

1-1-2016

# The Painful Long Head of the Biceps Brachii: Nonoperative Treatment Approaches

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**Keywords:** Rehabilitation; Shoulder; Elbow; Biceps

### **Key points**

- Abnormality involving the long head of the biceps has a variety of clinical conditions affecting either the tendon or the supporting tissues.
- The long head of the biceps tendon can be a primary source of pain or a secondary source of pain as a result of shoulder dysfunction.
- A comprehensive evaluation to determine the causative factors is critical in developing an appropriate treatment program.
- Incorporating applied stresses and forces in a systematic application via functional and sport-specific training ensures a proper return to prior level of function.

Pain associated with the long head of the biceps (LHB) brachii seems to be increasingly recognized in the past 4 to 5 years. The LHB has long been considered a troublesome pain generator in the shoulder. Abnormality involving the LHB brachii has long been an area of debate, with Codman<sup>1</sup> in 1934 even questioning the specificity of the diagnosis of biceps tendinitis. Biceps tendon abnormality is often associated with rotator cuff impingement.<sup>2</sup> Shoulder pain originating from the biceps tendon can be debilitating, causing a severe decrease in shoulder function.<sup>3, 4, 5, 6 and 7</sup> As a result of the frequent clinical presentation of biceps pain, there is currently a great deal of interest regarding the diagnosis, treatment, and prevention of biceps abnormality. This article describes a classification system of LHB pain and discusses nonoperative treatment concepts and techniques for the painful LHB.

### **Function**

There exists much controversy regarding the function of the proximal segment of the LHB brachii. The biceps brachii functions at both the shoulder and the elbow, and although there is general agreement that it is a strong supinator of the forearm and weak flexor of the elbow, there is, however, much controversy regarding its function in the shoulder due to contradictory experimental findings. The LHB is thought to function as a humeral head depressor and is also thought to provide stabilization of the glenohumeral joint. Simulated contractions of the LHB performed in cadaveric shoulders have shown significantly decreased anterior, superior, and inferior translation of the humeral head.<sup>8</sup> Biomechanical analysis has demonstrated that the LHB functions to provide anterior stabilization with the glenohumeral joint in abduction and external rotation (ER) with increased contribution noted with anterior instability.<sup>9</sup> Rodosky and colleagues<sup>10</sup> showed via simulated contractions of the biceps in the

cadaveric shoulder that the LHB provides resistance to torsional forces with the shoulder in the abducted and externally rotated position, thus providing anterior stability of the glenohumeral joint. The investigators also noted increased strain and less torsional rigidity with detachment of the biceps-labral complex.

Electromyographic (EMG) studies of the LHB remain controversial. Sakurai and colleagues<sup>11</sup> demonstrated activity of the LHB in stabilizing the humeral head, while Levy and colleagues<sup>12</sup> noted that the LHB served as a functional stabilizer only during elbow and forearm activity. Biomechanical analysis during pitching has revealed that the biceps is predominantly active in elbow flexion during arm cocking and during follow-through to decelerate the forearm in order to prevent hyperextension of the elbow.<sup>13</sup> Similarly, Rojas and colleagues<sup>14</sup> noted greater biceps activity during windmill pitching as compared with overhead throwing.

### *Classification of Long Head of the Biceps Pain and Pathophysiology*

The authors have classified LHB pain into 6 specific categories (Box 1) based on the pathophysiology and clinical presentation: traumatic injuries, instability, tendinopathy, biomechanical (scapular dysfunction, glenohumeral joint hypermobility), capsular involvement, and superior labral anterior posterior (SLAP) lesions. Although all of these conditions may present with shoulder pain, the pathogenesis, patient population, and treatment will vary.

#### **Box 1.**

Classification of long head biceps brachii pain

- Traumatic injuries
- Instability
- Tendinopathies
- Tendonitis
- Tendinosis
- Biomechanical dysfunction
- Scapular dysfunction
- Glenohumeral joint hypermobility

Capsular involvement  
SLAP lesions

## *Traumatic injuries*

Long head of the biceps tendon (LHBT) ruptures commonly occur as a result of the degenerative process as a result of tendon instability or impingement. Ruptures involving the LHBT are more frequent than those of the short head or the distal tendon, representing 96% of all ruptures.<sup>15</sup> The ruptures usually occur at the tendon's origin or as it exits the bicipital groove near the musculotendinous junction.<sup>16</sup> Rupture of the LHBT normally creates a Popeye deformity as the muscle belly moves distally; however, a vincula, adhesion, or hypertrophy of the tendon can prevent this distal migration.<sup>17</sup> These injuries are most common in individuals older than 50 years of age, and they are often associated with biceps tendinitis, which can lead to degeneration of the biceps tendon, causing rupture with minimal trauma.<sup>15, 16 and 18</sup>

## *Instability*

The biceps is secured as it travels from the intra-articular space into the bicipital groove by the biceps reflection pulley, which is formed by the coracohumeral ligament, superior glenohumeral ligament (SGHL), and fibers from both the subscapularis and the supraspinatus tendons.<sup>19</sup> Four different types of lesions have been observed arthroscopically: isolated SGHL (type I), SGHL lesion and partial articular-sided supraspinatus tendon tear (type II), SGHL lesion and deep surface tear of the subscapularis tendon (type III), and a lesion of the SGHL combined with a partial articular-sided supraspinatus and subscapularis tendon tear (type IV).<sup>19</sup> Braun and colleagues<sup>20</sup> conducted a prospective study of 229 patients undergoing shoulder arthroscopy and noted a significant correlation between pulley lesions and SLAP tears, LHB, and rotator cuff abnormality. Distribution of the pulley system can be due to either a traumatic episode or a degeneration that is often associated with rotator cuff abnormality.<sup>21 and 22</sup> Lesions of the pulley can be a result of contact with the posterosuperior labrum in the late cocking phase of throwing<sup>23</sup> as well as stresses that incur within the tendon with the arm at end range

of ER and abduction position that can place stress on the pulley system.<sup>19 and 24</sup>

Subcoracoid impingement, defined as the subcoracoid bursa and subscapularis tendon impinging between the coracoid and lesser tuberosity, has also been described as a potential cause of degeneration of the pulley sling and subscapularis tendon insertion.<sup>22</sup> Narrowing of the coracohumeral interval, the distance between the humeral head and the coracoid tip, has been shown to be related to LHB and rotator cuff abnormality.<sup>22</sup>

Following a lesion of the pulley, the LHB becomes unstable, causing degenerative changes of the tendon and the surrounding tissues. Instability of the tendon most frequently occurs medially, which typically affects the subscapularis tendon. Two variations of instability can occur: subluxation and dislocation. Subluxation is the most common, with these patients having more subjective complaints of pain. Patients with dislocations often have pseudoparalysis as a result of the associated rotator cuff abnormality.<sup>25</sup>

## *Biceps Tendinopathy*

Biceps tendonitis is inflammation of the LHBT and is most often a result of other pathologic conditions at the shoulder, including rotator cuff lesions and impingement syndrome, and is therefore often considered a secondary condition.<sup>26</sup> Bicipital tendonitis presenting as a primary condition is rare and has been estimated to occur in only 5% of all cases.<sup>27</sup> Rotator cuff abnormality has been associated with LHBT tendonitis, as Chen and colleagues<sup>28</sup> reported 76% of rotator cuff tears had associated LHBT tendonitis, while Gill and colleagues<sup>29</sup> found 85% of patients with partial rotator cuff tears had associated LHBT tendinopathy. Chronic tenosynovitis can cause enlargement of the tendon and thickening of the tendon sheath, which has been described as the hourglass biceps.<sup>30</sup> As a result, the tendon can become entrapped within the groove as the intra-articular portion of the tendon gets incarcerated within the joint, creating mechanical symptoms of pain and locking. Tendons have a 7.5 times lower oxygen uptake than skeletal muscles, potentially decreasing the healing capacity.<sup>31</sup> As a result, tendinosis can occur due to chronic degeneration without the presence of inflammation.

## *Biomechanical Dysfunction*

Proper positioning of the scapula is important in normal upper extremity function. Scapular dyskinesis is abnormal positioning or motion of the scapula during coupled scapulohumeral movements.<sup>32</sup> Scapular dyskinesis has also been associated with subacromial impingement<sup>33</sup> and can affect biceps function and should therefore be assessed in the evaluation of biceps abnormality.<sup>32</sup> The commonly seen presentation of a rounded shoulder and forward head position reduces the subacromial space.<sup>34</sup> Because of an altered length-tension relationship, this position can cause muscle weakness/inhibition of the posterior scapular muscles, particularly the rhomboids and lower trapezius. Decreased flexibility or adaptive shortening of the pectoralis minor can also occur due to scapular malpositioning.

Secondary LHB abnormality can develop from glenohumeral instability, which has been shown to cause increased rotator cuff and biceps activity in order to provide anterior stability of the glenohumeral joint.<sup>35 and 36</sup> In addition, increased humeral translation and resultant internal impingement can occur as a result of the subtle glenohumeral instability that is often noted in the overhead athlete. This microinstability can cause fraying of the posterior rotator cuff and superior labral biceps anchor. Tendon degeneration or anchor failure can occur as a result of these stresses.

## *Capsular Involvement*

The synovial lining of the biceps tendon sheath is continuous with the glenohumeral joint; therefore, synovitis of the glenohumeral joint capsule can cause pain into the LHB as a result of this relationship. Furthermore, inflammation of the glenohumeral joint capsule can cause pain in the LHB as a result of capsular mechanoreceptor input.

## *Superior Labral Anterior Posterior Lesions*

SLAP lesions can occur as a result of several mechanisms, including a fall on an outstretched hand,<sup>37</sup> tensile forces on the biceps anchor as a result of eccentric biceps contraction during the throwing

motion,<sup>38</sup> or a peel-back mechanism as the arm is maximally externally rotated during throwing.<sup>39</sup> Synder and colleagues<sup>37</sup> have classified these injuries into 4 types, with type II and IV SLAP lesions resulting in instability of the biceps anchor. SLAP lesions have been reported to have a strong correlation with glenohumeral instability,<sup>10</sup> and<sup>39</sup> rotator cuff tears,<sup>40</sup> and scapular dyskinesis.<sup>39</sup>

## **Clinical examination**

The symptoms associated with biceps abnormality can often be difficult to distinguish from that of other shoulder abnormality and often occur in conjunction with other pathologic conditions of the shoulder. Biceps tendonitis commonly presents with anterior shoulder pain with tenderness noted at the bicipital groove and a positive Speed test. However, when using these criteria, 90% of all painful shoulders could be considered as having biceps tendinitis.<sup>41</sup> As a result, it is important to be cognitive of other potential causative factors when considering the biceps as a source of pain. Therefore, a complete and comprehensive evaluation is needed to determine the causative factors.

## *History*

Patients commonly present with chronic pain in the proximal anterior shoulder that may extend into the belly of the biceps muscle. The patient is usually young or middle aged with a history of pain that increases with activity and decreases with rest. Symptoms commonly increase at night as the patient lies either on the affected arm (compressive loading) or in a supine position (decreased venous return and shoulder in an extended position).

Although the term bicipital tendonitis is often used, it is a misnomer because histologic inflammatory changes within the tendon are rarely seen, representing approximately 5% of all cases.<sup>27</sup> and<sup>42</sup> Patients presenting with peritendinitis will have pain that is worse with activities that are accentuated with overhead sports and movements away from the body. Palpation of the biceps tendon is best performed with the arm in approximately 10° of internal rotation (IR), which positions the biceps tendon anteriorly with pain noted with palpation 3

inches below the acromion.<sup>43 and 44</sup> Although it will not differentiate biceps tendinopathy from biceps instability, if a biceps lesion is present, this groove tenderness will migrate with rotation of the arm. This palpation with movement strategy can allow the examiner to differentiate bicipital abnormality from other conditions such as subdeltoid bursitis or impingement, because symptoms in the latter are often more diffuse and will not migrate with arm movement. Special tests aimed at the direct evaluation of the biceps such as Speed test<sup>45</sup> and Yergason test<sup>46</sup> can be useful. Because of the concomitant presentation of biceps abnormality with SLAP and rotator cuff abnormality, special tests such as the biceps tension sign<sup>37</sup> and the active compression test<sup>47</sup> are warranted to evaluate the status of these structures.

Tendinosis can be difficult to discern from peritendinitis because the patient will have similar subjective complaints, and the clinical examination will be similar. However, tendinosis is a result of tendon degeneration, and thus, the patient will often report pain at rest. The authors also perform passive flexion and extension of the elbow with the aim of allowing the tendon to slide within the tendon sheath; this moves the patient's point tenderness as the tendon translates within the sheath. Rupture of the biceps tendon is frequently associated with tendon degeneration, most often occurring at the tendon's origin or at the myotendinous junction as it exits the bicipital groove,<sup>16 and 18</sup> which will result in the formation of the Popeye deformity.

Biceps instability can be a result of different types of lesions involving the SGHL, subscapularis, or supraspinatus.<sup>19</sup> Clinical tests to evaluate for the presence of a pulley lesion causing instability of the biceps include the Biceps Instability Test<sup>3</sup> and Ludington test,<sup>48</sup> which is performed by having the patient place his or her hands behind the head and contract the biceps as the examiner palpates in the groove to detect subluxation. Assessing the stability of the glenohumeral joint with such tests as the anterior and posterior drawer<sup>49</sup> or the apprehension test<sup>50</sup> can assess for the presence of hypermobility.

## **Nonoperative treatment**

The nonoperative rehabilitation program is based on the clinical examination of each patient. This program is adaptable to allow the

treatment of both traumatic and atraumatic injuries. Treatment of biceps abnormality will often focus on an associated shoulder dysfunction, including rotator cuff tendinopathy, glenohumeral instability, subacromial impingement, and SLAP lesions.<sup>35, 51, 52 and 53</sup>

## **Phase 1: acute phase**

The goals in the first phase of treatment are to diminish pain and inflammation, normalize motion and muscle balance, restore baseline dynamic stability, and correct postural adaptations. The patient may be prescribed nonsteroidal anti-inflammatory medication and/or a local corticosteroid injection, which have been shown to provide pain relief with biceps tendinopathy.<sup>41</sup> In the presence of more significant biceps tendinopathy, the patient may not respond to this injection and may require an injection directly into the tendon sheath.<sup>41, 54 and 55</sup> Barber and colleagues<sup>53</sup> described injections directly into the glenohumeral joint to avoid any potential complications of direct tendon injection, to administer the medication directly to the often-irritated intra-articular portion of the biceps. In the acute phases of treatment of peritendinitis, the rehabilitation specialist will use local modalities to diminish pain and inflammation, such as ice, laser (Fig. 1), and iontophoresis (Fig. 2). The clinician can decrease pain and muscle guarding by stimulating type 1 and 2 mechanoreceptors with active assistive range of motion (AAROM), light stretching activities, and grade 1 and 2 joint mobilizations.<sup>56, 57 and 58</sup> A 23% reduction in EMG with a 32% resultant decrease in ER force production has been reported in a painful shoulder.<sup>59</sup> Consequently, because of the interwoven relationship of the rotator cuff and the biceps, pain relief is sought during this phase of treatment. However, in the presence of a tendinosis, the treatment will focus on increasing local circulation to augment tendon healing. Therefore, the clinician may use moist heat, laser, and ultrasound to increase local circulation/soft tissue extensibility and promote healing.



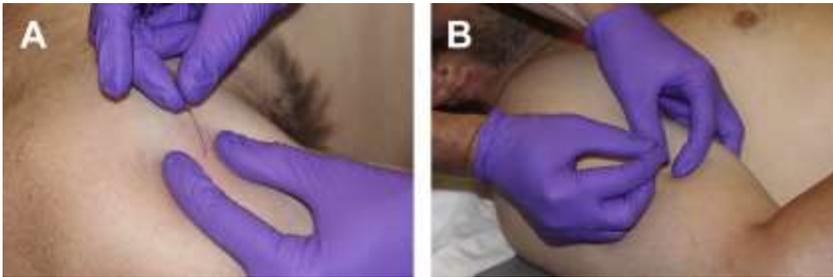
**Fig. 1.** Therapeutic laser applied to the LHB.



**Fig. 2.** Iontophoresis treatment applied to the biceps tendon to decrease local inflammation.

Mechanical stimulation using dry needling can be included to augment the healing in the treatment of biceps tendinopathy.<sup>60, 61, 62, 63 and 64</sup> Trigger points have been shown to cause a decrease in local blood flow<sup>65 and 66</sup> and create a subsequent hypoxic environment that can contribute to tendon dysrepair.<sup>67</sup> In addition, trigger points have been shown to be a source of nociceptive input<sup>68 and 69</sup> and contribute to abnormal muscle activation patterns.<sup>70</sup> Dry needling has been demonstrated to increase blood flow via local vasodilation<sup>61, 62, 63 and 71</sup> and collagen proliferation by increasing fibroblastic activity.<sup>60 and 64</sup> Repeated fenestration of the tendon by needling mechanically causes bleeding by disrupting the local scar tissue.<sup>72 and 73</sup> The bleeding stimulates growth factors by mediating transforming growth factor- $\beta$  and basic fibroblastic growth factor.<sup>63 and 74</sup> These growth factors stimulate healing by increasing matrix synthesis and promoting cellular proliferation<sup>75</sup> to aid in the remodeling of the tendon and restoring its

mechanical properties.<sup>76</sup> Dry needling has also been shown to have central effects via activation of the descending pain inhibitory systems, cortex, hypothalamus, and the inactivation of the limbic system,<sup>77, 78, 79, 80 and 81</sup> rendering this treatment useful in the reduction of pain. Therefore, a thorough assessment for the presence of trigger points in the biceps and the surrounding musculature is warranted to aid in the treatment of bicapital pathologic conditions (Fig. 3).



**Fig. 3.** Dry needling treatment to (A) LHB brachii, and (B) muscle belly of the biceps brachii trigger point.

The clinician should restore normal range of motion (ROM) for the shoulder and elbow joint by incorporating AAROM, passive range of motion, manual stretches, and joint mobilization techniques. Ensuring full physiologic mobility of the biceps via stretching exercises should be included to decrease tension in the tendon and the musculotendinous junction. The overhead athlete will typically exhibit a loss of IR. A loss of IR of  $18^{\circ}$  in the throwing shoulder has been associated with shoulder and elbow injuries.<sup>82 and 83</sup> Wright and colleagues<sup>84</sup> have also reported an average loss of  $7^{\circ}$  elbow extension in professional baseball pitchers.

Proper mobility and stability of the scapula are essential for normal function of the upper extremity. Scapular positioning has been shown to contribute to subacromial impingement,<sup>33</sup> with a decreased subacromial space noted as the scapula moves into a protracted position.<sup>34</sup> Because of an altered length-tension relationship, this position can cause muscle weakness of the posterior scapular muscles, particularly the rhomboids and lower trapezius. In addition, a protracted scapula may result in increased biceps muscle activity and muscle spasm. Decreased flexibility or adaptive shortening of the pectoralis minor can occur due to scapular malpositioning. Stretching exercises aimed at the pectoralis minor muscle can be performed as

the patient places the scapula in a retracted and posteriorly tilted position with 30° of shoulder flexion as the humerus is maintained in abduction and ER.<sup>85 and 86</sup> Corrective positioning of the scapula has been shown to open the subacromial space as well as increase the strength of the supraspinatus in patients with subacromial impingement.<sup>87 and 88</sup> Tactile stimulation provided by specially designed postural shirts can be worn during activities of daily living and during the rehabilitation program to improve scapular positioning (Fig. 4).



**Fig. 4.** A postural cueing shirt designed to give tactile stimulation for optimal positioning. (Intelliskin, Huntington Beach, CA.)

In addition, for sympathetic pain relief, the clinician can tape or brace the biceps brachii in an attempt to reduce pain during activities of daily living or rehabilitation exercises. Examples include Kinesio taping and use of a Cho-Pat strap.

Strengthening exercises are incorporated in the first phase of rehabilitation aimed at restoring muscle balance and retarding muscle atrophy.<sup>89 and 90</sup> Clinical judgment can dictate the initiation of either isometrics in the presence of excessive pain or soreness, which will be progressed to isotonic as tolerated. Rhythmic stabilization (RS) exercises are performed for the biceps and triceps and can also be performed at the shoulder by performing internal and external rotation beginning with the arm at 30° of abduction and with the arm placed at approximately 100° of elevation and 10° of horizontal abduction. This balanced position is beneficial because the deltoid and rotator cuff resultant force vectors provide a centralized compression of the humeral head.<sup>91 and 92</sup> The authors attempt to improve glenohumeral joint dynamic stabilization through rotator cuff muscle efficiency, thus decreasing the demands of the LHB to stabilize the humeral head in the glenoid fossa.

Microtrauma or macrotrauma can affect proprioceptive awareness; therefore, drills to increase the neurosensory properties of the joint capsule and surrounding soft tissue should be included in the early phases of rehabilitation.<sup>93 and 94</sup> RS drills improve proximal stability by performing exercises for the rotator cuff and the scapulothoracic musculature and can be progressed to proprioceptive neuromuscular facilitation (PNF) patterns while incorporating RSs aimed at enhancing proprioception and dynamic stability.<sup>89, 90, 93, 94, 95 and 96</sup> Weight-bearing drills, such as weight shifts, wall pushups, and quadrupled exercises, aimed at stimulating the articular mechanoreceptors and restoring proprioception can also be included in the first phase of treatment.<sup>90, 97 and 98</sup> Utilization of a full prone plank can be effective for core stabilization and coactivation of shoulder muscles. Efficient transfer of kinetic energy and effective proximal stability are important for upper extremity overhead activities such as throwing. Core exercises are also included to provide proper stability, mobility, and postural education.

In addition, light biceps brachii strengthening exercises are initiated during this phase. The authors gradually begin with light Theraband biceps curls in the seated position with the elbow supported by the patient's leg. The patient is instructed to emphasize the eccentric phase during the exercise in an attempt to stimulate collagen synthesis and organization.

## **Phase 2: intermediate phase**

The intermediate phase is designed to continue to progress the strengthening program; increase flexibility, mobility, and ROM of the elbow and shoulder joint complex; and further enhance the patient's neuromuscular control. Strengthening exercises are progressed in this phase to include more aggressive isotonic aimed at restoring optimal muscle force couples by performing the Thrower's 10 program,<sup>97</sup> which is designed to restore muscle balance and is based on EMG data.<sup>13, 99, 100, 101, 102, 103, 104, 105 and 106</sup>

The clinician will continue to progress the strengthening program to include manual resistance drills and can also include concentric and eccentric contractions and incorporate RS drills during the exercise. Neuromuscular drills are progressed by performing stabilization holds at the end ROMs. In addition, PNF exercises that include RS drills in various degrees of movement are performed throughout the patient's available ROM. These exercises and drills serve to improve dynamic stability and local muscle endurance.

Optimal scapular function is crucial to provide proximal stability and allow for efficient distal arm mobility and optimal shoulder function.<sup>107, 108, 109 and 110</sup> The scapular retractors, protractors, and depressors are commonly emphasized because of the inherent muscle weakness commonly seen due to poor posture and deconditioning. The authors implement a program designed with specific exercises to isolate weak muscles, improve muscle activation, and normalize the muscular force couples of the scapulothoracic joint and stimulate neuromuscular control.<sup>90</sup> These exercises include wall slides (serratus anterior, Fig. 5), lower trapezius modified robbery (Fig. 6), prone horizontal abduction (rhomboids/middle trapezius, Fig. 7), prone row into ER, side-lying scapular neuromuscular control exercise (Fig. 8), and prone full can.



**Fig. 5.** Wall slide exercise to facilitate serratus anterior activity.



**Fig. 6.** Activation and strengthening exercise for the lower trapezius muscle, referred to as the modified robbery exercise.



**Fig. 7.** Prone horizontal abduction performed bilaterally on a Swiss ball to incorporate core stabilization (this exercise is often referred to as prone T's).



**Fig. 8.** Side-lying neuromuscular control drills for the scapula using tactile and manual resistance.

Isolated biceps brachii strengthening is progressed during this phase; during this phase, the amount of resistance is increased and a longer eccentric phase is used to produce more load onto the biceps tendon. In addition, brachioradialis, triceps, and wrist extensors/flexors are all exercised as well.

Closed kinetic chain exercises are progressed to include proprioceptive drills, such as table pushups on a tilt board or ball. These exercises have been shown to generate increased upper and middle trapezius, and serratus anterior activity as compared with a standard pushup.<sup>111</sup> Stabilization drills can be progressed to include placing the hand on a small ball against a wall performed in a RS drill (Fig. 9). Progression from a full prone plank to a side plank can be beneficial and challenging to the core and scapular musculature.



**Fig. 9.** Dynamic stability training with the hand placed onto a ball to provide compressive forces into the glenohumeral joint while the arm is in the scapular plane as the clinician provides RSs.

### **Phase 3: advanced strengthening phase**

The goals of treatment during phase 3 are to initiate aggressive strengthening exercises and functional drills, progress muscular endurance and power, and prepare for a return to sporting activity. Muscle fatigue has been shown to decrease neuromuscular control, diminish proprioception, and alter scapular positioning.<sup>112 and 113</sup> The Advanced Thrower's 10 program was designed to incorporate alternate movement patterns of the upper extremity to further challenge the patient's neuromuscular control and restore muscle symmetry and balance and improve muscular endurance.<sup>114</sup> The sustained holds that are incorporated into this program are designed to challenge the patient to maintain an isometric position while performing a reciprocal isotonic movement with the opposite upper extremity. These exercises are usually performed in 3 alternating sets with the first set performed with bilateral isotonic movement, then unilateral isotonic movement with contralateral sustained hold, followed by alternating isotonic/sustained hold sequencing. In addition, the patient can perform these exercises on a stability ball to further challenge the core. Manual resistance provided by the clinician can be implemented to augment muscle co-contraction and improve muscular endurance of the shoulder and core.

Neuromuscular control drills are progressed to include side-lying ER with manual resistance. Concentric and eccentric ER is performed as the clinician provides resistance, including RS at end range. These drills can also be progressed to being performed standing using exercise tubing at 0° and finally at 90° abduction.

Eccentric exercises are included in the rehabilitation program particularly in the treatment of biceps tendinosis. In the overhead athlete, the biceps muscle is an important stabilizer during the follow-through phase. Elbow eccentrics can be performed with manual resistance, dumbbells, or elastic tubing to emphasize both slow- and fast-speed contractions. Strengthening exercises are further progressed to include weight machines to further increase strength and power; traditionally, the authors focus on training on the posterior scapula using seated rows and latissimus dorsi pull-downs.

It is important for the patient to continue to perform postural correction exercises during this phase. These exercises would include corner stretches for pectoralis minor tightness, wall circles for posture and lower trapezius activation, and continuation of the scapular muscle strengthening exercises listed above in phase 2.

An interval sports program can be introduced during the third phase.<sup>115</sup> These programs (golf, tennis, football, baseball, softball, and others) were designed to gradually introduce quantity, intensity, and duration of sporting activities to allow an athlete to return to sporting activities while minimizing the recurrence of injury and pain with activities.

## **Phase 4: return to activity phase**

Phase 4 of the rehabilitation program allows the patient to continue to progress with functional activities and drills that are designed to return the patient to his or her prior level of functional activities. The criterion to initiate this phase of treatment includes full ROM, no pain or tenderness, and a satisfactory clinical examination. Patients are encouraged to maintain and continue to improve upper extremity and core strengthening, flexibility, and neuromuscular drills. Usually athletic patients are placed on the Thrower's 10 program to maintain shoulder strength and flexibility during their competitive season. During this return to activity phase, it is critical for the patient to continue their strengthening, activation, and postural exercises to maintain proper posture and body awareness.

## **Summary**

The LHB has gained recent attention due to its association with shoulder dysfunction and its potential for pain generation. LHB abnormality often occurs concomitantly with other shoulder conditions, and as a result, making a diagnosis can often be difficult. It is imperative that the clinician is able to accurately recognize all underlying causative factors to establish a successful nonoperative rehabilitation program. Based on the abnormality, the rehabilitation program will focus on restoring dynamic stability, restoring muscular

endurance, addressing postural adaptations, and providing the appropriate stimulation to augment the healing response to the LHBT.

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