Rotator Cuff Pathology in Olympic Weightlifting: A Comprehensive Review of Incidence, Diagnosis, Management , and Rehabilitation

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Declaration

I do hereby attest that I am the sole author of this project/thesis and that its contents are the only the results of the readings and research I have done

Brian Serrano

Acknowledgement

I dedicate this paper to God, my parents Audelio and Priscilla, and Wife Jackie.

Thank you God for blessing me with the opportunity to live out my dreams.

To my parents Audelio and Priscilla; I will never be able to thank you enough for all of the sacrifices you have made for Erick and me. But let me say thank you for giving me the opportunities you never had.

To my incredible wife Jackie; You are such an amazing partner and best friend to me. Thank you for always being the first one to support me and my crazy dreams.

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Abstract

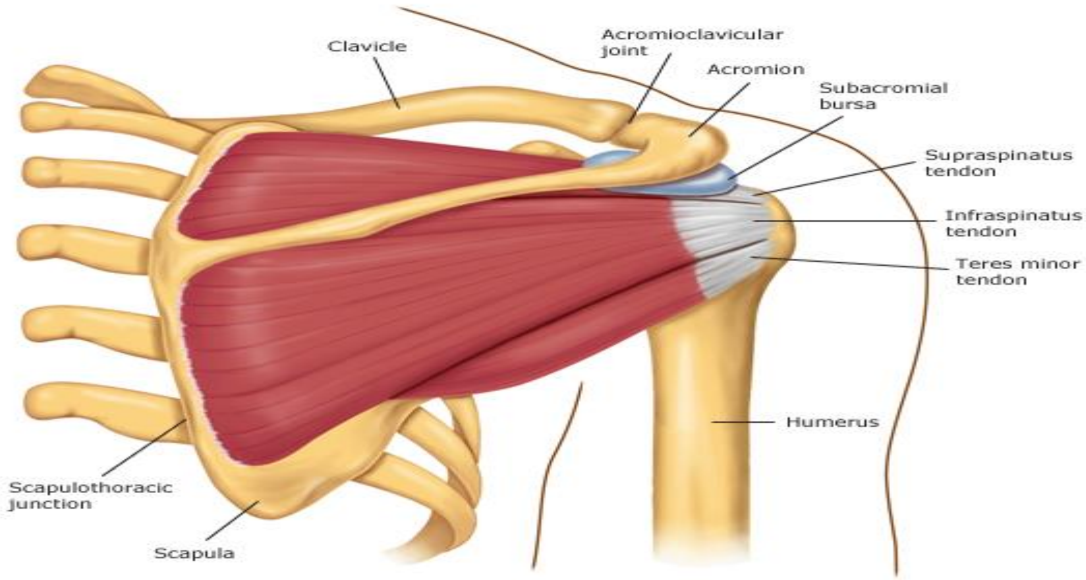
Introduction: Olympic Weightlifting is a sport which involves two lifts: The Clean and Jerk and The Snatch. Due to the high demands on the body from the sport, injury is common. Injury rates tend to be lower as compared with other sports at about 2.3-3.0 per 1000 contact hours. The most common injuries in Weightlifting occur at the knees, low back, and shoulder. Injury reports within Weightlifting tend to be general and scarce. The purpose of this Dissertation is to explore rotator cuff injuries specific to this population of athletes. **Methods/Materials:** Due to the scarcity of research in this sub-field; it was deemed necessary to explore journals articles, textbooks, and sports medicine books to gather complete information. Pubmed, EBSCO, SPORTdiscus, and CINAHL were used for the systematic review portion of the paper. **Analysis:** SPSS Analysis was used to perform statistics during the systematic review. There was enough literature to be able to perform a meta-analysis using SPSS programs. **Results:** Rotator Cuff tears are common shoulder injuries in this population that are usually chronic due to the high demands impose by the sport. Degenerative partial-thickness tears are common with a propensity to turn into full-thickness tears if not managed appropriately. **Conclusion:** Rotator cuff injuries are common injuries in this athletic population with the rate of partial thickness tears to the supraspinatus and infraspinatus being underdiagnosed and undertreated. Clinicians should strive to manage partial thickness tears with a trial of consistent, aggressive conservative therapy to the entire shoulder girdle and kinetic chain. If the tear is deemed to be more than 50% thickness than surgical repair is warranted for a return to sport.

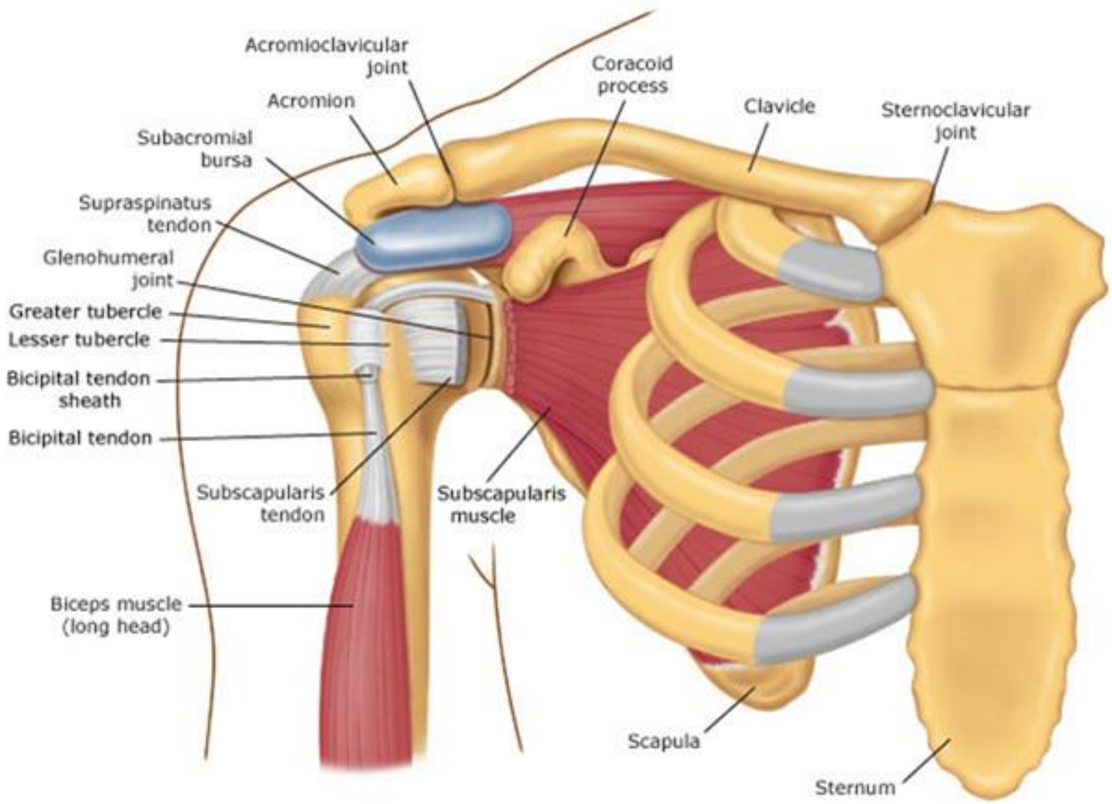
Key Words: Olympic Weightlifting; Weightlifting; Shoulder; Rotator Cuff Injury

Introduction

Olympic Weightlifting is a sport that has been around for hundreds of years and can be traced back to Ancient time (1). Olympic Weightlifting can be confused with other styles of lifting such as bodybuilding, resistance training, and powerlifting (2). However, weightlifting is a sport all of its own. It involves two lifts: The Clean and Jerk and The Snatch in which the participant aims to lift the maximal amount of weight (3) During competition, a participant has 3 attempts to get a highest “total” (4). Within the sport, there are weight classes (bodyweight in kilograms) and age classes (youth, junior, senior, master) (4). Due to the lack of professional weightlifting other than at The Summer Olympic Games level, there are less resources available into the sport as opposed to other sports that are televised and have huge followings in the United States such as: Baseball (MLB), Football (NFL), and Basketball (NBA). The national governing body (NGB) for Weightlifting in the United States (USAW) does a phenomenal job of promoting, growing , and fostering the sport. However, more resources are needed to explore pertinent topic in Sports Medicine and Sports Performance as they relate to the sport. In Weightlifting, the high demands biomechanically and physiologically imposed on the body may lead to chronic injuries similar to those seen in other sports and athletic activities (5). Injuries to the low back, knees, and shoulder are common and include strains, sprains, and overuse syndromes (6). For the intents of this paper, acute injury will be classified as a single event that led to injury and usually associated with a single mechanism of injury (MOI). Chronic injury are those that are caused by overuse, have a slow and insidious onset that the patient may describe as bothering them for a period of time (>3 months) (7). Injury will be described an incident(s) that result in loss of exposure hours to the sport (training or competition) (7). Of the common injuries described above, this paper will focus on the shoulder (Gleno-humeral joint). The shoulder is a spheroid joint within the synovial joint classification and has movement in all three planes of motion (8). Due to anatomical incongruency of the shoulder it must rely on static and dynamic stability which makes it vulnerable to injury (9). Injury at the shoulder includes labral pathology, instability, and rotator cuff pathology. Due to scarcity of rotator cuff pathology literature as it pertains to Olympic Weightlifting that will be the focus of this paper. I seek to humbly gather the best current literature on this subject and synthesize and contribute to the advancement of clinicians working with this population of athlete. This paper will focus on the incidence, diagnosis, management, and rehabilitation of rotator cuff pathology in Olympic Weightlifters.

Shoulder Anatomy

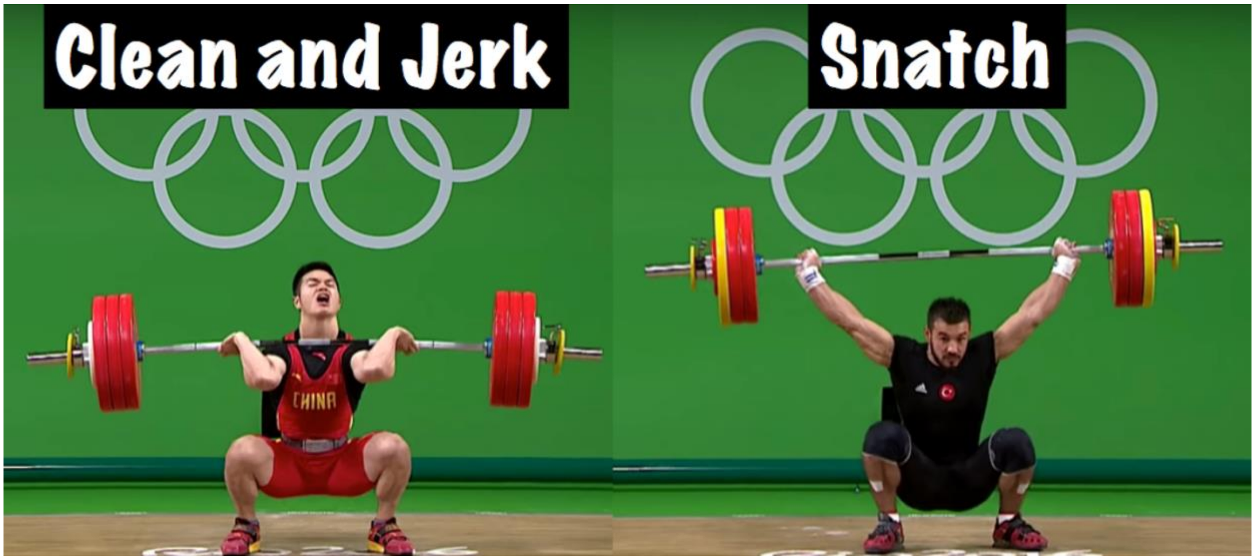




Chapter 1: Olympic Weightlifting

Olympic Weightlifting is a unique sport which can be confused with Powerlifting and other forms of resistance training (1). Powerlifting is another sport where a participant seeks to lift a maximal amount of weight (total) with three lifts: The Bench Press, Deadlift, and Back Squat (10). Olympic Weightlifting similarly involves a participant attempting to lift a maximal amount of weight (total) in two lifts: The Snatch and The Clean and Jerk (11). Each participant has three attempts in each lift to achieve a total. In competition, The Snatch is performed first and involves moving the barbell from ground to overhead in one smooth motion and demonstrating control in the overhead position by holding still with the barbell for 3 seconds (11). There are three judges that either give a green or red light for each lift and a "good lift" must be determined via unanimous decision. Common faults include "pressing out" by the elbows; ideally the athlete should land underneath the bar with their elbows fully extended and stand the bar up. The Clean and Jerk is performed next and involves two movements. The bar begins from the ground and is moved to the front rack position across the shoulders and chest (11). The athletes then Jerks the bar from the shoulders to the overhead position in one movement (11). They must demonstrate control in the overhead position by bringing the feet to hip width apart and hold the bar still for 3 seconds. There are two forms of Jerk: Split Jerk and Push Jerk. The Split Jerk involves splitting of the feet with one foot forward and the other foot back while the bar is caught with the elbows fully extended in the overhead position and the feet are then walked back to hip width to demonstrate control. The Push Jerk involves the athlete taking hips and torso and dropping into varying depths of a squat to get underneath the bar and standing up from this position similar to an overhead squat. Once at standing position the athletes must bring their feet to hip width apart if the jerk brought them wider. Once again, 3 judges rule this lift good or not with similar criteria. During the clean, elbows can’t touch the knees, or it is a no lift. These are the two lifts in Olympic Weightlifting and will form the basis for the discussions in the chapters to come.

Weightlifting Pictures



Chapter 2: The Shoulder

The shoulder (Gleno-Humeral Joint) is a spheroid (ball and socket) joint under the synovial joint classification because it can move in all three planes of motion (12). The shoulder is inherently unstable due to its anatomy, which can be likened to a golf ball sitting on a tee (13). The humeral head being the golf ball and the glenoid labrum being the tee. As you can see, there is a large disparity in sizes which makes the shoulder mobile, which is necessary for life and activity, but also inherently unstable. The shoulder is the most mobile joint in the body and also the most commonly dislocated. Dislocations usually occur in the anterior-inferior location (14). Preventing dislocation are two types of stabilizers: static and dynamic (14).

2.1 Static Stabilizers

The primary static stabilizers of the shoulder are the GH ligaments and labrum (15). The inferior GH ligament (IGHL) serves to prevent anterior and posterior translation of the humerus respectively. Each of the GH ligaments act like a sling (Inferior, Superior, Medial) to surround the humeral head and increase stability (16). However, the most important static stabilizer is the glenoid labrum (17). The glenoid labrum is a ring of fibrocartilaginous structure that surrounds the entirety of the glenoid cavity increasing its surface area by about 75% in the superior-inferior direction and 50% in the anterior-posterior direction (17). This function allows for a greater coverage of the glenoid cavity-labrum complex over the humeral head.

2.2 Dynamic Stabilizers

The dynamic stabilizers of the shoulder are the rotator cuff muscles and long-head biceps complex. (LHBC) The rotator cuff muscles work together to promote joint centration of the humeral head into the glenoid cavity (18). Specifically, the rotator cuff muscles acts to counteract the superior pull from the Deltoid during shoulder abduction (18). The LHBC is a less recognized but is considered to be dynamic due to the contractile-transmitting forces of tendons (19) . The LHBT originates on the supraglenoid tubercle and superior labrum directly (19). This connection directly into the labrum means the LHBC is responsible at least partly for stabilization the humeral head in the antero-superior aspect of its movement and activity.

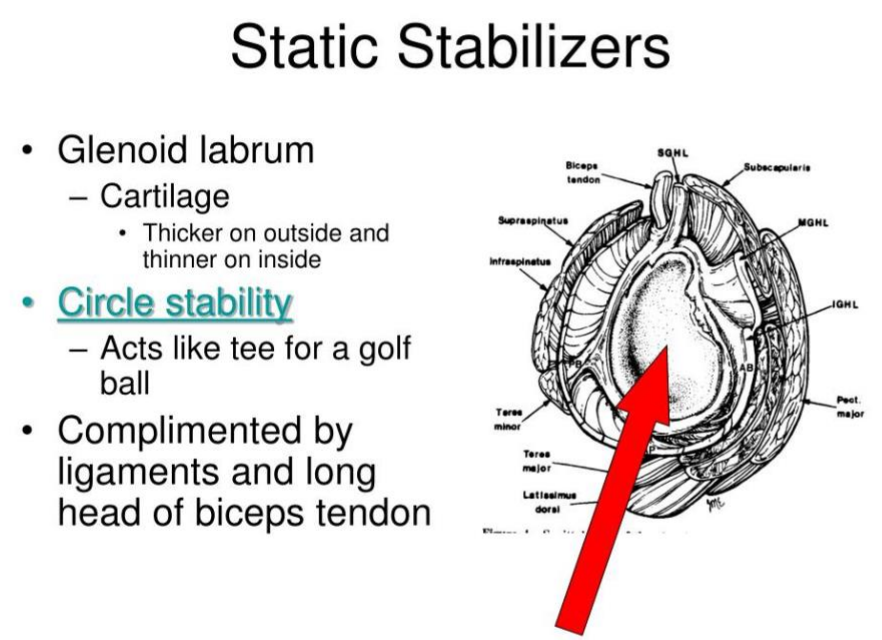
2.3 Scapulo-Thoracic Articulation (ST Joint)

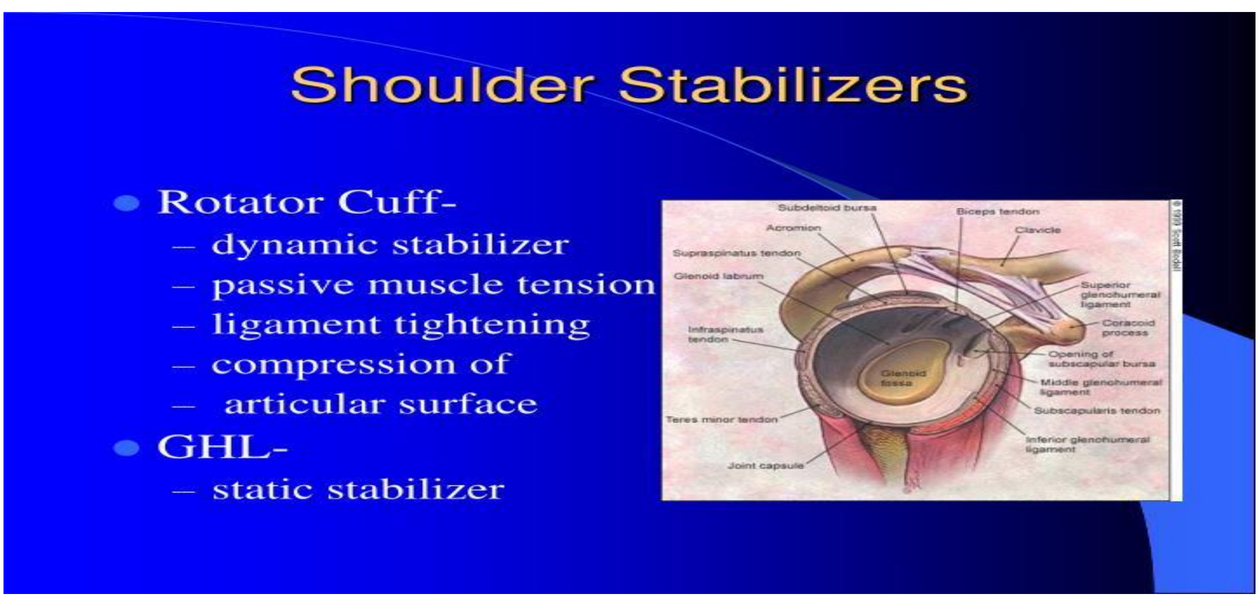
The Scapula (shoulder blade) and posterior thorax make an articulation or functional joint which is critical for optimal shoulder function (20). The ST Joint must make a stable platform for the Shoulder to function from (20). Both joints must work seamlessly for optimal function. This is termed scapula-humeral rhythm. Normal Scapulo-humeral rhythm involves the upward rotation, external rotation, and posterior tilting of the scapula followed by elevation, inferior glide, and external rotation of the humerus (21).

2.4 Musculature

There are several muscles that are important to optimal shoulder function: the rotator cuff as previously discussed, trapezius, serratus anterior, rhomboids, levator scapulae, and pectoralis minor. These muscles work in coordinated patterns called force couples to control scapular motion. The upward rotation force couple involves the upper portion of the trapezius and the lower portion of the trapezius and serratus anterior (22).

Shoulder Stabilizers





Chapter 3: The Rotator Cuff

The rotator cuff (RC) consist of 4 muscles which surround the shoulder joint and function to increase its stability through dynamic stabilization (22). The RC serves to center the humeral head during different movements known as Joint Centration (23). Keeping the humeral head centered within the glenoid fossa ensures optimal function through proper length-tension relations. For example; during the primary phases of abduction the humeral head has a biomechanical tendency to migrate superiorly (24). During external rotation, the humeral head migrates anteriorly and superior-anteriorly during internal rotation (24). The RC plays a crucial role in preventing excessive motion during scapula-humeral motion. The RC is composed of the Supraspinatus, Infraspinatus, Teres Minor, and Subscapularis (22). These muscles are unique in that all 4 have attachments directly from the scapula onto the humerus. For the purposes of this Dissertation, I will use the terms origin and insertion when referring to muscles however as put by Dr. Andrea Spina it is more accurate to think of muscles as having multiple attachments. As we can see, the RC is crucial to humeral and scapular function. Next, we will explore how the RC plays a particularly important role in the sport of Olympic Weightlifting.

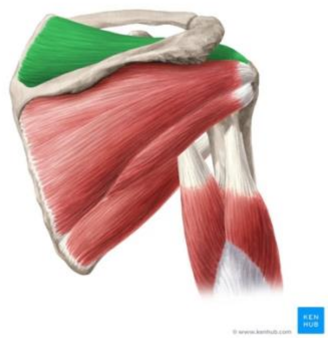
3.1 Supraspinatus (25)

Origin: Supraspinous fossa of the scapula

Insertion: Greater Tubercle (Superior facet) of Humerus

Nerve Supply: Suprascapular Nerve

Action: Shoulder Abduction



3.2 Infraspinatus (26)

Origin: Infraspinous fossa of the scapula

Insertion: Greater Tubercle (Middle facet) of Humerus

Nerve supply: Suprascapular Nerve

Action: External rotation of Shoulder, especially at 0 degrees of abduction

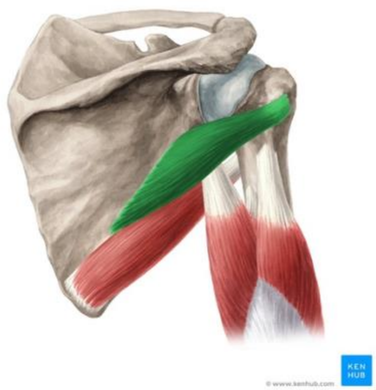
3.3 Teres Minor (27)

Origin: Lateral border of the scapula

Insertion: Greater Tubercle (Inferior facet) of Humerus

Nerve Supply: Axillary Nerve

Action: External Rotation of Shoulder, especially at >45 degrees of abduction



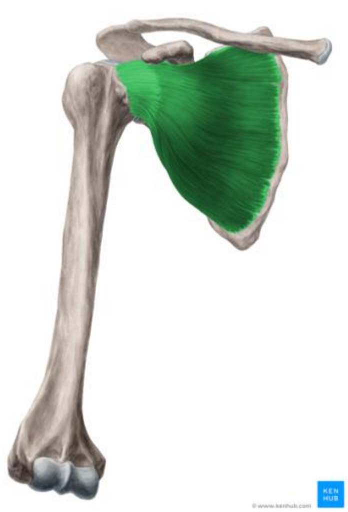
3.4 Subscapularis (28)

Origin: Subscapular Fossa

Insertion: Lesser Tubercle of Humerus

Nerve Supply: Subscapular Nerve (Upper and Lower)

Action: Internal rotation and Adduction of Shoulder



Chapter 4: The Shoulder in Olympic Weightlifting

Now that the anatomy and biomechanics of the shoulder have been discussed, it can be applied directly to Olympic Weightlifting. In general, the shoulder has been explored significantly in other sports especially overhead sports such as Baseball, Volleyball, and Javelin (29,30,31). Even contact sports like Football have explored shoulder injuries within their athletes (32). However, research in scarce in regard to recent (last 10 years) of shoulder injuries in Olympic Weightlifting (33). Olympic Weightlifters should be considered overhead athletes, although this concept may be faced with certain resistance. Overhead athletes in the traditional sense are throwing an implement of some form which is easy to understand. With weightlifters, they are not necessarily throwing anything but rather lifting a loaded a barbell overhead and in technical terms during the Snatch and Clean portion of the Clean and Jerk actually dropping under the barbell. I propose a new classification in this paper that Weightlifters in biomechanical terms are throwing and catching a barbell overhead in both competition lifts.

4.1 The Shoulder in the Snatch

The Snatch is the competition lift which involves lifting the barbell from ground to overhead in one fluid motion (11). There is an extreme amount on the shoulder throughout the entire movement and is easier to follow when each lift is broken into its respective phases (34). The first pull bring the bar from the floor to above the knee into the mid-thigh level. At this point, the shoulders are primarily in an isometric contraction as the rotator cuff and Latissimus Dorsi function to pull the barbell into the body (34). The lower body is the primary mover in this phase. (35) The second pull is when the barbell begins accelerating and triple extension occurs through plantar flexion of the ankle, knee extension, and hip extension. (35) The shoulders are primarily isometrically pulling the barbell into the body to keep the bar path close to the body (34). From a biomechanical perspective, keeping the bar path close to the body will make the participant as efficient as possible. The third pull is when the shoulders become the most active of the three pulls (36). This is when the lifter readies their body to catch the barbell and the shoulders go into the “turnover: which is a combination of shoulder flexion, abduction, and external rotation. The athletes then proceeds into the turnover phase which is when the barbell will be elevated into the overhead position and the shoulder is the most active. Once the barbell has reached a sufficient height and the athletes has dropped into their receiving position (varying depth of a squat), the shoulders must work to stabilize the barbell in this overhead position. It is at this point the shoulder experiences the highest amount of isometric EMG activity due to having to stabilize a weighed barbell in a sub-optimal position of squatting (36). Once the shoulder has stabilized the barbell sufficiently (no excessive translation in any direction) then the recovery phase begins in which the athlete must stand with the barbell and come to a complete stop, demonstrating control. Once this occurs, the lift is complete, and the athlete may drop the barbell. Olympic plates are made of specialized material which minimizes bounce when dropped en-face making this a relatively safe maneuver. The Olympic platform is also made of shock-absorbing material and is completely level helping to reduce any bouncing of the loaded barbell.

4.2 The Clean and Jerk and The Shoulder

The Clean and Jerk is the second competition lift and involves moving the barbell from the ground to the shoulder, (Clean) and from the shoulder to the overhead position (Jerk) (11). The first pulls moves the barbell from the ground to just below the knee through the use of the lower extremity. The shoulders in this phase are isometrically active to keep the barbell close to the body. (37) The second pull involves moving the bar from under the knees to about the mid-thigh position, the shoulders are simply keeping the barbell close to the body (38). Coaches will use the cue “the arms are straps” to convey the message of not using the arms to pull the barbell and bending the elbows too early. The third pull begins when the barbell is at or close to the hip crease and involves use of triple extension; the shoulders and arms now become active in the turnover phase. The shoulders are shrugged, and the elbows are brought up high and outside right into aggressive forward flexion with the elbows pointed directly straight at chest level to catch the bar. If the elbows are not quick enough, this may result in a missed lift. Once the barbell is caught at the shoulder level the athlete will stand to complete the Clean. From here, Athletes may widen their grip to shorten the distance they must jerk the barbell overhead. The Jerk involves moving the barbell from the shoulders to overhead in one smooth motion (39). This begins with the athlete performing a short dip and immediately reversing the movement to drive the bar upward and themselves underneath the barbell. Whether a split- or push-Jerk is performed does not matter because the shoulders are extremely active in both variations. The shoulders are working isotonically in conjunction with the lower extremity to Jerk the barbell overhead (40). Once the Jerk phase is over, the shoulder most turn from isotonic to isometric to stabilize the barbell overhead. The athlete then comes to a standing position and shows control by standing still for a total of 3 seconds. The barbell can then be dropped onto the platform like it was done on the Snatch.

After learning more about the shoulder, specifically the rotator cuff and all hoe active it during each lift and their respective phases it is easy to see how injury can occur during weightlifting. The next chapter will explore shoulder injuries in this sport.

The Shoulder in Olympic Weightlifting

Chapter 5: Shoulder Injuries in Weightlifting

The shoulder is under large amount of compressive and distractive forces during the sport of weightlifting 41). Weightlifters routinely lift more than bodyweight overhead; weightlifting is a sport of paradox because shoulders have to be mobile enough to move the barbell beyond physiological ranges yet be stable enough to stabilize more than bodyweight. 3 common areas of injury to the shoulder include: labral injuries, injuries to the long head of the biceps tendon (LHBT), and the rotator cuff.

Labral Injuries

The glenoid labrum has been described in this paper as the fibrocartilaginous covering which surround the entirety of the glenoid cavity to increase its surface area (42). Labral tears are common in overhead athletes are have been thoroughly investigated through great researchers like Gorantla et al. Snyder et al. (43,44). The Snyder classification is composed of 4 types of labral injuries specific to the antero-superior labrum (SLAP) tears (45). Type 1 is when the labrum and biceps are fraying with an intact biceps anchor. Type 2 tears involve fraying of the labrum with a detached biceps tendon anchor and are also referred to as "peel back lesions". Type 3 SLAP tears is called a bucket handle tear and involves a tear of the labrum but the biceps anchor is still intact. Type 4 SLAP tears are bucket handle tears that extend into the biceps tendon. Maffet et al. expanded the classification into 10 sub-types of SLAP tears continuing from type 4 (ie: 5-10) (46). The labrum is a 360 degrees structure making other parts vulnerable as well. For example, anterior-inferior injuries are known as Bankart lesions and are either soft tissue or bony. A soft-tissue Bankart lesion is direct damage to the anterior-inferior portion of the labrum (47). While a bony Bankart lesion also involves a fracture to the glenoid rim in the same anatomical area (47). Lastly, posterior labral lesions are also prevalent in the overhead athlete population. For example, a Kim's lesions is a superficial tear between the posterior glenoid labrum and glenoid articular cartilage and is postero-inferior in anatomical location (48). Another variation of posterior labral injury is overuse in nature because it is a mineralization of the posterior band of the inferior glenohumeral ligament (IGHL) (49). Please note this is a concise summary of labral injuries and should not be interpreted as all-encompassing on this topic. Labral injuries are most likely to occur during the turnover phase of the Snatch and Clean due to the traction force imparted on the labrum. In the Snatch, the labrum is most likely injured as the barbell goes into the turnover phase which twists the labrum onto itself in a known "peel back" mechanism of injury or traction as the barbell transitions into the overhead position.

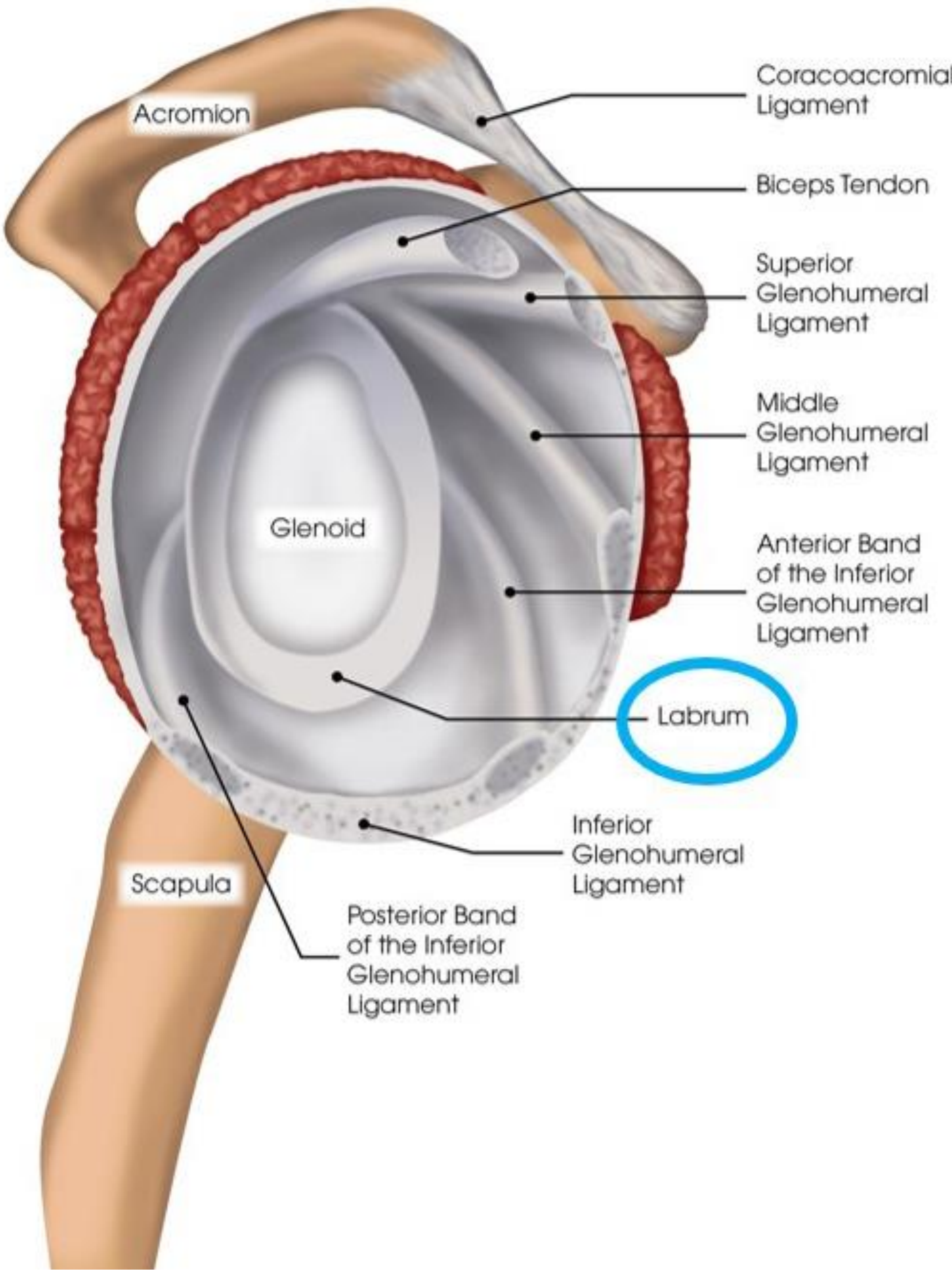
Long Head Biceps Tendon Pathology

The Long head biceps of the tendon (LHBT) is a unique structure because it originates from the supraglenoid tubercle (50%) and labrum (50%) making it cross both the shoulder and elbow joint (50). This Dissertation focuses on the shoulder thus will focus on the proximal portion of the tendon. The LHBT is both an intra-articular structure at its origin which turns extra-synovial as it passes through the anterior rotator cuff interval to enter the bicipital groove (50). The LHBT has been found to be a potent pain generator due its numerous nociceptors. Additionally, it is a biomechanically disadvantaged structure subject to overuse evident by a diffuse anterior shoulder pain. Although, the LHBT is subject to inflammation and can be described an tendonitis, a paradigm shift is happening in the field of tendon pathology. Tendinosis is a more accurate term because of the degenerative nature without inflammation that is occurring at the tendon (50). Injuries can also occur in conjunction with the biceps reflection puller system because this is the internal stabilization system (51). The pulley system is formed primarily by the superior gleno-humeral ligament (SGHL) and coraco-humeral ligament (CHL). Injury to the pulley system may lead to an increase in humeral instability and ligament translation (51). Due to the proximal and partly intra-articular location of the tendon it can be part of other injuries. The LHBT can be involved in labral injuries and directly involved in type 2 and 4 SLAP tears (45). These are some reasons why the proximal biceps tendon is injured and is a potent pain generator in the shoulder. The LHBT is most likely injured from the repetitive use of shoulder shrugging combined with forward flexion. The biceps is also active during a majority of both lifts being subject to chronic overuse injuries. And with its close relationship with the antero-superior labrum, any sort of SLAP tear has the potential to hurt the biceps anchor (52).

Rotator Cuff Pathology

The rotator cuff consists of the 4 muscles which work to create the concavity-compression effect and centrate the humeral head into the glenoid cavity (53). Due to this biomechanical effect and the large external forces imposed by a loaded barbell on the shoulder that creates multiple vectors, the function of the RC is very difficult. The RC must be strong enough to counteract these external forces while being durable enough to work over long periods of time isotonically and isometrically (54). The RC is most vulnerable during the turnover phase of each lift because of the high amount of torque generated by the shoulder onto the RC (54). The large amount of volume and load that accompanies weightlifting, especially during training cycles can wear the RC down. Specific RC pathology will be investigated in the following chapter.

Anatomy Relevant to Shoulder Injuries



Chapter 6: Rotator Cuff Injuries in Weightlifting

The RC is subject to extreme forces during each of the lifts due to the high loads being lifted. Specifically, the supraspinatus and infraspinatus are more commonly injured although all 4 muscles can be injured (55). Part of the supraspinatus tendon is in the sub-acromial space which can be decreased during overhead activities such as lifting making it susceptible to injury (56). This tendon compression may be the beginning of pathologic changes leading to tendinopathy. This tendinopathy then leads to a supraspinatus tendinosis in which the tendon itself becomes disorganized and shows mucoid degeneration at the microscopic level (57). Similarly, the infraspinatus acting as a primary external rotator is subject to large forces during the turnover phase of each lift, the jerk phase, and during training (58). During training, athletes may have multiple reps, multiple variation of lifts which involve lowering the bar from either the overhead position to the shoulders or all the way to the ground. Lowering of the barbell from a higher to a lower position is an eccentric internal rotation stress on the infraspinatus and to a lesser extent the teres minor. This eccentric internal rotation stress on the infraspinatus over time may also lead to tendinosis. Due to the prolonged activity of the RC throughout each lift, injury may occur. For example, during the first two pulls of the Snatch and Clean the RC works isometrically along with the latissimus dorsi to keep the barbell close to the body. In the third pull and turnover phases of both lifts the RC becomes isotonically active in moving the barbell to the shoulders or straight into the overhead position of the snatch. Even though, the barbell should keep a fairly vertical path close to the body, the sheer weight and velocity causes traction at the RC. Once training volume is factored into the patho-mechanical equation: full lifts, variation of lifts, and accessory exercises; we can see where and how injury occurs. If tendinosis continues untreated, volume continues increasing, or technique is poor this can lead to degenerative partial thickness RC tears. Partial RC tears can involve any of the 4 muscles and cause symptoms of achy pain along any aspect of the shoulder depending on the injury (59). A partial RC tear is categorized as a tear that does not extend through their entirety of the injured area (59). The anatomical footprint is still intact, and there are still muscle and tendon fibers intact. Management will be discussed in the next chapter but in general partial-thickness RC tears are treated with a first-line course of conservative care. If care is not taken to manage the partial thickness it may progress into a full-thickness RC tear (60). The full-thickness RC tear is described by an injury that extends the through the full muscle or tendon area (60). There is a complete hole or defect in the area of injury and retraction may be present. Full-thickness tears is where most patients begin describing pseudo-paralysis where they can't abduct their shoulder past 90 degrees due to pain inhibition (61). Lastly, full thickness may turn into massive RC tears (MRCT) where there is significant retraction of tendons present and surgical intervention is most likely due to extent of damage (62). There have been many classifications of MRCT such as Gerber (2 or more tendon involvement) and Cofield (>5 cm in size) (63,64). However, Schumaier et al. recently proposed a new classification that is multi-faceted (65). This group defines MRCT as a more than 67% exposure of the greater tubercle in the sagittal plane and retraction of tendons to the glenoid rim in the axial and coronal view on MRI (65). The next chapter will investigate how to diagnose the various types of RC pathologies.

RC Tear Classifications

1) Gerber Classification: Based on number of injuries tear
2) Cofield Classification: Based On Size of tear
3) Schumaier Classification: Based on amount of tendon retraction and anatomical footprint exposed

Chapter 7: Diagnosis of Rotator Cuff Injuries

History and Physical Assessment

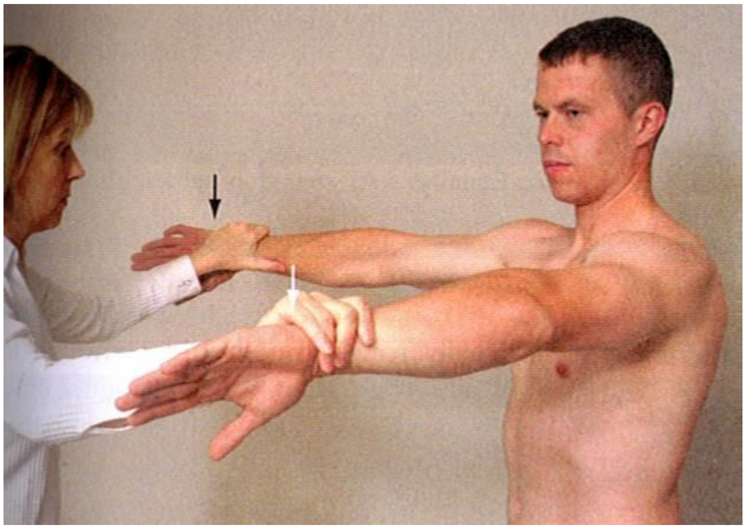
With the advent of new technologies, there are an increasing number of ways to diagnose RC injuries. The first line of diagnosis that will never be replaced is a thorough history and physical examination (66). When the patient reports to the respective clinical setting, a conservation begins to understand their history, signs/symptoms, possible mechanism of injury (MOI), and other factors associated with their injury (66). In regard to the Weightlifting athletes, additional questions must be asked such as: training load, lifting style (push jerk vs split jerk), current programming, and competition cycles. These additional questions will help guide the clinician to the specific injuries and give background on the athlete. For example, an athlete who is competing in 3 weeks is increasing their intensity and slowly decreasing their volume (i.e.: more load, less repetitions) while an athlete who is competing is 4 months might have a heavy training volume and loads. As a general rule, for an upper extremity complaint at least an upper extremity neurological screening to rule out the cervical spine as the source of injury (67). The upper extremity screening should include at least: Dermatomes, Myotomes, Deep Tendon Reflexes (DTR), and Pathological Reflexes. Once the history has been completed, special tests should proceed (67).

Pain Provocation Tests

There are many pain provocation tests in the shoulder, many of which are theorized to stress the RC. The term pain provocation tests (PPT) will be instead of special test to resonate that in the shoulder, PPT's should be used as an adjunct to help make a diagnosis as no one test or even group of tests can make a diagnose (68). The issue with most RC tests is their high sensitivity but moderate specificity at best (68). Recently, cluster testing has been proposed that increases a positive likelihood ratio. However, there is a general theme that RC tests are not sensitive enough to differentiate between structures (69). For example, Salamh and Lewis (2020) found the empty can test which is supposed to stress the supraspinatus actually stresses the sub-acromial bursa exploiting the innate weakness of "special tests" (68). Thus, PPTs will be discussed for this Dissertation to be thorough but please keep in mind they are low in helping to find a diagnosis.

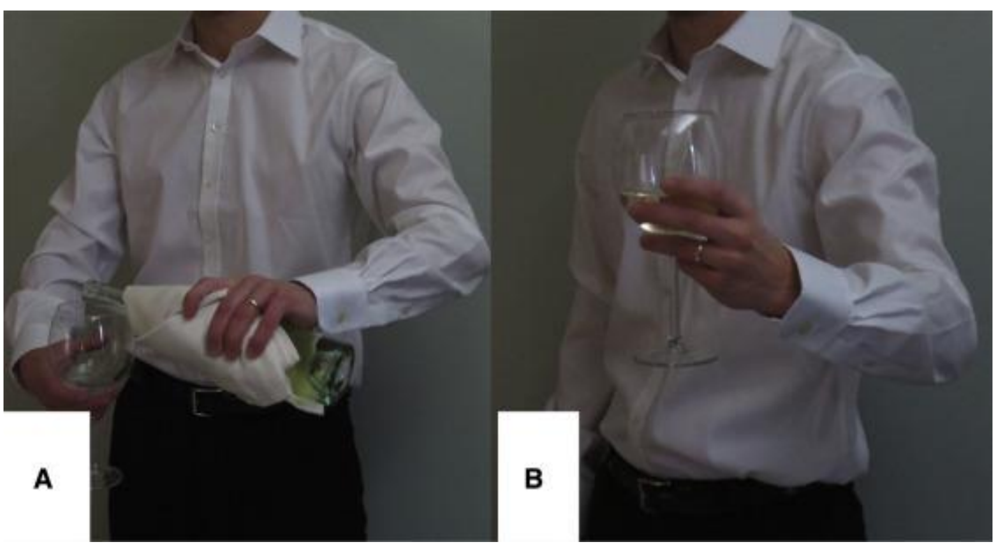
PPT Supraspinatus: (70)

1) **Empty Can Test:** Examiner Resists elevation in the scapular plane with the thumb pointing up



2) **Full Can Test:** Examiner resists elevation in the scapular plane with the thumb pointing down

3) **Champagne Test:** According to the literature, this is currently the most sensitive and specific test to stress the supraspinatus and involves the patient holding the arm in the scapular plane with 30 degrees of forward flexion with the elbow bent while the examiner resists abduction. (71)



PPT Infraspinatus/ Teres Minor (72)

These two muscles function to externally the RC. The infraspinatus functions at lower degrees of abduction while the teres minor functions at higher degrees of abduction.

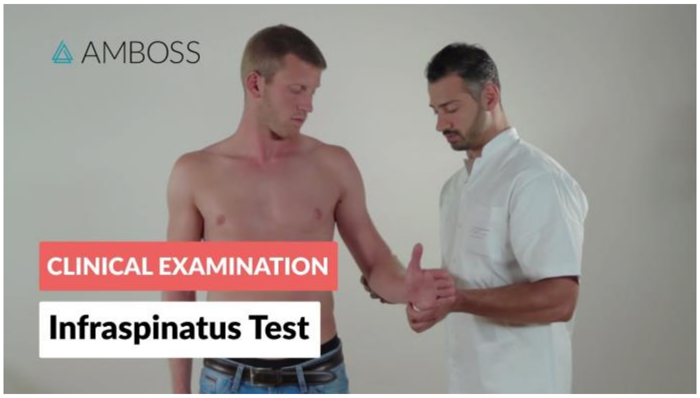
1) **External rotation lag sign:** The patients arm is placed in a position of shoulder abduction and external rotation passively and then is let go to see if they can hold the position actively.

2) 

3) **Hornblower Sign:** The patients arm is placed into 90 degrees of shoulder adduction, 90 degrees of flexion, and external rotation upon which they must resist an internal rotation-oriented force by the examiner.

4)

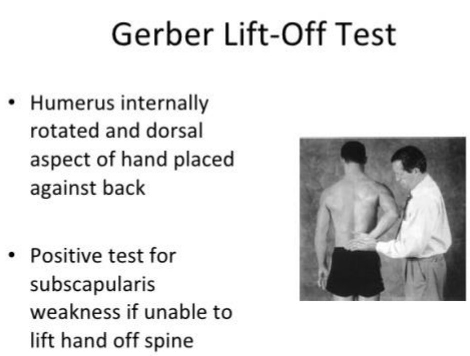
5) **Infraspinatus Tear Test:** The patients arm is put into 0 degrees of abduction, 90 degrees of elbow flexion, and 45 degrees of internal rotation while the patient externally rotates the shoulder against examiner resistance.

6) 

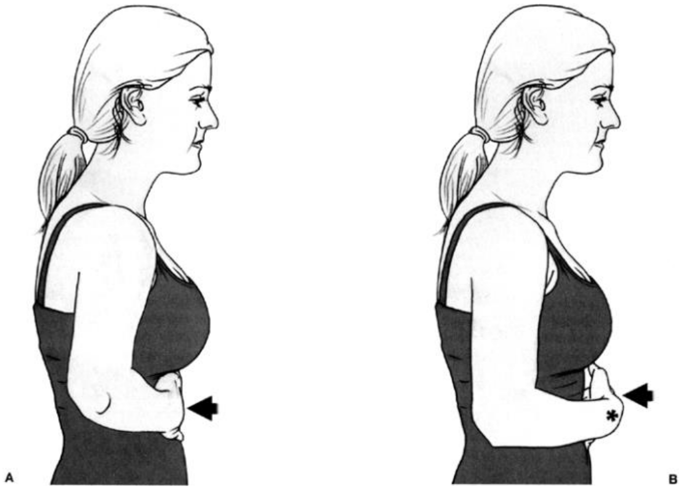
PPT Subscapularis (72)

1) **Gerber's test:** The patient attempts to put dorsal aspect of their hand onto their back

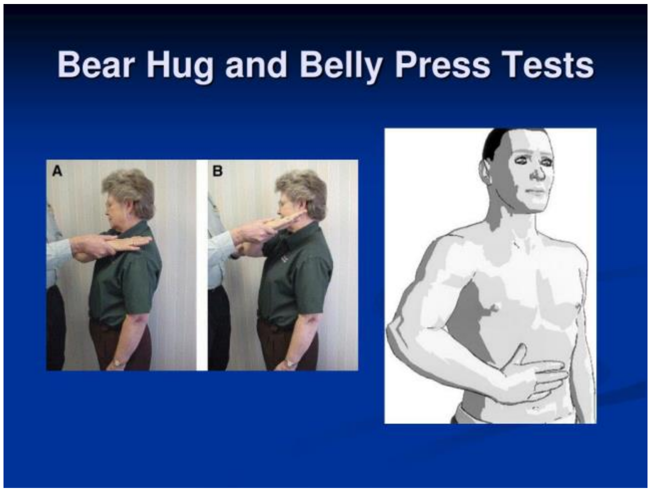
2) **Gerber's Lift-Off Test:** The patient starts with the dorsal aspect of their hand onto their back and attempts to lift the hand of the back



3) **Belly-Press Test:** The patients pushes their hand into the examiners hand which is in from

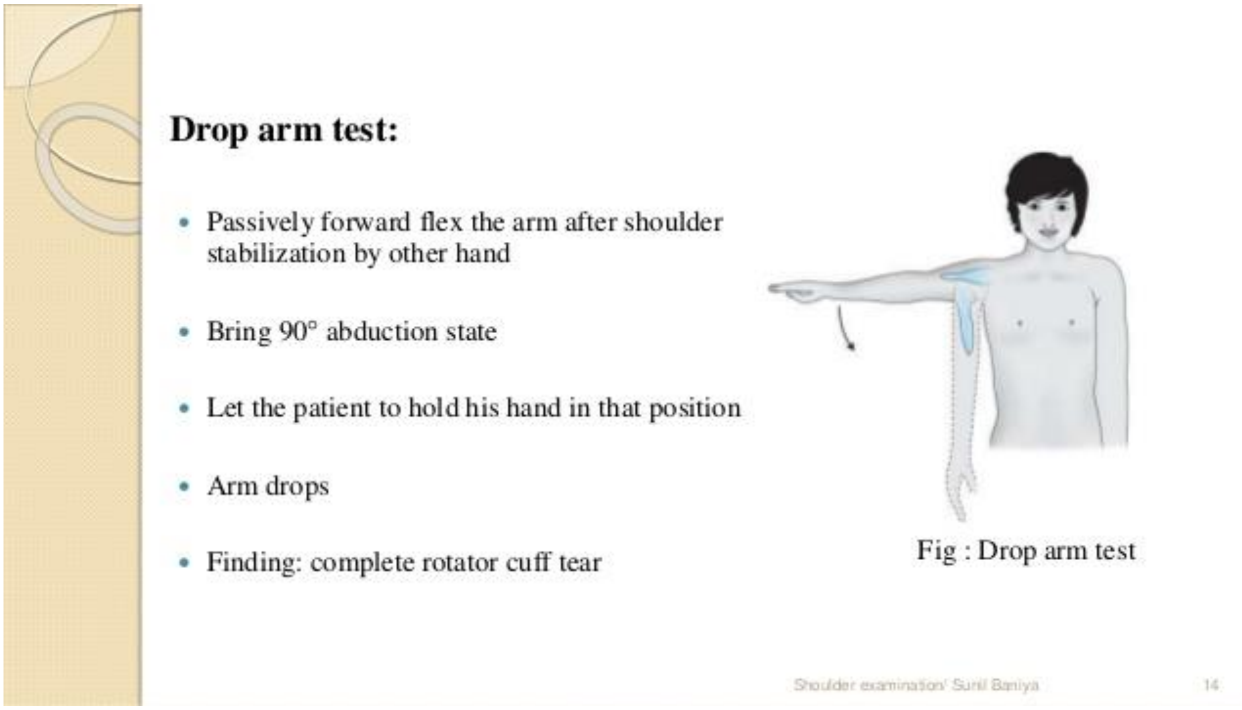


4) **Bear Hug Test:** The patient will put their arm onto the opposite shoulder and the examiner will attempt to take the arm off the shoulder by externally rotating the arm.



PPT Rotator Cuff (73)

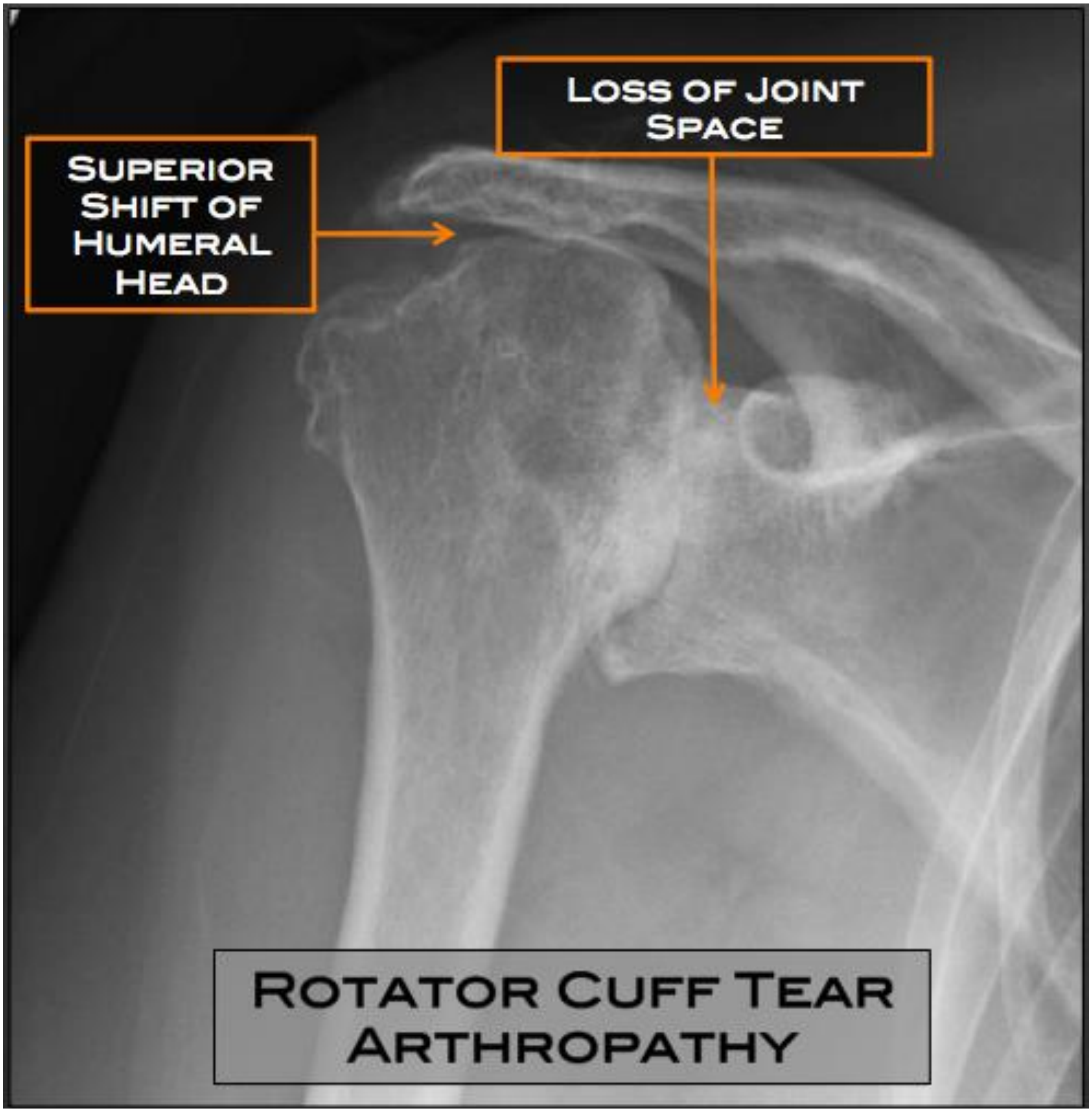
1) **Drop-Arm Test:** The patient attempts to slowly control adduction from at least 120 degrees of abduction down to 0 degrees.

2) 

Imaging

X-ray

X-ray will usually be the first imaging tool that will be used when a patient reports with shoulder pain and is suspected of having a RC pathology (74). Although X-ray is primarily used to explore bony pathologies, its time and accessibility make it a first line imagine tool. While it is not possible diagnose RC pathology on X-ray, there may indirect clues to guide the clinician. For example, sclerosis of either tuberosities may indicate overuse injuries like tendinosis (74). Specific to RC pathology may be suspected by visualizing superior migration of the humeral head. The next step would be MRI.



MRI/MR Arthrogram

The MRI is considered the gold standard in diagnosing rotator cuff pathology, especially tears (75). MRI imaging is very sensitive and specific at exploring soft tissue pathology making it ideal to aid in the RC (75). Using MRI imaging, the clinician can easily classify and quantify the injury, severity, and location (76). MRI are useful because they do not use ionizing radiation, however cons include cost, time to acquire imaging, and claustrophobia if a closed-body scanner is used. Although the availability of open-body scanners is growing to reduce this problem. The use of contrast has become a topic of interest in the shoulder because it can better visualize intra-articular structures. Even though the RC is extra-articular, MR Arthrogram has proven more sensitive in visualizing articular sided RC tears (77). Recently, Liu et al. (2020) performed a systematic review comparing the diagnostic accuracy of MRI vs MR Arthrogram and found MRI to be a more comprehensive tool as a first line advanced imaging in the RC (78).

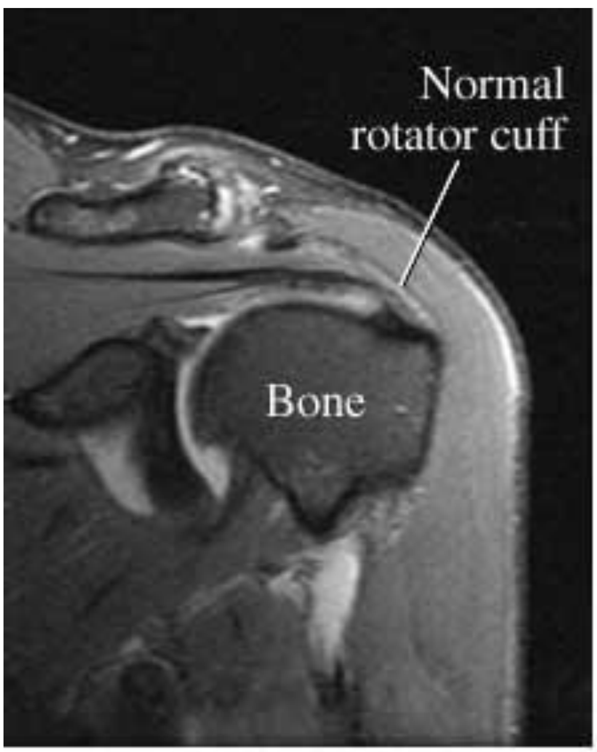


Figure 1

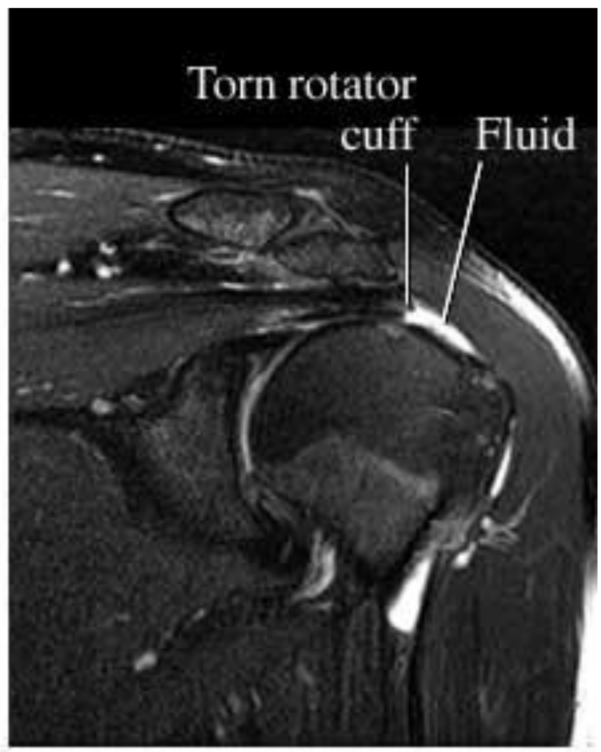
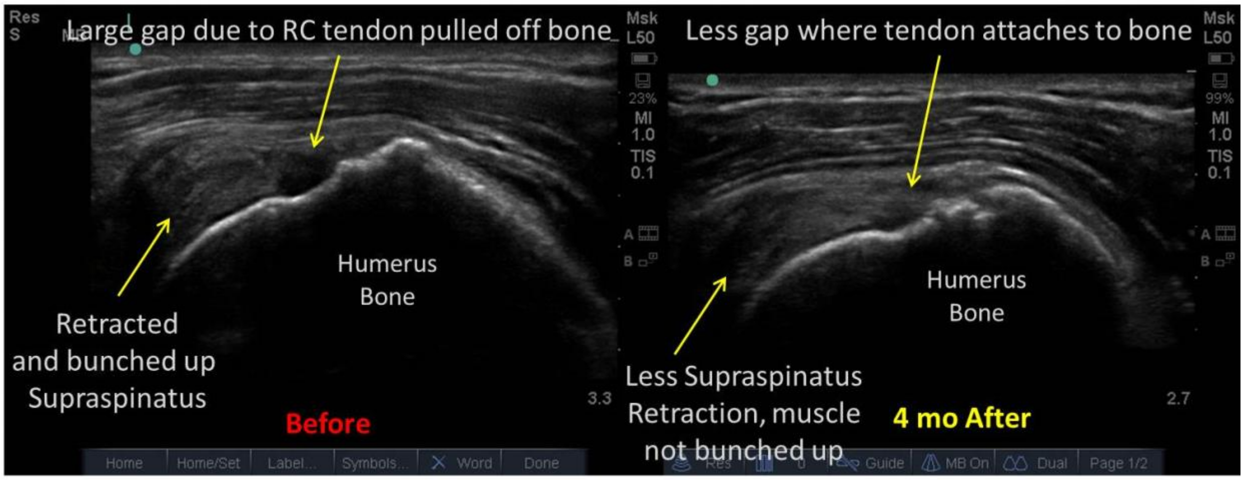


Figure 2

Diagnostic Ultrasound

Diagnostic Ultrasound has emerged as a comparable modality that is cost-effective and timesaving for both the clinician and the patient (77). Since anatomy can be visualized in realtime, this can play an important part in the shared decision-making process (79). However, in comparison to MRI, ultrasound is not yet as sensitive and is user-dependent making it a good acute tool is available but one that should be compared to MRI (79).



Chapter 8: Management of Rotator Cuff Injuries

Most RC pathology will be approached with a first line care of conservative treatment which may include manual therapy, instrument assisted soft tissue mobilization (IASTM), joint mobilization, and corrective exercises (80). Manual therapy is a very broad topic and its various forms are beyond the scope of this Dissertation; however, no matter which type the clinician may use its importance has been well documented by people like Antonio Stecco, Ida Rolf, Tim Speicher, and many more (81,82,83,84). Similarly, corrective exercises encompasses a large field known by different names such as rehab and neuromuscular control exercises. Although the types and techniques are beyond the scope of this book I would like to highlight the contributions of clinicians and researchers like Craig Liebenson, Stuart McGill, and Sue Falsone (85,86,87).

Part of the patient centered model of healthcare if putting patients first. Thus, once a physical and clinical examination has been completed it should be the duty of the clinician to take the time to explain the diagnosis and options revolving treatment (88). If the clinician does not have access to advanced imaging depending on licensure restrictions, resources, or time it is recommended to consult with an orthopedic surgeon. The orthopedic surgeon can order advanced imaging and give the patient other treatments as well (orthobiologics, surgery, etc). Once conservative treatment has been established, it is important to treat the entire kinetic chain of the weightlifting athlete. For example, the entirety of the shoulder, thoracic musculature, core, and hip complex should be strengthened so the athlete can have proper stability, endurance, and power to excel in their sport. Guidelines will differ but the goal is the same. This Dissertation seeks to gather the most relevant data and synthesize for other clinician to use as a guideline for RC pathology in the weightlifting athlete.

Phase 1: This phase is meant to regain full range of motion if a patient does not have it or has pain in a certain range. For example, in subacromial impingement there may be loss of motion due to pain between 90-120 degrees of shoulder abduction (89). This phase may include joint mobilizations, manual therapy techniques, IASTM, along with pain relief modalities that allow for ROM to be regained. The low back and hips may begin strengthening from Day 1 as long as the positions do not aggravate the shoulder. The specificity of Olympic Weightlifting allows the athletes to continue doing core, low back, and lower extremity to maintain his strength without aggravating the shoulder. Even from day 1 of rehab, the athlete should strive to maintain as much strength and power as possible at least in the areas mentioned above.

Criteria for progression into Phase 2: Full or near full pain free range of motion

Phase 2: The purpose of this phase is to rebuild strength and endurance in the mid- back muscles in movements below the plane of the shoulder (90 degrees). Focus should be on strengthening: rhomboids, mid/lower traps, serratus anterior, and rotator cuff muscles. This phase may benefit from blood flow restriction training if the patient is limited in lifting adequate loads to gain strength (90). Lower extremity exercises like multi-directional lunges, split squats, and hip thrust variations.

Criteria for progression into Phase 3: Full range of motion with strength 70% as compared to the uninvolved side as assessed by handheld dynamometer or manual muscle test (4+/5)

Phase 3: This is when patient should have enough baseline strength and

scapulothoracic stability to begin progressive overhead activity. This means performing strengthening above the shoulder plane and using concepts like end-range strengthening. Focus on strengthening and increasing the endurance of the rotator cuff musculature and their ability to promote a proper gleno-humeral rhythm and scapula- thoracic rhythm (90).

Criteria for progression into phase 4: Strength at least 75-80% assessed by handheld dynamometer or manual muscle test (5-/5).

Phase 4: This is the phase where a patient begins activities that will translate directly into Olympic weightlifting. Clinicians should strive to mimic the same motor control patterns as will be encountered by the patient in The Snatch and Clean and Jerk (91). In weightlifting this will include positions of 90/90 and overhead strengthening. Incorporating jumps into programming for power production is appropriate here.

Criteria for progression into phase 5: At least 85-90% of the uninvolved side or manual muscle test 5/5. Please note that being 85-90% strong does not mean the patient is done with rehab, simply they are strong enough to handle activities of most training and daily life. From here, the patient can transition into a strength and conditioning program.

Sport Specific Rehab Guidelines

This phase is where the athlete begins incorporating the new strength and neuromuscular control patterns at normal training loads. The approach to this phase is one of gradual progression with increasing volume and intensity (92). For example, Olympic weightlifters would follow a progression from least intense to most intense would be clean+ strict press> clean+ push press> clean+ push jerk> clean + split jerk. Using patient soreness as a load indicator is a great tool in assessing tolerance. Patient soreness can be measured the following day compared to a numerical rating scale (NRS). For example, after a workout a 3-4/10 NRS may be rated as appropriate soreness, in the return to sport athlete the same criteria applies. If an athlete is below or above these numbers, load should be modified respectively. Other, more objective criteria should also be used to monitor response and rate of recovery. Two practical methods are heart rate variability (HRR) which measures the ability to recover when going from physical activity to rest and ratio of Acute: Chronic workload in which it is best to avoid spikes in a micro cycle or training cycle above the average workload that is being performed. According to current guidelines, going above a ratio of 1.0 begins increasing the rate of injury or reinjury and clinicians should strive to stay within the range of 0.8-1.3, ratios above 1.5 begin to exponentially increase risk of injury and re-injury (93-97).

Current literature states at least 12 visits or sessions should be tried before deeming if the program has been successful or not. However, the rate of tear progression is well-documented with larger tears being more susceptible to growing, retraction, and fatty infiltration.

If surgery is indicated, an arthroscopic RC repair is usually performed along with other procedures such as: sub-acromial bursectomy or distal clavicle resection. The next chapter will explore a RC post-surgical rehabilitation protocol.

Chapter 9: Post-Surgical RC Repair Rehab Protocol

Rotator cuff repair through shoulder arthroscopic repair has become the most common of surgically managing partial-thickness, full-thickness, and in some cases massive tears. Please note this Dissertation will focus on RC tears that are reparable, respective. The purpose of this Dissertation will be to synthesize the most current data to layout a RC repair rehab protocol for clinician to refer to as it pertains to Olympic Weightlifters (98,99,100,101)

Phase 1 – Immediate Post-Surgical Phase (Weeks 1-4):

Goals:

- Maintain integrity of repair
- Diminish pain and inflammation
- Prevent muscular inhibition
- Independent with ADL's
- Delay muscle atrophy

Precautions:

- No active range of motion (AROM) of Shoulder
- Use of arm sling for 4 weeks
- No lifting of objects
- No shoulder motion behind back
- No excessive stretching or sudden movements
- No supporting of body weight by hands
- Keep incision clean and dry

Criteria for progression to the next phase 2:

- Passive range of motion (PROM) Flexion to at least 100 degrees
- PROM ER in scapular plane to at least 45 degrees
- PROM IR in scapular plane to at least 45 degrees
- PROM Abduction to at least 90 degrees in the scapular plane

Week 1

- Abduction brace / sling
- Sleep in brace / sling
- Begin scapula musculature isometric exercises; cervical ROM
- Cryotherapy for pain and inflammation

- Wrist exercises to offset fascial and joint stiffness

Week 2-4

- Continue use of brace / sling
- Pendulum Exercises begin Week 3 (Day 21)
- Start passive Shoulder ROM to tolerance Week 3 (Day 21)
- Continue Elbow, wrist, and finger AROM / resisted
- Cryotherapy as needed for pain control and inflammation

Phase 2 – Protection Phase (Week 4-10):

Goals:

- healing of soft tissue
- Do not overstress healing tissue
- Gradually restore full passive ROM (week 4-5)

Precautions:

- No lifting
- No supporting of body weight by hands and arms
- No excessive behind the back movements
- No sudden jerking motions

Criteria for progression to the next phase 3:

- Full AROM
- Scapular Neuromuscular Control

Week 4:

- Continue grip strengthening exercises
- Continue PROM of the shoulder
- Initiate light isometrics of scapular muscles at week 4
- Discontinue brace at the end of week 4

Week 5-6:

- Continue use of brace / sling full time until end of week 5
- Between weeks 5 and 6 may use brace / sling for comfort only
- Initiate

- Progressive passive ROM until approximately Full PROM at Week 5-6.

- Gentle Scapular/glenohumeral joint mobilization as indicated to regain full passive

- Initiate Grade 1-2 joint mobilizations

Strength:

- Initiate light isometrics of rotator cuff at week 6
- Initiate supine AROM exercises with no resistance
- Initiate seated PROM pulley exercises
- Initiate Seated scapular clock exercises
- Seated scapular squeezes

ROM

- Continue previous exercises in Phase 1 as needed
- Precautions from Phase 1 still apply
- Continue cryotherapy as needed
- May use pool (aquatic therapy) for light ROM exercises
- Ice after exercise

Week 6-8:

- Initiate AAROM and stretching exercises
- Initiate rotator cuff isometrics
- Initiate active ROM movements week 6

Strength

- Continue Rotator Cuff Isometrics
- Continue Scapular Clock exercises
- Prone Rowing
- Seated low row
- Bicep/Tricep Work

Lower Body Strength Exercises that do not stress the shoulder (Leg Press, Bodyweight multi-planar lunges)

Phase 3 – Intermediate phase (week 10-14):

Goals:

- Full AROM (week 10-12)
- Maintain Full PROM
- Dynamic Shoulder Stability
- Gradual restoration of shoulder strength, power, and endurance
- Optimize neuromuscular control
- Gradual return to functional activities

Precautions:

- No heavy lifting of objects (no heavier than 5 lbs.)
- No sudden lifting or pushing activities
- No sudden jerking motions
- Initiate RC strengthening at Week 12

Criteria for progression to the next phase 4:

- Able to tolerate the progression to low-level functional activities
- Demonstrates return of strength / dynamic shoulder stability
- Re-establish dynamic shoulder stability
- Demonstrates adequate strength and dynamic stability for progression to higher demanding work/sport specific activities.

Week 10:

- Continue stretching and passive ROM (as needed)
- Dynamic stabilization exercises
- Initiate strengthening program

Strength:

- Seated rows with resistance
- Supine punches with resistance
- Prone Shoulder Extension
- Prone rowing
- Standing D1-D2 Patterns
- Lateral shoulder raises

Week 12:

Goals

- Continue all exercise listed above
- Initiate light functional activities
- Initiate rotator cuff strengthening

Strength

- IR/ER standing at neutral
- Rhythmic stabilization at 90 degrees

- Bodyblade below 90 degrees
- Standing PNF patterns with resistance bands

Week 14:

- Continue all exercise listed above
- Strength
- Continue mid-back and upper-back strengthening exercises
- Continue progressing RC strengthening
- Continue progressing ER/IR but stay below 90 degrees

Phase 4 – Advanced strengthening phase (week 16-22):

Goals:

- Maintain full non-painful active ROM
- Advance conditioning exercises for Enhanced functional use of UE
- Improve muscular strength, power, and endurance
- Gradual return to full functional activities

Week 16:

Goals

- Continue ROM and self-capsular stretching for ROM maintenance
- Continue progression of strengthening
- Advance proprioceptive, neuromuscular activities
- Begin functional shoulder exercises overhead

Strength

- Initiate single arm plyometric toss
- Prone ER plyometric toss
- Quadruped Shoulder ER PAILs
- Begin Clean grip Deadlift
- Begin Snatch grip Deadlift
- Begin Isometric Overhead holds with dumbbells
- Begin Sled Pulls

Week 20:

- Continue all exercises listed above
- Continue to perform ROM stretching, if motion is not complete

Strength

- Begin Clean pulls
- Begin Snatch pulls
- Begin Push Press
- Begin sled pushes
- Begin Dumbbell Snatches

Phase 5 – Return to Weightlifting (week 20-26):

Goals:

- Gradual return to weightlifting training
- Gradual return to recreational activities

Week 23:

- Continue strengthening and stretching
- Continue stretching, if motion is tight

Strength

Begin 3-position Power Cleans

Begin Push Jerk Progression

Continue Dumbbell snatches

Week 26:

Begin Power Snatch Progression

Begin Clean and Jerk Progression

Systematic Review of Current Protocols

Paper	Sling	AROM	RC Isometrics	RC Strength	Overhead Activity
NorthEast Orthopedics	D/C at 6 weeks	Week 3-6 Supine AROM	Week 4		Week 16-20
and Sports Medicine					
Massachessets General Hospital	D/C at 6 weeks	Week 9-10		Week 13-16	Week 20+
Sports Medicine					
Brigham and Young Women's Hospital	D/C at 6 weeks	Week 6-8	Week 6-8	Week 10	Week 16-20
OrthoIndy	D/C at 6 weeks	Week 6	Week 6-8	Week 9-10	Week 16
The Stone Clinic	D/C at 4 weeks	Week 4	Week 4	week 12	
Canadian Surgery Solutions	D/C at 4-6 weeks	Week 6	week 4	Week 12	Week 20
South Shore	D/C at 4 weeks	Week 6-12	Week 6-12	Week 12	Week 24
Hospital					
University of Wisconsin	D/C at 6 weeks	Weeks 8-12		Week 12	Week 20

Chapter 10: Return to Weightlifting Progression

Many rehabilitation and performance protocols have sufficient detail to replicate in phases 1-4. Phases 1-4 are defined as the acute or protective phase of post-surgical to the functional phase. While current protocols do a good job of describing goals, precautions, and criteria progression there is a lack of information into the Phase 5 (Return to Sport). As this Dissertation is meant to contribute to the growing body of literature in Olympic Weightlifting it will lay out a general Phase 5: Return to Weightlifting program. Please note this is meant to be used as a guideline and if any questions arise during this phase seek the help of a weightlifting or strength and conditioning coach.

Phase 5: Return to Weightlifting

Goal: Return to Weightlifting with a sufficient strength base and technique to give the athlete psychological confidence and a proposed safety margin from re-injury.

1. **Clean and Jerk Progression:**
   - A) Power Clean: High-Hang; Hang; Full
   - B) Follow power clean sequence but add in a Push Press
   - C) Full Clean: High-Hang; Hang; Full
   - D) Follow full clean sequence but add in a Push jerk
   - E) Follow this full clean sequence but add in a Split Jerk (if this is jerking style of athlete)
2. **Snatch Progression:**
   - A) Power Snatch: High-Hang; Hang; Full
   - B) Snatch Balance: High-Hang; Hang; Full

C) Full Snatch: High-Hang, Hang; Full

3. **Olympic Lifting Variations**

   Goal: This section is to begin working on athletes weaknesses that are expected after shoulder arthroscopic surgery which may include lack of gleno-humeral and scapula-thoracic neuromuscular control.

   A) Overhead Squats: For the purpose of overhead stability

   B) Overhead Holds: From the rack, the athletes practices standing up the barbell from the split position to standing or from the wider snatch stance to hip width apart.

4. **Accessory Exercises**

   Goal: To continue rebuilding the strength and power base of the Weightlifter

   A) Squats (Back and Front)

   B) Strict Press

   C) Offset Deadlifts

Phase 5 of Rehabilitation should not be taken with absolute time periods of progression. In general, each week of progressive complexity and load on the shoulder should not increase by more than 10% in training volume. Different athletes may progress through these exercises and lifts at different lifts, but the goal is to help create a better athlete than underwent surgery. This is why Phase 5 does not last any specific time but can only end when the athletes at minimum when the athlete can perform at 100% of their previous surgery numbers.

Chapter 11: Conclusion

Shoulder injuries are common in the general population and even more so in the athletic population. Overhead athletes are prone to shoulder injuries due to the large force generated at this joint. Although shoulder injuries are well documented in overhead sports such as Baseball, the data is scarce for Olympic Weightlifting. Within shoulder injuries, the rotator cuff is susceptible to injury due to its dynamic stabilizing function. In weightlifting, because the shoulder has to eccentrically decelerate the barbell in the Clean and Jerk during the receiving phase of the clean and in the Jerk position when the barbell goes from the shoulder to overhead it is again the rotator cuff that decelerates the barbell. In the Snatch, the rotator cuff is most active concentrically during the turnover phase as the barbell visually goes from under chest level to above chest level. It is eccentrically most active in the receiving position when the barbell is caught in an overhead squat position of varying depths depending on the Weightlifter.

Most rotator cuff injuries are caused by the overuse accumulated through training volume in the shoulder joint. Other confounding variables such as technique, mid-back strength, and previous injury may also play a role in injury susceptibility. Injury to the RC may begin as a tendinosis that progresses into a tear (partial thickness vs full thickness) is not addressed. Currently, MRI is the most sensitive and specific modality that should be used to determine the extent and severity of the injury.

Once the injury has been diagnosed, a trial of conservative care is usually the first line of treatment after a discussion with the patient and possible orthopedic surgeon. It has been found that 12 sessions should be completed before deciding if the athlete has responded favorably or negatively to treatment. If the Weightlifter has responded favorably then this rehabilitation program is maintained through the entirety of their career in an effort to make a muscular sling to aid the RC around the shoulder and reduce the course of RC pathology. If the athlete fails to respond to conservative then surgical management is usually warranted.

Rotator cuff repair via shoulder arthroscopy is the most common procedure used because it has been found to yield favorable outcomes as compared to the mini-open and open techniques. Rehabilitation following arthroscopic RC repair vary but the salient timepoints include use of sling, when active range of motion and strengthening can begin, when overhead strengthening can begin, and when Weightlifting can begin again.

Since a return to Olympic Weightlifting protocol does not exist as of the writing of this Dissertation one has been synthesized by the author using the most current literature taking into account rotator cuff healing rates, shoulder stress, and the sport of Weightlifting. This is the culmination of the Dissertation which lays out a full Phase 5: Return to Weightlifting Protocol.

The purpose of the Dissertation was to create and contribute new knowledge into the sport of Olympic Weightlifting regarding rotator cuff injury. It is humbly the hope of the author this criterion has been met.

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SELINUS UNIVERSITY OF SCIENCES AND LITERATURE PhD Thesis

IN DEFENCE OF MY DISSERTATION

As per one of the requirements of the Selinus University of Sciences and Literature for the award of the Ph.D. Degree

This Dissertation Defense is to fulfill the partial requirements for the Ph.D. degree in Kinesiology, Rehabilitation Science.

Sports Medicine is my life’s passion and I have been so blessed to be able to pursue this endeavor to the highest degree. The Doctor of Philosophy degree in Kinesiology with an emphasis in Rehabilitation Sciences represents the fruition of my professional goals and aspirations. This journey began with my undergraduate exploration into the field of Kinesiology when I first became fascinated with Sports Medicine and this led me to a Bachelor of Science degree in Athletic Training. Once becoming an Athletic Trainer I was amazed by how much I did not know, and my curiosity and thirst for knowledge began to take its true form. This specificity was in human movement, biomechanics, and corrective exercise. I learned this niche within Kinesiology was called Rehabilitation Science. This led to me to pursue a Master of Science degree from California University of Pennsylvania. Simultaneously, in California the Athletic Training certification is not regulated which makes it difficult to use in other settings other than scholastic. I decided to pursue a Doctor of Chiropractic degree from Southern California University of Health Sciences which I completed it granting me the honor of becoming a licensed chiropractor. However, I still yearned to learn more about and truly become an expert in the field of Kinesiology, I ultimately wanted to contribute research to this field. This led me to pursue this Ph.D. degree in Kinesiology from Selinus University. I would like to explore and become a humble expert of rotator cuff injuries within the sport of Olympic Weightlifting and that is the Dissertation Topic I have chosen to pursue and defend to the esteemed Dissertation Committee.

The Introduction of this Dissertation echoes my passion for this profession and how I would like to contribute to the small body of knowledge that exists within the field of Weightlifting. There are a fair amount of biomechanical, application to athletic performance, power increases, and general injury. My goal was to explore and increase the body of knowledge into shoulder injuries within the sport.

Chapter 1 introduces the sport of Olympic Weightlifting for those who may not be familiar with the sport, its lifts, and some basic technical terminology necessary to understand this Dissertation.

Chapter 2 lays the anatomical and physiological foundation for the complexities and of shoulder, scapula, and related joints. The purpose of this chapter is to understand the stability-mobility paradox that exists with joints and why the shoulder is prone to dislocation and subluxation injuries.

Chapter 3 goes further into the topic of this Dissertation by exploring its main structure: the rotator cuff (RC). My goal into this chapter if for the reader to completely the RC, its actions, attachments, and most importantly why it is so crucial in this sport.

Chapter 4 brings together the anatomical area of interest (the shoulder) and the sport (Olympic Weightlifting). This further seeks biomechanical and motor control aspects of why the shoulder and Olympic weightlifting are so intertwined.

Chapter 5 synthesizes the current literature regarding shoulder injuries and Olympic Weightlifting. Current literature is non-specific, but I was able to find that most injuries occur at the LHBT (proximal biceps pathology), labral pathology, and rotator cuff injuries.

Chapter 6 finds that there is a scarcity of research in rotator cuff injuries. Thus, I gathered relevant data from other more studied sports such as baseball. Baseball is similar in the sense that both athletes are throwing an implement, baseball throwing in the anterior direction with a concurrent distraction force the rotator cuff must counteract. Olympic Weightlifting during both lifts involves the barbell moving in the superior distraction with a superior distraction force on the rotator cuff. Rotator cuff injuries are common weightlifting due to large activation of this musculature that leads to overuse injuries such as tendinosis and varying types of tears.

Chapter 7 explains the most current literature in the diagnosis of rotator cuff injuries. The history and physical exam are still the most important part of obtaining a diagnosis. Beyond this, An MRI is deemed the gold-standard when it comes to diagnosing the extent and severity of RC injury. Diagnostic Ultrasound is also proving to be a quick and reliable way to image RC pathology, although it is highly user reliable and not as sensitive as MRI.

Chapter 8 is important because the vast majority of RC pathology conservative care is the first line of treatment implemented and includes exercises to increase shoulder and scapular neuromuscular control. However, I take this further because the Olympic weightlifter needs to entire the kinetic chain thus having them continue performing lower body exercises and core exercises because this sport requires use of the whole body to produce power.

Chapter 9 talks in depth about the post-operative care when conservative care has failed. The most common procedure performed today is a rotator cuff repair via shoulder arthroscopy. The rehab guidelines used in this Dissertation synthesize the most current and best literature in the field of RC repair. The first three phases of any protocol will be similar because tendon healing and protection of the repair site are of utmost importance. Phase 4 is when I begin to add in weightlifting exercises to make it pertinent for this athletic population.

Chapter 10 is when Phase 5: Return to Weightlifting is addressed which becomes specific to this sport only. There is a need for this rehab protocol because to the knowledge of the author no such protocol exists or has been written about. This chapter is meant to empower athletes, coaches, and clinicians and give them a resource for practical use.

The purpose of this Dissertation has been to explore rotator cuff pathology in Olympic Weightlifters and explain the diagnosis, imagine, management, and return to sport. Seeing as this is the first paper of its kind to do so, I humbly seek to defend the validity and reliability of this Dissertation to the esteemed Dissertation committee of Selinus University to have the degree of Doctor of Philosophy in Kinesiology, Rehabilitation Science bestowed upon me.