30 to 60 degrees of arm abduction in the scapular plane, the proportion of humeral elevation to upward scapular elevation is approximately 8:1, and then it follows the 2:1 ratio glenohumeral to scapulothoracic motion through the full abduction arc.⁴⁰ The patient can either repetitively forward flex the shoulder or abduct the

shoulder in the scapular plane, with or without five-pound weights, to elicit scapular winging or dysrhythmia.

Winging is typically displayed by medial border or inferior angle displacement away from the posterior thorax.

Dysrhythmia is defined as early or excessive scapular elevation or shrugging on arm elevation and/or a rapid downward rotation during arm lowering, or a non-smooth or stuttering motion during these actions.^{39, 1, 41}

McClure et al. found weighted shoulder flexion to most commonly result in dyskinesia.³⁹

Relief of Symptoms through Scapular Corrective Maneuvers

Both the scapular assistance test (SAT) and the scapular retraction test (SRT) are evidence-based corrective maneuvers to reestablish proper scapular positioning and are valuable tools in determining if the painful arc can be relieved or ROM can be improved.^{41, 42, 38} The SAT is administered by applying gentle pressure to assist scapular upward rotation and posterior tilt as the patient elevates the arm. A positive result occurs when the painful arc of impingement symptoms is relieved and the arc of motion is increased. The SRT is accomplished by grading the supraspinatus muscle strength following standard manual muscle testing procedures, before and after placing the scapula in a retracted position. A positive test occurs when supraspinatus strength is increased when the scapula is placed in the retracted position.^{1, 9}

Potential Causative Factors from Other Structures

It is common for overhead throwing athletes to have a glenohumeral internal rotation deficit (GIRD) in their dominant limb, and deficits of greater than 20 degrees are often clinically significant. The more proximal portions of the kinetic chain also should be assessed, including hip range of motion (especially hip internal rotation), lumbosacral spine range of motion, and thorough assessment of functional tests, including prone planks and the single leg

squat. The single leg squat is a particularly effective maneuver for assessing the proximal kinetic chain in a way that simulates real-world overhead activities. The single leg squat is abnormal when the patient is unable to complete a controlled single leg squat with the contralateral leg flexed at the hip and extended at the knee. When performing the prone plank maneuver, if the athlete is unable to maintain the plank or push-up position with the weight distributed on the forearms and toes for 30 seconds, this is suggestive of core weakness that may be affecting the distal parts of the kinetic chain, including the scapula and shoulder.

Management of Scapular Dyskinesia

While treatment is primarily rehabilitation, there are no published studies showing if one approach is superior to another. Thus, most treatments have been developed from expert consensus opinion. Future research that critically examines outcomes is needed. The literature does show that the abnormal biomechanics do respond to rehabilitation and the patient can expect reduction of pain and resolution of scapular dyskinesia with appropriate therapy.

Scapular retraction is facilitated with the momentum produced by hip/trunk extension and trunk rotation, whereas scapular protraction is facilitated by hip/trunk flexion.¹ Exercises, such as the single leg squat work on hip and core musculature in order to aid appropriate scapular movement.¹⁷ Correcting the abnormal muscle firing patterns of the scapular stabilizers as it relates to the upper, middle, and lower fibers of the trapezius, serratus anterior, and rhomboids requires both open- and closed-kinetic chain exercises. It may be useful to start with closed-chain exercises (hand fixed) such as scapular clock or wall washes to work on the scapular translations

(upward/downward and retraction/protraction) and then progress to open-chain exercises (hand moving) to promote scapular stabilization. There are numerous exercises described in the literature tailored for each individual muscle. However, there are certain exercises confirmed by EMG, which specifically target the muscular imbalance and weakness commonly seen in scapular dyskinesia. Examples of these exercises include the low-row, lawnmower, robbery, and inferior glide.⁴³

Examples and instruction for the exercises discussed can be viewed and downloaded at <http://pmr.medicine.pitt.edu/content/RGR/Dyskinesia.pdf>.

Rotator cuff stretching and strengthening are recommended after scapula stabilizing exercises are performed. A typical rotator cuff strengthening program would include both free weights and Thera-Band® resistance, with emphasis placed on the eccentric phase of motion. Initially, since abduction of the arm may be painful, external and internal rotation exercises may be performed with the shoulder at 0 degrees of abduction, but since the goal is to return to overhead activities, these exercises should be progressed to greater degrees of abduction, and eventually to a standing position with the arm at 90 degrees of abduction, at least. When pain-free bilateral scapular movement symmetry has been restored, the athlete may integrate dynamic exercises that work the entire kinetic chain with gradual transition to full range of shoulder motion into the rehabilitation program. The athlete should then progress to sport-specific exercises, and finally transition back to full sports activities.¹⁷

It is important to institute a stretching program to restore or maintain range of motion. An example of a passive posterior capsule stretch is the sleeper stretch, designed to increase glenohumeral internal rotation.¹⁸ Stretching of