

Case Reports

# The Management of Valgus Extension Overload Syndrome Experienced with Hitting in a High School Baseball Player: A Case Report

Andrew B Piraino<sup>1</sup>, Brent M Davis<sup>2 a</sup>

<sup>1</sup> Houston Methodist Clear Lake Orthopedics & Sports Medicine, Friendswood, TX, USA; University of Southern California Division of Biokinesiology and Physical Therapy, Los Angeles, CA, USA, <sup>2</sup> Houston Methodist Clear Lake Orthopedics & Sports Medicine, Friendswood, TX, USA

Keywords: Baseball, Movement System, Valgus Extension Overload, Batting

<https://doi.org/10.26603/001c.38168>

---

## International Journal of Sports Physical Therapy

Vol. 17, Issue 6, 2022

---

### Background

Valgus extension overload syndrome (VEOS) of the elbow is a condition associated with overhead athletes. However, the non-surgical management of these individuals is not well documented.

### Purpose

To discuss the unique presentation, management, and outcomes of an adolescent baseball player with a chronic history of VEOS experienced during hitting.

### Case Description

A 15-year-old right-handed high school baseball catcher presented with a six-month history of right-sided ulnar elbow pain. Elbow MRI w/ contrast was consistent with VEOS. The initial examination demonstrated excessive resting right-sided humeral external rotation compared to his left. Valgus stress testing in the subject's hitting position reproduced symptoms, which were alleviated with retest while correcting excessive humeral external rotation. Weakness of the humeral internal rotators and stiffness/shortness of the posterior shoulder were found and thought to relate to the humeral contribution to his elbow movement dysfunction. Rehabilitation emphasized addressing impairments contributing to excessive humeral external rotation with reintegration into batting.

### Outcomes

After five weeks of physical therapy, the subject returned to soft toss hitting at approximately 75% velocity for the first time since symptom onset, without pain. At seven months after discharge, a phone conversation confirmed that the subject had returned to baseball without limitations.

### Discussion

Despite the concept of 'regional interdependence', common proximal impairments are often assumed to contribute to elbow pain without a clear biomechanical rationale. Future research demonstrating the specific biomechanical effects of the shoulder on the

---

**a Corresponding author:**

Brent M Davis, PT, DPT, OCS, FAAOMPT  
Senior Physical Therapist  
Houston Methodist Orthopedics & Sports Medicine: Friendswood  
505 S. Friendswood Dr. Suite 101 Friendswood, TX 77546  
Phone: 281.648.4250  
Fax: 281.648.4822  
Email: [bdavis4@houstonmethodist.org](mailto:bdavis4@houstonmethodist.org)

elbow is needed, in addition to more accessible examination strategies to assess their relationship.

### Level of Evidence

5

## BACKGROUND AND PURPOSE

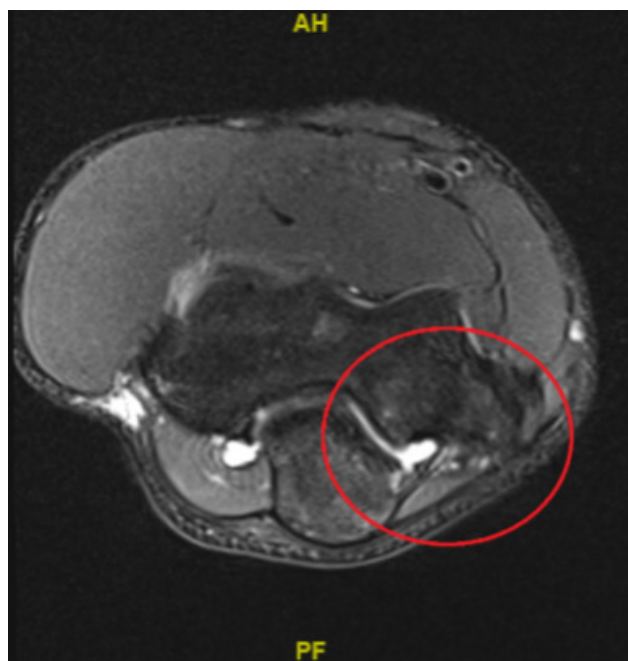
Valgus extension overload syndrome (VEOS) is a condition that results from impingement of the posteromedial tip of the olecranon process on the posteromedial wall of the olecranon fossa. VEOS is common among overhead athletes such as baseball pitchers. During pitching, the elbow is said to be exposed to angular velocities up to  $3000^{\circ}/\text{sec}^1$  with valgus forces of 64 Nm, during late cocking, and compressive forces of 500 N experienced at the lateral radiocapitellar joint as the elbow rapidly moves from  $120^{\circ}$  of flexion to  $25^{\circ}$  at ball release.<sup>2</sup>

In  $20$ - $120^{\circ}$  of flexion, the anterior bundle of the ulnar collateral ligament (UCL) is the primary restraint to valgus forces, when the elbow is moving into extension. Repeated valgus forces upon the UCL can lead to micro instability, resulting in excessive stress where the posteromedial portion of the olecranon contacts the olecranon fossa. This stress can create osteochondritis dissecans (OCD) of the capitulum, UCL injuries, and pathology at the posteromedial compartment of the humeroulnar joint (i.e. osteophyte formation, olecranon stress fractures, chondromalacia).<sup>3</sup>

Osteochondritis dissecans occurs at the anterolateral or central capitulum almost exclusively, comprising 97.5% of OCD lesions of the elbow and is correlated with valgus stress and axial loading. Stable lesions (those with patency of the articular cartilage and subchondral bone) often respond well to conservative treatment. Unstable lesions typically require procedures such as osteochondral autograft transplantation (OAT) or internal fixation. Return to sport is extremely variable after surgery, ranging from 62-100%.<sup>4</sup>

Conservative treatment for associated UCL injury focuses on restoring glenohumeral internal rotation and strength of the axioscapular, rotator cuff, and flexor-pronator musculature.<sup>5</sup> Should conservative intervention be unsuccessful, UCL reconstruction (Tommy John) surgery is preferred with an approximate 85% return to play for adolescent baseball players.<sup>6</sup>

Little is documented on conservative treatment for posteromedial impingement without frank compromise of the articular cartilage, subchondral bone, or UCL. Surgical outcomes for adolescents with posteromedial impingement has not been documented. In adults, surgical outcomes for posteromedial impingement are mixed, with greater success rates (72%) for those with isolated posteromedial compartment pathology<sup>7</sup> compared to those with combined lesions or UCL insufficiency (42%).<sup>8</sup> There have been no case reports of adolescent baseball players with persistent VEOS symptoms and difficulty returning to hitting. Therefore, the purpose of this case report is to describe a movement-focused examination and treatment strategy for such an individual, emphasizing the role of the physical therapist as a movement expert.

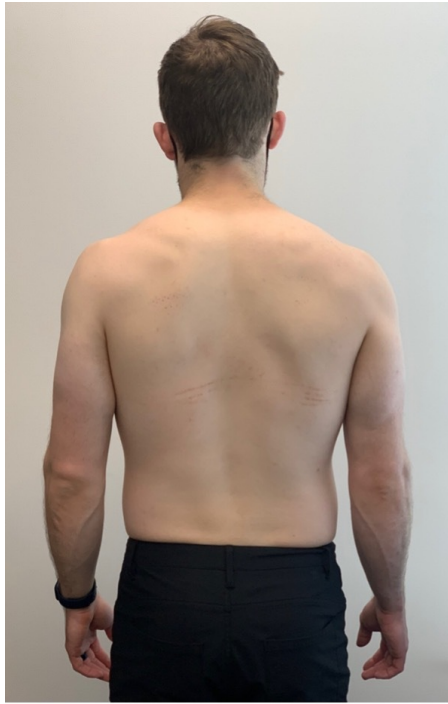


**Figure 1. Elbow MRI with intra-articular contrast demonstrating bone marrow edema of the medial epicondyle (red circle).**

## CASE DESCRIPTION

A 15-year-old right-handed male high school catcher presented to physical therapy with an approximate six-month history of medial elbow pain of gradual onset, having had an MRI with contrast (Figure 1). The accompanying radiologic report confirmed no presence of osteochondral lesion, fracture, or compromise of the anterior band of the ulnar collateral ligament. The report noted “marrow edema pattern of the distal humerus, medial epicondyle, olecranon, and proximal ulna involving the sublime tubercle and coronoid process most consistent with stress reaction in the setting of valgus extension overload.”

The subject denied a specific mechanism of injury, but reported a gradual increase with throwing, after which he began to experience “sharp” pain at the medial elbow with right-handed hitting. He initially underwent an initial set of six weeks (12 sessions) of physical therapy with another clinician at the same clinic, approximately three months after onset, consisting of forearm pronator strengthening at  $90^{\circ}$  of elbow flexion, scapular stabilizer, trunk, and sagittal plane lower extremity exercise (e.g. squats). Throwing improved significantly with treatment without any recurrence reported during follow-up with his orthopedic surgeon approximately 2.5 weeks after discharge. However, he reported a return of his medial elbow symptoms when resuming hitting.



**Figure 2. Standing alignment posterior view.**

Reproduction of subject's initial posture demonstrating scapular asymmetry and increased humeral external rotation.

He followed up with his hitting coach for several weeks, hitting off a tee, while continuing his home exercise program from previous physical therapy treatment. However, pain continued to persist with ball contact during hitting. He elected to take a break from throwing and hitting. He consulted his orthopedist, who referred him for further physical therapy. The subject of this case report was informed the data of this case would be submitted for publication and consented to the release of information.

## EXAMINATION

The subject was 5'10", weighing 155 lbs., with an ectomorphic body build. Subject's static posture was significant for the discrepancy between the subject's right humeral position in comparison to his scapula. The right scapula was relatively depressed and abducted in comparison to the left, which may have been expected given the subject's right-hand dominance.<sup>9</sup> However, despite greater right scapular internal rotation, the right humerus appeared to rest in greater external rotation and extension. The increased observed right scapular internal rotation suggested external humeral rotation was especially prevalent (Figure 2).<sup>10</sup>

Movement observation consisted of overhead elevation and simulation of subject's hitting position in combination with single leg squat due to the gluteal demand required during optimal hitting.<sup>11</sup> Overhead elevation demonstrated early right scapular upward rotation and greater internal rotation, a pattern associated with posterior shoulder mobility deficits.<sup>12</sup> The subject's hitting motion was simulated during the examination, with marked right humeral external rotation observed during the drive phase. The humeral

alignment appeared to compensate for the expected forearm supination of the trailing upper extremity, with the medial and lateral epicondyle near-parallel to the predicted line of force that would occur during ball contact. Sudden valgus force applied to the elbow in this position to simulate sudden ball contact reproduced the subject's symptoms. Manually internally rotating the humerus and then reapplying valgus force to the elbow made the motion pain free (Figure 3). No laxity was appreciated during valgus stress testing. At this point in the examination it was hypothesized the subject's primary movement dysfunction was excessive humeral external rotation resulting in increased valgus force at the elbow on the trailing upper extremity during ball contact. Additional impairments that could contribute to the preference for this hitting strategy were also assessed.

Shoulder and elbow range of motion were evaluated. Primary deficits included loss of bilateral shoulder internal rotation, although significantly more limited on the right (L 30°, R 10°; measured at 90° of abduction). Although humeral retroversion is common in overhead athletes, the total arc of motion on the subject's symptomatic side was 125°, well below previously established estimates (e.g. 160°).<sup>15</sup> Forearm supination was more limited on the left (L 80°, R 90°), while pronation was more limited on the right (L 80°, R 60°).

Key muscles involved in scapulohumeral and elbow mechanics were tested (strength measures are noted in table) using manual muscle testing (MMT). The subject's right serratus anterior, middle, and lower trapezius were graded equal or greater than the strength of the left. However, the subject's humeral internal rotators including the subscapularis and pectoralis major were a full grade weaker (L 5/5, R 4/5). Muscles were all tested by the same examiner using MMT, which has been found to have acceptable intrarater reliability.<sup>14</sup>

Lower extremity and trunk movement patterns were also screened, as the gluteal and trunk musculature are crucial for force development during hitting. Rolling was chosen as a transverse plane trunk stability pattern based on prior implementation in athletes and the absence of an established gold standard assessment for transverse plane lumbopelvic control,<sup>15</sup> which was symmetrical and negative for trunk and extremity dissociation. The single leg squat was chosen to functionally assess gluteal performance, as it has been shown to correlate to weakness of the hip extensors.<sup>16-18</sup> Observational analysis during the single leg squat demonstrated greater hip adduction and internal rotation on the right.

## ASSESSMENT

The subject demonstrated signs and symptoms consistent with valgus extension overload syndrome, confirmed on MRI and during physical examination. During both static standing and simulation of the batting position during the drive phase, the subject's humerus (and therefore elbow joint) appeared to be in excessive external rotation. This external rotation appeared to be a significant contributor



**Figure 3. Initial painful varus stress test (left) vs. painless varus stress test (right) with a red line to denote position of the humeral epicondyles.**

Note original test position was performed in a position simulating hitting, although modified above for clarity to the reader.

**Table. Objective Examination Data**

Examination Measure	Data
Shoulder PROM	ER (0° abduction): L 90°, R 95° ER (90° abduction): L 100°, R 105° IR (90° abduction): L 30°, R 10°
Elbow PROM	Extension (forearm supinated): L 10° of hyperextension, R 5° of hyperextension Supination: L 80°, R 90° Pronation: L 80°, R 60°
Flexibility Assessment	Wrist flexor-pronator flexibility (wrist and elbow extended with palm supinated): Stiffness throughout mid and end-range on right only
Manual Muscle Testing	Pectoralis Major (sternal fibers): L 5/5, R 4/5 Pectoralis Major (clavicular fibers): L 5/5, R 4/5 Serratus Anterior: L 4-/5, R 5/5 Middle Trapezius: L 4-/5, R 4/5 Lower Trapezius: L 4/5, R 4/5 Subscapularis: L 5/5, R 4/5 Pronator Teres: L 5/5, R 4/5 Grip Strength (2 <sup>nd</sup> position on Jamar hand dynamometer) tested in the following positions was symmetrical (100-110 lbs/force bilaterally): <ul style="list-style-type: none"> <li>• Elbow flexed to 90°:                             <ul style="list-style-type: none"> <li>◦ Forearm fully supinated</li> <li>◦ Forearm neutral</li> </ul> </li> <li>• Elbow fully extended:                             <ul style="list-style-type: none"> <li>◦ Wrist fully supinated</li> </ul> </li> </ul> Gluteus Maximus: L 5/5, R 3+/5

to the loads sustained at the right medial elbow. Symptom reproduction during the rapid applications of valgus force with complete resolution with medial rotation of the humerus assisted in confirming a movement diagnosis of

excessive humeral external rotation and the interpretation of relevant impairments to kinesio pathology.

There exists a paucity of data regarding elbow forces sustained during hitting or ball contact during baseball. However, during a baseball swing, the rear forearm must supinate to optimize bat contact with a pitch while the elbow rapidly extends at approximately 1200 to 1500°/sec.<sup>19</sup> If the humerus excessively externally rotates instead of forearm supination occurring, then the valgus moment at the humeroulnar joint significantly increases. Of significance was the subject's posterior shoulder stiffness. During swing, the rear humerus horizontally adducts to make ball contact. Flexibility impairments of the posterior shoulder are more profound in horizontal adduction and would contribute to increased humeral external rotation during swing as the humerus adducts,<sup>20</sup> driven by stiffness of the posterior cuff and external rotators.

Although very little is known about upper extremity muscle activation during baseball hitting, it is known key humeral internal rotators such as the pectoralis major and latissimus dorsi are active during ball contact.<sup>21</sup> Strength has also been correlated to upper quarter alignment.<sup>22</sup> The combination of excessive stiffness or shortness of the posterior shoulder with inadequate humeral internal rotator strength and activation during hitting would contribute to the excessively externally rotated humeral position and valgus stress at the elbow during ball contact. Although the lack of pronounced weakness (when tested via MMT) of the subject's right scapular stabilizers and posterior cuff musculature was somewhat surprising, the subject had previously completed a six-week physical therapy program focused on improving strength of these muscle groups.

Signs of weakness of the right gluteus maximus (e.g., during MMT and single leg squat)<sup>16-18</sup> were also thought to contribute to decreased pelvic rotation induced through the rear limb during the swing. This would result in a need

for increased humeral horizontal adduction, placing further strain on the subject's stiff and short posterior shoulder musculature and exacerbating humeral external rotation induced through the flexibility deficits of the posterior glenohumeral structures.

Although the subject's supination range of motion was slightly greater on the right, this could be explained through decreased pronator teres strength, which would also contribute to decreased dynamic resistance to valgus force.<sup>23,24</sup> The discrepancy between sides was minor and falls within the standard error of measure for goniometry at the elbow, which has been reported up to 11.5°. <sup>25</sup> As several thousand pounds of force occur during bat ball contact,<sup>26</sup> the primary focus of treatment was to prevent excessive humeral external rotation placing the coronal axis of the humeroulnar joint in-line with ball contact rather than attempting to improve dynamic elbow stability through pronator strength alone.

The above findings suggested a final movement diagnosis of excessive humeral external rotation contributing to the subject's symptoms and limitations during baseball.

## INTERVENTION

The treatment plan for this subject was focused on improving posterior shoulder flexibility, increasing strength and stiffness of the humeral medial rotators, and progressively integrating the concept of slightly increased humeral medial rotation into hitting maneuvers to decrease valgus stress at the medial elbow. The subject was provided insight regarding the underlying hypothesis and singular goal of treatment based on the excessive humeral external rotation movement diagnosis throughout the examination process. This was intended to empower him early on to correct any daily habits that may contribute to excessive humeral external rotation. Recent literature suggests in regard to rehabilitation, activity performance changes result in longer lasting and more meaningful change than exercise alone.<sup>27</sup>

Kinesiology tape was applied in a novel method, originating at the right medial antebrachial and elbow regions, and then spiraling proximally across the humerus to the right scapular region (Figure 4). The purpose of this taping was primarily to provide medial elbow support while reducing external humeral rotation throughout the day. Only one study has investigated the use of kinesiology tape for medial elbow pain,<sup>28</sup> which improved forearm control over that of sham taping. However, multiple studies have found benefits for the use of kinesiology tape for treatment of lateral epicondylitis regarding decreasing pain and improving grip strength.<sup>28,29</sup> Multiple authors have that found the direction of kinesiology tape does not change outcomes.<sup>30,31</sup>

Soft tissue mobilization to the posterior shoulder musculature was also performed early within treatment to improve the subject's ability to perform humeral internal rotation exercise through a larger range. Soft tissue mobilization has been shown to improve posterior shoulder flexibility in multiple populations<sup>32,33</sup> including baseball players. Humeral internal rotation at 90° of abduction improved 30° after a single session of soft tissue mobilization.



**Figure 4. Novel kinesiology taping technique to promote humeral internal rotation.**

Stretch was applied distal-to-proximal across the proximal antebrachium and medial epicondyle to the scapula.



**Figure 5. Prone shoulder internal rotation exercise to promote subscapularis use while inducing a stretch to the posterior shoulder.**

The subject was instructed on self-soft tissue mobilization to preserve these gains, an intervention which has been shown to be effective at improving humeral internal rotation.<sup>34</sup>

Manual therapy was combined with exercises to decrease posterior shoulder stiffness while concurrently increasing humeral internal rotator strength and stiffness. Prone (Figure 5) and supine (Figure 6) humeral rotation exercise in 90° of abduction was prescribed. Rotation with the humerus in 90° of abduction has been found to result in a relatively high percentage of subscapularis activation.<sup>35</sup>

Supine shoulder internal rotation with a dumbbell was also prescribed to eccentrically activate the humeral external rotators (Figure 6). Eccentric exercise was chosen to decrease actual stiffness and shortness of the posterior shoulder contributing to inadequate humeral internal rotation, as this contraction type has been shown to add sarcomeres in series.<sup>36</sup> Although very short-duration stretching pro-



**Figure 6. Supine shoulder internal rotation exercise to promote increased posterior shoulder flexibility (left).**

Incorrect performance (right) with compensatory anterior migration or extension of the humerus.

grams may improve stretch tolerance and ROM, their effects on changing the actual biomechanical properties of tissues is still being investigated.<sup>37</sup>

Strengthening of the pectoralis major and forearm pronators was also performed. The subject stood with a heavy band anchored to the side, while he horizontally adducted the humerus and pronated the forearm against resistance (Figure 7). The subject was cued to avoid internally rotating the scapula during this exercise to impart a stretch to the posterior shoulder. This exercise was aimed to optimize posterior shoulder flexibility by allowing the subject to assume a humeral position nearly identical to an across body stretch position<sup>38</sup> while maximizing force generation of the pectoralis major.<sup>39</sup>

As the subject advanced, neuromuscular reeducation during gripping was added to train the subject to allow for forearm supination without compensatory external rotation of the humerus (Figure 8). A two-pound bar was used, which the subject could simulate using his aluminum bat. The subject stood with the humerus flexed to 90° and observed his cubital fossa. He was instructed to grip the “bat” and then first rotate his humerus medially. He then rotated the “bat” outward, ensuring he did not also externally rotate the humerus during forearm supination. This was aimed to both teach control of the humerus during horizontally adducted positions that would be required during batting while also activating the flexor-pronator forearm musculature to assist in providing dynamic stability against elbow valgus.<sup>24,40</sup>

Integration of the gluteal musculature in a transverse pattern using a heavy resistance band was prescribed to improve pelvic and trunk rotation during batting, therefore reducing the requisite amount of horizontal humeral adduction (and therefore decreasing posterior shoulder flexibility demands that could induce external humeral rotation), during this movement. It is important to note the subject reported an improvement in symptoms prior to any specific intervention to address the trunk and pelvis, which were implemented at visit 4. The specific effect of the lower limbs on shoulder and elbow positioning and force are not



**Figure 7. Humeral internal rotator strengthening with cues to prevent compensatory scapular internal rotation.**

well studied. However, it is known that the gluteus maximus is active during the earlier portions of swing<sup>41</sup> and that pelvic rotation is crucial for generating force to achieve ball contact.<sup>42</sup>

The subject’s daily activities and existing exercise regimen were reviewed and modified to augment gains from the above program. For example, bench pressing was modified with cueing to adduct the scapula and avoid scapular protraction during the concentric phase of the press (Figure 9). This position would not only encourage humeral horizontal adduction for high-load pectoralis major activation, but also contribute to stretch of the posterior shoulder musculature under load. Exercises such as Palflof pressing were



**Figure 8. Forearm supination neuromuscular reeducation exercise to teach dissociation from humeral external rotation.**

integrated into the subject’s standard gym routine to optimize transverse plane trunk stability while also encouraging humeral horizontal adduction for posterior shoulder flexibility.

After this time, focus was placed on returning to hitting while the subject continued the above exercises. Interval

return to sport programs exist as suggested by Reinold et al.<sup>42</sup> as well as return to hitting suggested by Monti in 2015.<sup>43</sup> Similar guidelines were utilized for this subject’s return to sport. Return to hitting was conducted in three phases; hitting from a tee, soft toss, then from a pitch at moderate effort behind L-screen in batting cage. Swings were complete at subject perceived effort of 75-80%. Each phase consisted of progressive swing repetitions with at least 1 day rest in between to assess tolerance. The subject remained at one step in each phase until he could bat without symptoms before progressing, a similar methodology to those utilized in previously established return to play interval programs.

Two drills also were performed to specifically address the trailing elbow position to improve maintenance of the elbow posterior to the knob of the bat, and therefore to decrease the magnitude of external rotation of the humerus and during the acceleration and follow through phases of the bat swing.<sup>43</sup> During the first drill, a 10 lbs. dumbbell was utilized while the subject moved the weight through the 1<sup>st</sup> half of the swing with an isometric hold at what would be the contact point of the swing (Figure 10). The second drill was completed with a PVC pipe, maintaining the same position as the first drill with the isometric hold, then carrying out the remainder of the swing (Figure 11). Video analysis with the subject’s phone was utilized as biofeedback.

**OUTCOMES**

After four physical therapy sessions, the subject had returned to practice and resumed all throwing activities. He denied any recurrence of symptoms with throwing and



**Figure 9. Bench press neuromuscular reeducation activity modified to promote a posterior shoulder stretch while strengthening the pectoralis major (left). Incorrect performance (right) with scapular internal rotation.**



**Figure 10. Hitting Drill for swing phase to ball contact to prevent positioning of the elbow anterior to the knob of the bat, therefore reducing potential varus force.**



**Figure 11. Hitting drill for retraining follow-through phase.**

Note the right humerus remains in significant relative internal rotation compared to the magnitude of forearm supination.

humeral internal rotation PROM at 90° of abduction had improved from 10° to 30°. After 9 physical therapy sessions, he reported a 100% alleviation of symptoms with hitting. At the conclusion of physical therapy treatment, he continued to be able to throw without any limitations and had returned to hitting from live arm without pain at full effort. Follow-up via phone at seven months after discharge revealed that the subject had returned to play at full-capacity without any symptom recurrence.

## DISCUSSION

The subject presented to physical therapy with chronic medial elbow pain and confirmed MRI evidence of VEOS. Although he noted mild symptoms with throwing, he reported his primary aggravating activity was hitting. He had participated in 12 physical therapy sessions earlier during the year including traditional scapular stabilizer strengthening

exercises (e.g. shoulder taps, Ys and Ts), but had experienced a recurrence of symptoms upon return to hitting. After completing nine physical therapy visits over five weeks, he was able to return to all activities such as hitting without any pain.

Regional interdependence has been discussed for two decades<sup>44,45</sup> and adapted to encompass the general interactions between various physiologic systems.<sup>46</sup> The prevalence of scapular dysfunction in overhead athletes<sup>47</sup> and comprehensive rehabilitation programs for the elbow that include exercises for the rotator cuff, lower and middle trapezius, and serratus anterior<sup>48</sup> may contribute to a profession-wide assumption that these exercises will address the underlying movement problems in this population.

This case exemplifies the importance of a systematic movement examination and assessment of potential relevant contributing impairments for individuals who do not fall in the majority regarding common movement dysfunctions that lead to a given condition. For example, the subject did not present with any findings suggestive of remarkable scapular stabilizer (serratus anterior, middle, and lower trapezius) weakness or dyskinesia<sup>49</sup> that could contribute to his elbow dysfunction. Grip strength, tested to determine function of the medial elbow stabilizers such as the flexor digitorum superficialis and profundus measured at 100-110 lbs. of force (symmetrical between hands) in multiple positions and elbow angles, well above the 75<sup>th</sup> percentile for a 15 year-old male.<sup>50</sup> The subject had previously participated in a strengthening program consisting of exercises to address the scapular and medial elbow stabilizers with little success, and thus determining an underlying aberrant movement cause of continued pain was the focus upon the subject's return to physical therapy.

Although medial elbow pain in relation to throwing is relatively well researched,<sup>51,52</sup> there exists a paucity of literature regarding its incidence with hitting. Furthermore, unlike throwing, the contribution of the lower extremities,<sup>53</sup> trunk,<sup>54,55</sup> the scapula,<sup>56</sup> and the humerus<sup>57</sup> to forces at the elbow during hitting have not been studied. Dissimilar to pitching, batting is a reactive movement pattern that changes significantly in response to the pitcher.<sup>58-60</sup> This makes the study of an optimal movement pattern for batting difficult, as multiple strategies may be ideal based on the location and velocity of the ball.

However, the general phases of batting have been well-defined<sup>43,61</sup> and include preparatory, stance, stride, drive, bat acceleration, and follow-through phases.<sup>43</sup> The preparatory phase describes the initial batting stance preferred by each hitter. This transitions into the stance phase, during which the batter lifts their front leg, shifting their weight to the rear leg while coiling their trunk and upper extremities in reverse of the pitcher. This coiling continues as the batter then brings the front leg forward (stride phase) and then makes lead leg contact with the ground (drive phase). During drive phase, maximal energy storage is achieved through a further 12° of reverse arm motion.<sup>43</sup> At the end of the drive phase, the trailing elbow should be flexed with the shoulder adducted. The goal of these initial phases is to capitalize on the stretch-shortening cy-



cle to generate optimal force during the swing. This kinetic energy is transferred during the bat acceleration phase through rapid uncoiling beginning at the lower extremities, and then transitioning to the pelvis, trunk, shoulder, and elbows.<sup>61</sup> The final follow-through phase allows the batter to optimize pelvic rotation.

The moment of ball contact during the bat acceleration phase in relationship to the subject's pattern of humeral rotation is of specific relevance to this case. Bat velocity is assisted through rapid elbow extension just prior to ball contact, previously estimated at 948°/sec.<sup>61</sup> The rapid elbow extension to accelerate the bat combined with excessive humeral external rotation would increase valgus force on ball contact and replicate forces that occur during VEOS often seen in pitchers.<sup>62</sup>

Based on these phases of batting, a reasonable comprehension of movement requirements (e.g. rapid pelvic rotation, rear upper extremity horizontal adduction, rapid elbow extension) can be established by a physical therapist and systematically tested. The importance of beginning a physical examination with movement observation and tests confirming specific hypotheses of an underlying movement cause cannot be overstated. For example, for this subject, excessive right humeral external rotation was noted both at rest and with functional movements. The valgus stress test was positive for symptom reproduction when the subject replicated upper extremity position simulating ball contact and rapid valgus force was applied manually by the physical therapist. This test was implemented to simulate forces experienced by the subject during ball contact.

The hypothesis that excessive humeral external rotation was resulting in the subject's pain and pathology viewed on MRI was supported by then manually rotating the humerus into slightly greater internal rotation and repeating the same valgus stress test. For many subjects, multiple movements that are symptom provoking could be used with systematic modification of the movement to establish a pattern suggesting an underlying movement dysfunction. This is analogous to prior research that has found a battery of tests in physical examination is generally more useful in establishing a diagnosis than a single test.<sup>63,64</sup>

Impairments were then systematically assessed based on the movement diagnosis and movement observations. Factors relevant to their contribution to excessive humeral external rotation with batting were examined. For example, inadequate participation or stiffness of the humeral internal rotators such as the subscapularis, pectoralis major, and latissimus dorsi, or excessive stiffness of the humeral external rotators (especially those which would be placed in tension with forward humeral flexion) could contribute to the subject's preferred but painful hitting strategy. These impairments were all tested based on the initial standing static postural, movement, and functional testing examination. For example, during forward reaching and shoulder elevation, excessive early scapular upward rotation was noted. This is a pattern suggestive of inadequate mobility of the glenohumeral joint<sup>12</sup> and therefore, posterior shoulder stiffness contributing to excessive humeral external rotation was hypothesized to be a relevant contributing factor

to the movement syndrome. This was then tested in more isolation during measures such as humeral internal rotation mobility and palpation to the posterior shoulder musculature. Using this strategy, the clinician was able to systematically establish relevant impairments to the subject's movement dysfunction.

This case exemplifies the unique role of physical therapists as movement experts who are well equipped to address specific kinesio pathology based on physical examination. Although the profession has more recently transitioned to various classification models that match intervention to specific presentations in regions such as the lumbar spine,<sup>65</sup> programs in the upper quarter trend toward consistently addressing the rotator cuff and axioscapular musculature.<sup>48,66</sup> The prevalence of scapular dysfunction in overhead athletes<sup>47</sup> and comprehensive rehabilitation programs for the elbow that include exercises for the rotator cuff, lower and middle trapezius, and serratus anterior<sup>48</sup> may contribute to the assumption that these exercises are beneficial for all subjects with elbow or shoulder movement conditions. For the above subject, previous treatment including traditional scapular stabilization exercise was not effective in reducing his symptoms upon return to hitting, suggesting the importance of customizing intervention to specific patterns of movement dysfunction.

## LIMITATIONS

The presented case report has notable limitations, including the inability to generalize and non-experimental nature of this study. Furthermore, due to a lack of normative data regarding humeroulnar rotation during batting and subject privacy logistics, actual video analysis of upper quarter position throughout the hitting maneuver was not obtained. Pelvic and lower quarter normative data exist for batting,<sup>61,67</sup> and therefore video analysis may have revealed whether the integration of specific pelvic and trunk retraining during physical therapy was actually needed. Additionally, certain physical examination measures such as manual muscle testing in the shoulder possess questionable interrater reliability and reproducibility<sup>68</sup> and should be interpreted with caution.

## CONCLUSIONS

This case report exemplifies the importance of a systematic movement examination to establish an underlying movement diagnosis with which to efficiently guide treatment. The subject presented with continued signs of VEOS and limitations with baseball batting despite prior participation in physical therapy including exercises typically cited in a regional interdependence model. A systematic evaluation established an atypical movement diagnosis of excessive humeral external rotation contributing to valgus force during ball contact. This diagnosis guided all subsequent intervention. After nine physical therapy visits over five weeks, the subject was able to return to soft toss hitting, confirming a 100% return to play without recurrence at seven month follow-up. These outcomes demonstrate the suc-

successful implementation of a movement-based intervention program. Furthermore, they imply the importance of a specific application of human movement knowledge rather than generally implementing the concept of regional interdependence.

.....

#### DISCLOSURES

The authors of this case report have no conflicts of interest.

Submitted: February 22, 2022 CDT, Accepted: June 27, 2022 CDT



This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CCBY-NC-4.0). View this license's legal deed at <https://creativecommons.org/licenses/by-nc/4.0> and legal code at <https://creativecommons.org/licenses/by-nc/4.0/legalcode> for more information.

## REFERENCES

1. Kibler WB. Pathophysiology of overload injuries around the elbow. *Clin Sports Med.* 1995;14(2):447-457. doi:10.1016/s0278-5919(20)30235-0
2. Fleisig GS, Andrews JR, Dillman CJ, Escamilla RF. Kinetics of baseball pitching with implications about injury mechanisms. *Am J Sports Med.* 1995;23(2):233-239. doi:10.1177/036354659502300218
3. Park JY, Yoo HY, Chung SW, et al. Valgus extension overload syndrome in adolescent baseball players: clinical characteristics and surgical outcomes. *J Shoulder Elbow Surg.* 2016;25(12):2048-2056. doi:10.1016/j.jse.2016.09.007
4. Chau MM, Klimstra MA, Wise KL, et al. osteochondritis dissecans: Current understanding of epidemiology, etiology, management, and outcomes. *J Bone Joint Surg Am.* 2021;103(12):1132-1151. doi:10.2106/jbjs.20.01399
5. Swindell HW, Trofa DP, Alexander FJ, Sonnenfeld JJ, Saltzman BM, Ahmad CS. Nonsurgical management of ulnar collateral ligament injuries. *J Am Acad Orthop Surg Glob Res Rev.* 2021;5(4). doi:10.5435/jaaosglobal-d-20-00257
6. Hadley CJ, Edelman D, Arevalo A, Patel N, Ciccotti MG, Dodson CC. Ulnar collateral ligament reconstruction in adolescents: A systematic review. *Am J Sports Med.* 2021;49(5):1355-1362. doi:10.1177/0363546520934778
7. Cohen SB, Valko C, Zoga A, Dodson CC, Ciccotti MG. Posteromedial elbow impingement: Magnetic resonance imaging findings in overhead throwing athletes and results of arthroscopic treatment. *Arthroscopy.* 2011;27(10):1364-1370. doi:10.1016/j.artthro.2011.06.012
8. Andrews JR, Pierre RK, Carson WG Jr. Arthroscopy of the elbow. *Clin Sports Med.* 1986;5(4):653-662. doi:10.1016/s0278-5919(20)31081-4
9. Pontin JCB, Stadnyk SP, Suehara PT, Costa TR, Chamlian TR. Static evaluation of scapular positioning in healthy individuals. *Acta Ortop Bras.* 2013;21(4):208-212. doi:10.1590/s1413-78522013000400005
10. Sahrman SA. *Movement System Impairment Syndromes of the Extremities, Cervical and Thoracic Spines: Considerations for Acute and Long-Term Management.* Mosby Elsevier; 2011.
11. Reyes GF, Dickin DC, Crusat NJK, Dolny DG. Whole-body vibration effects on the muscle activity of upper and lower body muscles during the baseball swing in recreational baseball hitters. *Sports Biomech.* 2011;10(4):280-293. doi:10.1080/14763141.2011.629208
12. Ludewig PM, Reynolds JF. The association of scapular kinematics and glenohumeral joint pathologies. *J Orthop Sports Phys Ther.* 2009;39(2):90-104. doi:10.2519/jospt.2009.2808
13. Cieminski CJ, Klaers H, Kelly SM, Stelzmilller MR, Nawrocki TJ, Indrelie AJ. Total arc of motion in the sidelying position: evidence for a new method to assess glenohumeral internal rotation deficit in overhead athletes. *Int J Sports Phys Ther.* 2015;10(3):319-331.
14. Wadsworth CT, Krishnan R, Sear M, Harrold J, Nielsen DH. Intrarater reliability of manual muscle testing and hand-held dynamometric muscle testing. *Phys Ther.* 1987;67(9):1342-1347. doi:10.1093/ptj/67.9.1342
15. Lehr ME, Cheek W, Dacko S, et al. Movement patterns and neuromusculoskeletal impairments observed in a female olympic field hockey team: An observational cohort study. *J Bodyw Mov Ther.* 2021;26:128-133. doi:10.1016/j.jbmt.2020.12.037
16. Stickler L, Finley M, Gulgin H. Relationship between hip and core strength and frontal plane alignment during a single leg squat. *Phys Ther Sport.* 2015;16(1):66-71. doi:10.1016/j.ptsp.2014.05.002
17. Alzahrani AM, Alzhrani M, Alshahrani SN, Alghamdi W, Alqahtani M, Alzahrani H. Is hip muscle strength associated with dynamic knee valgus in a healthy adult population? A systematic review. *Int J Environ Res Public Health.* 2021;18(14):7669. doi:10.3390/ijerph18147669
18. Friesen KB, Shaw RE, Shannon DM, Dugas JR, Andrews JR, Oliver GD. Single-leg squat compensations are associated with softball pitching pathomechanics in adolescent softball pitchers. *Orthop J Sports Med.* 2021;9(3):2325967121990920. doi:10.1177/2325967121990920
19. Dowling B, Fleisig GS. Kinematic comparison of baseball batting off of a tee among various competition levels. *Sports Biomech.* 2016;15(3):255-269. doi:10.1080/14763141.2016.1159320

20. Dashottar A, Borstad J. Quantifying range-of-motion changes across 4 simulated measurements of the glenohumeral joint posterior capsule: An exploratory cadaver study. *J Orthop Sports Phys Ther.* 2016;46(12):1080-1085. doi:10.2519/jospt.2016.6440
21. Escamilla RF, Andrews JR. Shoulder muscle recruitment patterns and related biomechanics during upper extremity sports. *Sports Med.* 2009;39(7):569-590. doi:10.2165/00007256-200939070-00004
22. Ucurum SG, Karabay D, Ozturk BB, Kaya DO. Comparison of scapular position and upper extremity muscle strength in patients with and without lateral epicondylalgia: A case-control study. *J Shoulder Elbow Surg.* 2019;28(6):1111-1119. doi:10.1016/j.jse.2018.12.010
23. Udall JH, Fitzpatrick MJ, McGarry MH, Leba TB, Lee TQ. Effects of flexor-pronator muscle loading on valgus stability of the elbow with an intact, stretched, and resected medial ulnar collateral ligament. *J Shoulder Elbow Surg.* 2009;18(5):773-778. doi:10.1016/j.jse.2009.03.008
24. Pexa BS, Ryan ED, Myers JB. Medial elbow joint space increases with valgus stress and decreases when cued to perform a maximal grip contraction. *Am J Sports Med.* 2018;46(5):1114-1119. doi:10.1177/0363546518755149
25. van Rijn SF, Zwerus EL, Koenraadt KL, Jacobs WC, van den Bekerom MP, Eygendaal D. The reliability and validity of goniometric elbow measurements in adults: A systematic review of the literature. *Shoulder Elbow.* 2018;10(4):274-284. doi:10.1177/1758573218774326
26. Adair RK. *The Physics of Baseball.* 3rd ed. Harper Perennial; 2002.
27. van Dillen LR, Lanier VM, Steger-May K, et al. effect of motor skill training in functional activities vs strength and flexibility exercise on function in people with chronic low back pain: A randomized clinical trial. *JAMA Neurol.* 2021;78(4):385-395. doi:10.1001/jamaneurol.2020.4821
28. Chang HY, Cheng SC, Lin CC, Chou KY, Gan SM, Wang CH. The effectiveness of kinesio taping for athletes with medial elbow epicondylar tendinopathy. *Int J Sports Med.* 2013;34(11):1003-1006. doi:10.1055/s-0033-1333747
29. Eraslan L, Yuce D, Erbilici A, Baltaci G. Does Kinesiotaping improve pain and functionality in patients with newly diagnosed lateral epicondylitis? *Knee Surg Sports Traumatol Arthrosc.* 2018;26(3):938-945. doi:10.1007/s00167-017-4691-7
30. Giray E, Karali-Bingul D, Akyuz G. The Effectiveness of Kinesiotaping, sham taping or exercises only in lateral epicondylitis treatment: A randomized controlled study. *PM R.* 2019;11(7):681-693. doi:10.1002/pmrj.12067
31. Choi IR, Lee JH. Effect of kinesiology tape application direction on quadriceps strength. *Medicine (Baltimore).* 2018;97(24):e11038. doi:10.1097/md.00000000000011038
32. Laudner K, Compton BD, McLoda TA, Walters CM. Acute effects of instrument assisted soft tissue mobilization for improving posterior shoulder range of motion in collegiate baseball players. *Int J Sports Phys Ther.* 2014;9(1):1-7.
33. Jurdado-García M, Cuesta-Barriuso R. Soft tissue mobilization and stretching for shoulder in crossfitters: A randomized pilot study. *Int J Environ Res Public Health.* 2021;18(2):575. doi:10.3390/ijerph18020575
34. Le Gal J, Begon M, Gillet B, Rogowski I. Effects of self-myofascial release on shoulder function and perception in adolescent tennis players. *J Sport Rehabil.* 2018;27(6):530-535. doi:10.1123/jsr.2016-0240
35. Suenaga N, Minami A, Fujisawa H. Electromyographic analysis of internal rotational motion of the shoulder in various arm positions. *J Shoulder Elbow Surg.* 2003;12(5):501-505. doi:10.1016/s1058-2746(03)00169-1
36. Douglas J, Pearson S, Ross A, McGuigan M. Eccentric exercise: Physiological characteristics and acute responses. *Sports Med.* 2017;47(4):663-675. doi:10.1007/s40279-016-0624-8
37. Freitas SR, Mendes B, Le Sant G, Andrade RJ, Nordez A, Milanovic Z. Can chronic stretching change the muscle-tendon mechanical properties? A review. *Scand J Med Sci Sports.* 2017;28(3):794-806. doi:10.1111/sms.12957
38. McClure P, Balaicuis J, Heiland D, Broersma ME, Thorndike CK, Wood A. A randomized controlled comparison of stretching procedures for posterior shoulder tightness. *J Orthop Sports Phys Ther.* 2007;37(3):108-114. doi:10.2519/jospt.2007.2337
39. Lee HM. Force direction and arm position affect contribution of clavicular and sternal parts of pectoralis major muscle during muscle strength testing. *J Hand Ther.* 2019;32(1):71-79. doi:10.1016/j.jht.2017.08.007

40. Hoshika S, Nimura A, Takahashi N, Sugaya H, Akita K. Valgus stability is enhanced by flexor digitorum superficialis muscle contraction of the index and middle fingers. *J Orthop Surg Res.* 2020;15(1):121. doi:10.1186/s13018-020-01640-7
41. Shaffer B, Jobe FW, Pink M, Perry J. Baseball batting. An electromyographic study. *Clin Orthop Relat Res.* 1993;292:285-293. doi:10.1097/00003086-199307000-00038
42. Reinold MM, Wilk KE, Reed J, Crenshaw K, Andrews JR. Interval sport programs: Guidelines for baseball, tennis, and golf. *J Orthop Sports Phys Ther.* 2002;32(6):293-298. doi:10.2519/jospt.2002.32.6.293
43. Monti R. Return to hitting: an interval hitting progression and overview of hitting mechanics following injury. *Int J Sports Phys Ther.* 2015;10(7):1059-1073.
44. Wainner RS, Flynn TW, Whitman JM. *Spinal and Extremity Manipulation: The Basic Skill Set for Physical Therapists.* Manipulations, Inc; 2001.
45. Wainner RS, Whitman JM, Cleland JA, Flynn TW. Regional interdependence: A musculoskeletal examination model whose time has come. *J Orthop Sports Phys Ther.* 2007;37(11):658-660. doi:10.2519/jospt.2007.0110
46. Sueki DG, Cleland JA, Wainner RS. A regional interdependence model of musculoskeletal dysfunction: research, mechanisms, and clinical implications. *J Man Manip Ther.* 2013;21(2):90-102. doi:10.1179/2042618612y.0000000027
47. Burn MB, McCulloch PC, Lintner DM, Liberman SR, Harris JD. Prevalence of scapular dyskinesis in overhead and nonoverhead athletes: A systematic review. *Orthop J Sports Med.* 2016;4(2):2325967115627608. doi:10.1177/2325967115627608
48. Wilk KE, Macrina LC, Cain EL, Dugas JR, Andrews JR. Rehabilitation of the overhead athlete's elbow. *Sports Health.* 2012;4(5):404-414. doi:10.1177/1941738112455006
49. Kibler WB, Sciascia A. Evaluation and management of scapular dyskinesis in overhead athletes. *Curr Rev Musculoskelet Med.* 2019;12(4):515-526. doi:10.1007/s12178-019-09591-1
50. Bohannon RW, Wang YC, Bubela D, Gershon RC. Handgrip strength: A population-based study of norms and age trajectories for 3- to 17-year-olds. *Pediatr Phys Ther.* 2017;29(2):118-123. doi:10.1097/ep.0000000000000366
51. Takagishi K, Matsuura T, Masatomi T, et al. Shoulder and elbow pain in junior high school baseball players: Results of a nationwide survey. *J Orthop Sci.* 2019;24(4):708-714. doi:10.1016/j.jos.2018.12.018
52. Kurokawa D, Muraki T, Ishikawa H, et al. The influence of pitch velocity on medial elbow pain and medial epicondyle abnormality among youth baseball players. *Am J Sports Med.* 2020;48(7):1601-1607. doi:10.1177/0363546520914911
53. Deal MJ, Richey BP, Pumilia CA, et al. Regional interdependence and the role of the lower body in elbow injury in baseball players: A systematic review. *Am J Sports Med.* 2020;48(14):3652-3660. doi:10.1177/0363546520910138
54. Bullock GS, Strahm J, Hulburt TC, Beck EC, Waterman BR, Nicholson KF. The relationship of range of motion, hip shoulder separation, and pitching kinematics. *Int J Sports Phys Ther.* 2020;15(6):1119-1128. doi:10.26603/ijsp20201119
55. Oyama S, Yu B, Blackburn JT, Padua DA, Li L, Myers JB. Improper trunk rotation sequence is associated with increased maximal shoulder external rotation angle and shoulder joint force in high school baseball pitchers. *Am J Sports Med.* 2014;42(9):2089-2094. doi:10.1177/0363546514536871
56. Itami Y, Mihata T, McGarry MH, et al. Effect of increased scapular internal rotation on glenohumeral external rotation and elbow valgus load in the late cocking phase of throwing motion. *Am J Sports Med.* 2018;46(13):3182-3188. doi:10.1177/0363546518800267
57. Dines JS, Frank JB, Akerman M, Yocum LA. Glenohumeral internal rotation deficits in baseball players with ulnar collateral ligament insufficiency. *Am J Sports Med.* 2009;37(3):566-570. doi:10.1177/0363546508326712
58. Cañal-Bruland R, Filius MA, Oudejans RR. Sitting on a fastball. *J Mot Behav.* 2015;47(4):267-270. doi:10.1080/00222895.2014.976167
59. Ranganathan R, Carlton LG. Perception-action coupling and anticipatory performance in baseball batting. *J Mot Behav.* 2007;39(5):369-380. doi:10.3200/jmbr.39.5.369-380
60. Kuo SY, Cheng KB, Lee YC. Differences in baseball batting movement patterns between facing a pitcher and a pitching machine. *Res Q Exerc Sport.* 2021;92(3):420-428. doi:10.1080/02701367.2020.1741499

61. Welch CM, Banks SA, Cook FF, Draovitch P. Hitting a baseball: A biomechanical description. *J Orthop Sports Phys Ther.* 1995;22(5):193-201. [doi:10.2519/jospt.1995.22.5.193](https://doi.org/10.2519/jospt.1995.22.5.193)
62. Dugas JR. Valgus extension overload: Diagnosis and treatment. *Clin Sports Med.* 2010;29(4):645-654. [doi:10.1016/j.csm.2010.07.001](https://doi.org/10.1016/j.csm.2010.07.001)
63. Laslett M, Aprill CN, McDonald B, Young SB. Diagnosis of sacroiliac joint pain: Validity of individual provocation tests and composites of tests. *Man Ther.* 2005;10(3):207-218. [doi:10.1016/j.math.2005.01.003](https://doi.org/10.1016/j.math.2005.01.003)
64. Wainner RS, Fritz JM, Irrgang JJ, Boninger ML, Delitto A, Allison S. Reliability and diagnostic accuracy of the clinical examination and subject self-report measures for cervical radiculopathy. *Spine (Phila Pa 1976).* 2003;28(1):52-62. [doi:10.1097/00007632-200301010-00014](https://doi.org/10.1097/00007632-200301010-00014)
65. Alrwaily M, Timko M, Schneider M, et al. Treatment-based classification system for low back pain: Revision and update. *Phys Ther.* 2016;96(7):1057-1066. [doi:10.2522/ptj.20150345](https://doi.org/10.2522/ptj.20150345)
66. Kibler WB, Sciascia A. Current concepts: Scapular dyskinesis. *Br J Sports Med.* 2010;44(5):300-305. [doi:10.1136/bjism.2009.058834](https://doi.org/10.1136/bjism.2009.058834)
67. Ae K, Koike S, Fujii N, Ae M, Kawamura T, Kanahori T. A comparison of kinetics in the lower limbs between baseball tee and pitched ball batting. *Hum Mov Sci.* 2018;61:126-134. [doi:10.1016/j.humo.2018.07.010](https://doi.org/10.1016/j.humo.2018.07.010)
68. Ijspeert J, Kerstens HCJW, Janssen RMJ, Geurts ACH, van Alfen N, Groothuis JT. Validity and reliability of serratus anterior hand held dynamometry. *BMC Musculoskelet Disord.* 2019;20(1):360. [doi:10.1186/s12891-019-2741-7](https://doi.org/10.1186/s12891-019-2741-7)