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Review article

Upper extremity weightlifting injuries: Diagnosis and management

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ABSTRACT

Common upper extremity injuries in resistance training athletes include muscle strains, ligament sprains, pectoralis major tendon ruptures, distal biceps tendon ruptures, and chronic shoulder pain and capsulolabral injuries. While each injury is unique in its specific anatomic location and mechanism, each is preventable with proper exercise technique, safety and maintenance of muscle balance.

Conservative treatment is the therapeutic modality of choice and these injuries generally resolve with workout modification, appropriate recovery, anti-inflammatory medication, and physical therapy. If conservative treatment fails, surgical intervention is often successful and can return the weightlifter to a level of performance near their pre-injury level.

1. Introduction

Resistance training is a common pursuit for many Americans from weekend warriors to the elite athlete. At least 45 million Americans participate in regular resistance training.[1] Improper training often leads to musculoskeletal injury and evaluation by an orthopaedist. The US Consumer Product Safety Commission studied a cohort of Emergency Departments and identified 25,335 weight training injuries, which they extrapolated to an average 970,801 total emergency department visits every year.[2] This number likely underestimates the total number of injuries as surveys have shown that 54% of strongmen athletes rely on self-treatment and only a modest percentage of these experienced weightlifters seek treatment from medical professionals.[3,4] Sprains or strains are the most common type of injury and account for 46.1% of all resistance training injuries.[3] Additionally, most injuries are acute in nature (60–75%) but may vary in type and severity.[5,6] Chronic weightlifting injuries are associated with overuse and make up the remaining 30% of injuries.[7] These chronic-type injuries are more common in aging athletes who suffer from increased rates of tendinopathy, tendon rupture and degenerative joint disease.[7]

Technical errors, fatigue, overloading, and dropping weights are associated with injury. The most common mechanism of acute injury is dropping weights, which accounts for 65.5% of injuries. Consequently, free weights are associated with more fractures and dislocations than the use of resistance machines. In fact, 90% of the fractures and dislocations reported were associated with free weights.[3] Additionally, technical errors contributed to 31% of injuries, and fatigue or overloading contributed to 81% of injuries in weight lifters.[8]

This review will explore injuries including pectoralis tendon ruptures, distal bicep injury, and shoulder capsulolabral complex injuries during weightlifting. Furthermore, appropriate techniques and shoulder injury prevention strategies will be discussed to enable the practicing orthopaedist to provide guidance to patients who participate in resistance training.

2. Pectoralis tendon ruptures

The pectoralis major muscle comprises the bulk of the anterior chest mass; it is fan-shaped with origins on the clavicle, sternum, and first through sixth costal cartilages. The clavicular head takes origin from the anterior surface of the medial two-thirds of the clavicle and the sternal head takes origin from the anterior manubrium and sternal body. The two muscle bellies converge and insert on the lateral lip of the bicipital groove of the proximal humerus.[9] Contraction of the muscle belly results in flexion, adduction, and internal rotation of the humerus.[10]

Pectoralis major muscle rupture has been reported to occur during weightlifting, boxing, windsurfing, and jiu-jitsu.[11] The pectoralis major muscle serves as a large source of power during upper extremity exercises and is an area of desired hypertrophy. The recent increase in

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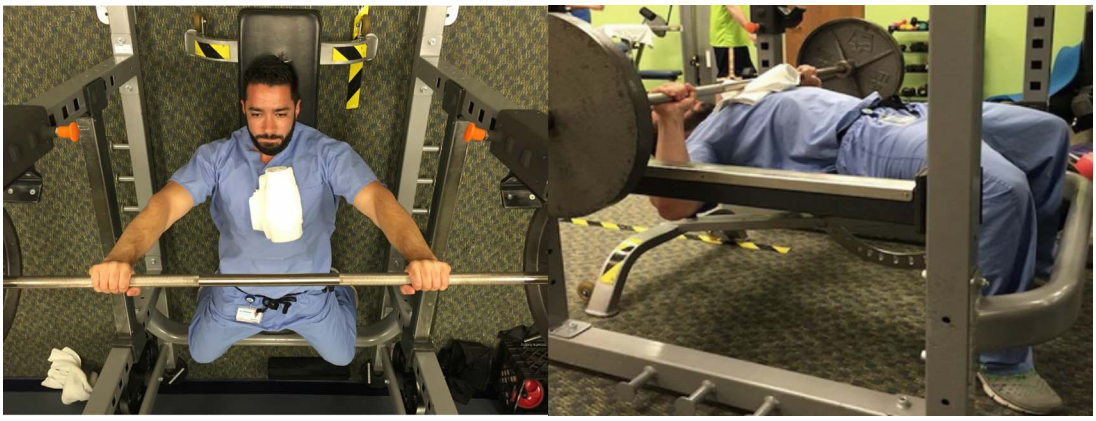

Fig. 1. The bench press entails a person lying supine on a bench and a weighted barbell is taken from a position of maximal extension at the elbows and lowered down to chest and then the bar is pushed back to full arm extension. The shoulders are abducted to a variable degree throughout this arc of motion.

injuries to this muscle is likely due to increases in resistance training and concerted efforts to augment the size of this muscle for cosmetic and functional purposes.

The bench press is a very commonly performed exercise, especially by novice weightlifters (Fig. 1). The majority (47–70%) of reported pectoralis major injuries are the result of bench pressing.[11] Injuries to the pectoralis major tendon can occur during this lift with forced abduction of the upper arm, which occurs at the point of maximal eccentric contraction.[9,12] Diagnosis of pectoralis tendon ruptures is predominantly clinical. Patients report pain at the time of injury, ecchymosis is frequently present, and a palpable defect is often encountered in the anterior axillary region. Patients may note weakness and pain with arm adduction and will have increased fullness in the pectoral region as the muscle belly is no longer under proper tension.[13] When clinical diagnosis is indicative of tear, confirmation of the diagnosis via either magnetic resonance imaging (MRI) or ultrasound is recommended. MRI is useful in the setting of these injuries to determine the precise location of the tear, as this can determine treatment.[10]

There is debate in the literature with respect to the most common location of rupture. In a meta-analysis of 112 patients, Bak et al. found the most common location of injury to occur at the tendinous attachment to the humerus.[14] However, a cadaveric study recreating these injuries found that the majority of tears occurred at the musculotendinous junction.[15] It is important to note that the average age of cadaveric specimens was between 58 and 63 years, compared with a much younger patient age seen with *in vivo* studies.

When pectoralis major rupture occurs, the location of the tear as well as its extent (partial vs. full) drive treatment. Complete tears at the myotendinous junction occur in 20% of cases.12 These tears are typically managed conservatively; however, tendon avulsions are managed operatively. Of note, tendon retraction can range from zero to 13 cm.[10] Non-surgical treatment entails sling immobilization in an internally rotated position for three weeks with symptomatic management.[16] At six weeks, active and passive range of motion exercises are initiated followed by a gradual increase in strengthening exercises in the subsequent weeks and months.[14] Conservative treatment is recommended for partial tears or complete tears in the absence of weakness.[11,14,16]

In cases of complete injury at the insertion point, surgical treatment is recommended and various surgical techniques can successfully manage this injury. Tears that are managed within three months of injury can be anatomically re-approximated by a number of techniques including transosseous sutures, use of screws and washer, and suture anchors.[17,18] When greater than three months has passed, tendon reconstruction is recommended because of the high likelihood of significant tendon retraction.[10]

Several studies demonstrate the superiority of surgical over conservative management with respect to functional outcomes for complete ruptures. Pochini et al.[11] recently published a prospective study of 20 male patients, comparing surgical versus nonsurgical treatment of pectoralis major tendon ruptures. At an average follow-up of 36 months, they found that surgically treated patients demonstrated 70% excellent results compared to 20% good results, 50% fair results, and 40% poor results in the nonsurgical group. Further, non-operatively treated patients demonstrated a 53.8% decrease in strength compared to a 13.7% decrease with operative treatment. Several other studies have also demonstrated superior results with operative treatment in these injuries.[14,19]

3. Distal biceps tendon ruptures

The biceps brachii muscle is composed of two heads originating at the scapula. The long head originates at the supraglenoid tubercle and the short head originates on the coracoid process as part of the conjoined tendon. As the long head passes through the glenohumeral joint, it is considered intracapsular but extrasynovial as it is invested in a double layer of synovium. The long head then passes through the bicipital groove or intertubercular sulcus formed by the greater and lesser tuberosities before joining the short head in a common muscle belly. The common distal insertion point is the radial tuberosity and lacertus fibrosus (bicipital aponeurosis), which allows the biceps to function in forearm supination, elbow flexion and shoulder flexion.[9,20]

The distal biceps tendon is most at risk for acute rupture during eccentric contraction with a weight of 68 kg or more.[10,21] This type of motion occurs during bicep curls and rowing movements. A biceps rupture can be clinically diagnosed based on the hook test or a “Popeye” sign. MRI can also be used to distinguish partial versus complete tears and demonstrate hematoma formation and retraction of the muscle belly. Ninety percent of tendon ruptures occur proximally in the long head of the biceps,10 often in the bicipital groove.[22] Distal biceps brachii injury is less common than proximal rupture and usually involves a tendinous avulsion off of the radial tubercle.[23]

Treatment of a distal biceps brachii tendon rupture consists of surgical repair.[24] When considering non-operative treatment, the risk of residual pain, muscle spasm, and the cosmetic appearance of the arm must be discussed with the patient. In younger patients, most surgeons advocate for operative treatment of distal biceps tendon ruptures using either one or two incision technique. Chronic ruptures may require allograft reconstruction of the tendon.[25]

4. Shoulder pain and capsulolabral injuries

Chronic injuries to the capsulolabral complex of the shoulder can plague any overhead athlete, including weightlifters. Researchers have found that 36% of injuries in the weightlifting population occur at the

Fig. 2. Reclining the torso 30 ° and avoiding behind the neck pull downs can help prevent shoulder injury.

shoulder complex.[8,26]

Most authors agree that chronic repetitive loading of the shoulder complex leads to capsular strain, occult instability, and persistent pain. Upper extremity resistance training exercises place emphasis on large muscle groups to create strength and hypertrophy while neglecting smaller muscles responsible for upper extremity joint stabilization. Specifically, exercises that emphasize larger muscle groups may create an imbalance of the internal versus external rotator cuff musculature, rotator cuff-deltoid force couple, and periscapular musculature. These imbalances have been associated with shoulder injury in various investigations.[27–29] The combination of repetitive loading, unfavorable positioning, and biased exercise selection creates joint and muscle imbalances that increase the strength trainer's risk of labral tears, labrocapsular junction dysfunction, and shoulder instability, which can precipitate RTC disease.[8,30,31]

Given the propensity for shoulder dysfunction in weightlifters, it is paramount that participants understand the risks that certain exercises pose and the modifications that can be made to prevent injury. While chronic shoulder problems are a common affliction of weightlifters, the mainstay of treatment is modification of the training regimen and conservative treatment with symptomatic management and guided physical therapy. Avoidance of high-risk exercises and strengthening of shoulder stabilizers obviates the need for surgical intervention in the vast majority of cases.

Bench pressers may be predisposed to rotator cuff tears because of the unfavorable position of the rotator cuff during lifting and the pursuit of higher one-repetition maximum lifts. Furthermore, there is a rapid alternation between eccentric and concentric muscle contraction with this motion.[32] One study stated that during maximal bench press, repetitive forces lead to eventual avulsion of the posterior scapular periosteum which may necessitate posterior labral repair to resume pain-free weightlifting.[33] Bilateral anterior glenohumeral dislocations have been reported as a result of bench-pressing.[34,35]

Squats and military press can strain the rotator cuff and proximal biceps tendon.[20] Repetitive motion can lead to degeneration of the long head of the biceps as it moves through the bicipital groove and the subacromial space, yet alternation between overhand and underhand grip can decrease this repetitive damage. The overhand grip moves the biceps tendon out of the subacromial space by internally rotating the humerus, which limits damage from impingement. Alternatively the underhand grip places the tendon in a position of decreased stress.[29] Additionally, a narrow hand grip of only 1.5 times the shoulder width during barbell exercises aligns the clavicle, pecs and biceps brachii into a mechanically advantageous position to maximize shoulder flexion. This allows the long head of the biceps to move smoothly through the bicipital groove.[29]

Fees et al. discussed additional modifications to protect the shoulder during resistance training for patients with rotator cuff tendinitis, impingement syndrome, acromioclavicular problems, shoulder instability, and glenoid labral/biceps anchor pathology. As mentioned previously, a narrow bench press grip decreases shoulder torque and minimizes shoulder adduction and extension.[36–38]A higher touch point on the chest above the xiphoid process also decreases shoulder torque.[39] Alternating grip patterns can offload specific pathologic entities: a pronated grip places the supraspinatus under the acromion,[30] while a supinated grip places the long head of the biceps under the acromion.[40] Patients with anterior shoulder instability or labral injuries require a handoff to a spotter for un-racking and re-racking[41] and avoidance of the incline bench and "high five" positions.[31,42]

Posterior shoulder instability requires increased grip width over two times biacromial width, which maximizes glenohumeral articulating surface area.[35] The bench press places heavy stress on posterior stabilizers and attempts at a one-rep max should be avoided because of the significant strain on shoulder capsule and labrum.[41,43]

The shoulder press should never be performed with the bar being lowered behind the neck. The physiologic effects of this exercise can be replaced by specific posterior deltoid muscle exercises such as rear deltoid raises, seated rows, or dumbbell rows. The shoulder press can be modified by starting at ear level and ending in the overhead position, or replaced with isometric exercises. Furthermore, utilization of machines or a power rack will limit horizontal (AP) translation to protect the anterior glenohumeral ligament. Similarly, with latissimus dorsi pulldown, the "behind the neck" position must be avoided. Transient upper extremity paralysis after completion of behind-the-neck latissimus dorsi pulldown has been reported in the literature.12 When performing pulldowns in front of the neck, the weightlifter should recline the body thirty degrees to protect the shoulder (Fig. 2). In summary, recommendations include: avoidance of the high five position, placing a towel on chest to limit the end-range positioning (no elbows behind the torso), avoiding behind-the-neck latissimus pulldowns or military presses, and avoidance of one-rep maximum lifts. When conservative treatment fails and abandonment of resistance training is not an acceptable option, surgical intervention has demonstrated success in returning athletes to their workout regimen. Mair et al. reported on 9 NCAA athletes with posterior labral detachments and painful bench press who were successfully treated with posterior labral repair and able to return to pain-free sport participation and weightlifting at minimum two year follow up.[44] Gross et al. demonstrated that ten patients (13 shoulders) treated conservatively with modified weightlifting techniques were able to return to symptom-free weightlifting. Furthermore, all ten of the surgically treated patients in their series returned to weightlifting. The goal of their study was not to compare different treatment modalities for the condition, but rather, to "demonstrate that weightlifting is an activity that can produce pathologic findings that require surgical correction."[30]

5. Conclusion

There are several categories of training with differing rates of injury, the highest of which is found in strong-men athletes, although no training regimen is without injury. Pectoralis major ruptures are most common during bench pressing with forced abduction of the upper arm at the point of maximal eccentric contraction. Myotendinous pectoralis tears can be managed conservatively with sling immobilization, while avulsions from bony attachment should be managed surgically. Level one evidence comparing the surgical options available to patients is lacking, owing to the rare nature of this injury. Biceps tendon ruptures are most common in the long head at the bicipital groove, and are most at risk during eccentric contraction with heavy weight, such as during biceps curls. These can be distinguished clinically by the presence of the "Popeye sign." Treatment is surgical with either a one or two incision technique.

Shoulder pain and capsulolabral injuries are a result of chronic repetitive loading of the shoulder as performed in overhead weight training. This can be associated with trainers focusing on large muscle groups, while neglecting to strengthen smaller groups responsible for joint stability. This imbalance, combined with repetitive loading can result in rotator cuff tears. Participant education and activity modification (i.e. grip alternation) in at-risk participants may obviate the need for surgery.

In summary, knowledge of the etiology and risk factors for injuries associated with weight training can inform the physician and patient alike, both in prevention and treatment of injuries sustained during exercise. Careful planning of training regimens on the part of trainers can help to avoid some of the syndromes discussed here. Due to the uncommon nature of these injuries, there is a relative lack of high quality data on their optimal management. Given the ever-increasing interest in fitness and resistance training, future efforts should be made in evaluating the risk for and management of weightlifting injuries.

Conflict of interest

None.

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