Strength Training for the Shoulder: Should Throwing Athletes Lift Weights Overhead?

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Should throwing athletes lift weights overhead? During the Rehabilitation and Performance Training of throwing athletes, especially baseball players, this is a common concern often expressed by both players and coaches. The specific baseball athlete where this topic appears to generate the greatest concern is the pitcher. The apprehension displayed by both coaches and players, is due to their fear of the possible adverse effect of this type of overhead training on the shoulder, and more specifically the rotator cuff, and throwing performance. Prior to determining if this type of strength training is not only safe, but of benefit to the throwing athlete, it is necessary for the rehabilitation/sports performance specialist to understand shoulder anatomy and biomechanics, as well as the performance of overhead strength training.

The Scapulothoracic and Glenohumeral Joints of the Shoulder

The scapulothoracic joint is comprised of the scapula and its position on the posterior thorax wall. The glenohumeral joint is comprised of the head of the humerous (ball) and the glenoid fossa (socket) of the scapula. Since the glenoid fossa or "socket" of the shoulder is actually a portion of the scapula, the role of the scapula is essential in achieving safe and effective overhead shoulder range of motion (ROM) and function. The surface of the glenoid fossa is only one-third to one-fourth that of the humeral head, which means that only part of the humeral head is in contact with the glenoid at any given time.

During any exercise performance requiring arm elevation, scapula protraction, tilting, and rotation are critical to ensure proper contact and position of the scapula on the thorax, as well as maintaining the proper position and contact of the humeral head in the glenoid fossa for appropriate and safe arm and hand function. Secondly, proper placement of the scapula maintains a safe position of the coracoacromial arch, formed by the corocoid and acromion processes and the connecting corocoacrominal ligament. This position prevents "subacromial impingement" of the soft tissue structures located in the subacromial space (supraspinatus, long head of the biceps, and subacromial bursa), by maintaining adequate spacing (approximately 9 to 10 mm) between the coracoacromial arch and head of the humerous. Third, due to the attachment of the rotator cuff muscles on both the scapula and humerous, the muscles of the scapula must be strong enough to provide a stable base or "platform" during rotator cuff function so the humerous may move both freely and when necessary, at high velocity, without placing the rotator cuff at increased risk of injury. Finally, and also due to the scapula attachments of the rotator cuff, the proper positioning of the scapula during humeral movement ensures the most advantageous length tension of the rotator cuff musculature for optimal muscle performance.

The Rotator Cuff

The four rotator cuff muscles, the supraspinatus, infraspinatus, subscapularis, and teres minor are responsible for the important movement and function of the shoulder. These muscles provide two basic functions at the glenohumeral joint. The rotator cuff provides multiplane movement and rotation of the humerous for optimal shoulder function and hand position. The second important role is the rotator cuff's opposing function to the deltoid muscle group. During overhead shoulder motion, the rotator cuff provides a compressive force on the head of the humerous directly into the glenoid, as well as an inferiorly directed force, both of which oppose the superiorly directed force on the humeral head by the deltoid muscle group (Figure 1). These rotator cuff forces assist to prevent a superior migration of the humeral head in the glenoid during overhead shoulder motion. By maintaining proper humeral head position in the glenoid, the incidence of rotator cuff "impingement" and injury is avoided.

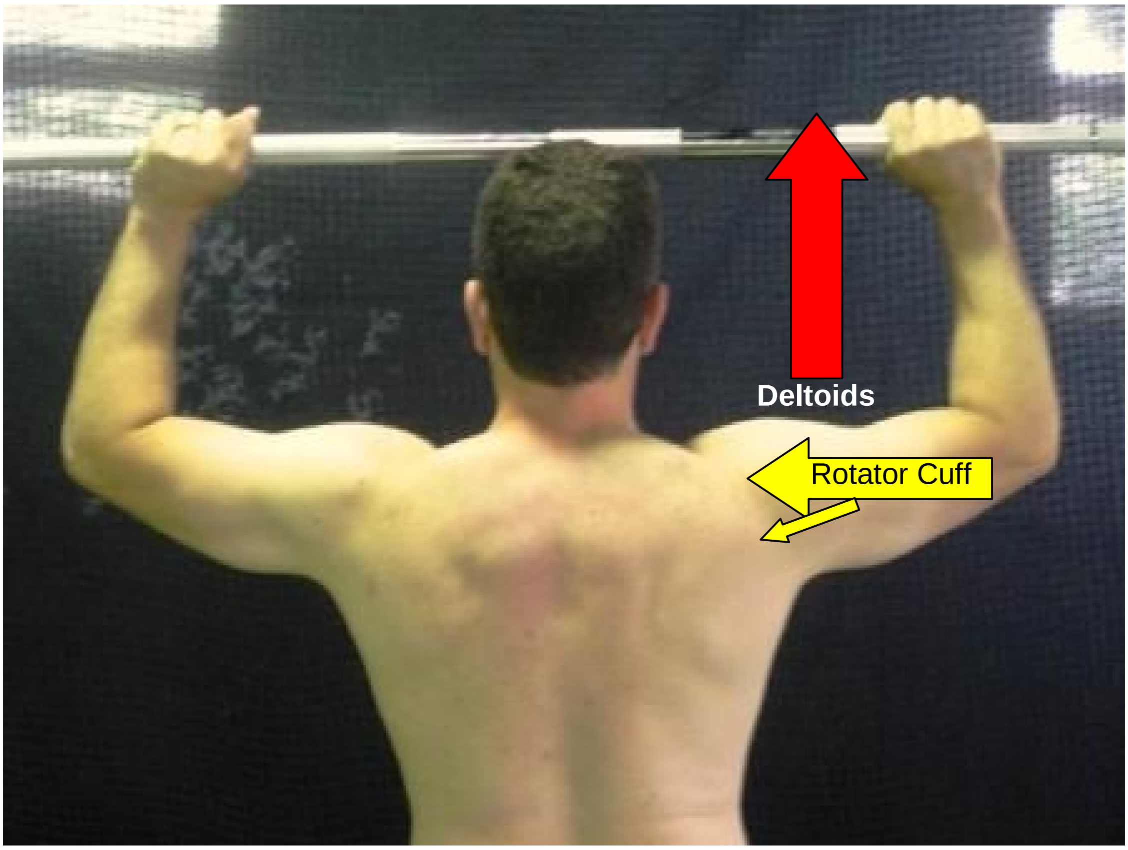

Figure 1 The Deltoid – Rotator Cuff Force Couple

Shoulder Biomechanics and Overhead Range of Motion

The shoulder is a very mobile joint allowing for 180 degrees of overhead motion. This overhead ROM is achieved by the combined efforts of humeral elevation with scapular motion. During overhead ROM, the initial 30 degrees of elevation is directly achieved by the humerous. This is known as the ‘setting phase” of the shoulder ROM. As the humerous continues to elevate, there is an overall 2:1 ratio of humeral elevation to scapula rotation to conclude directly overhead at 180 degrees.

It should also be noted that overhead shoulder function does not usually occur in a straight plane of motion. Functional overhead shoulder ROM usually occurs in the *plane of the scapula* (POS). The POS has a resting orientation of the glenoid fossa at a position of approximately 30 to 45 degrees anterior to the coronal plane of the body. Since the POS is the normal “plane of overhead function”, it is highly recommended that the initial athletic performance training of overhead strength training exercises, especially with the post-operative/post-rehabilitated shoulder athlete, occur in this plane of motion. Overhead strength training in the POS provides a safe transition for the athlete to eventually initiate overhead training from the “racked” bar position. Lifting weights from this “racked” position will then occur in the sagittal plane of the body (Figure 2).

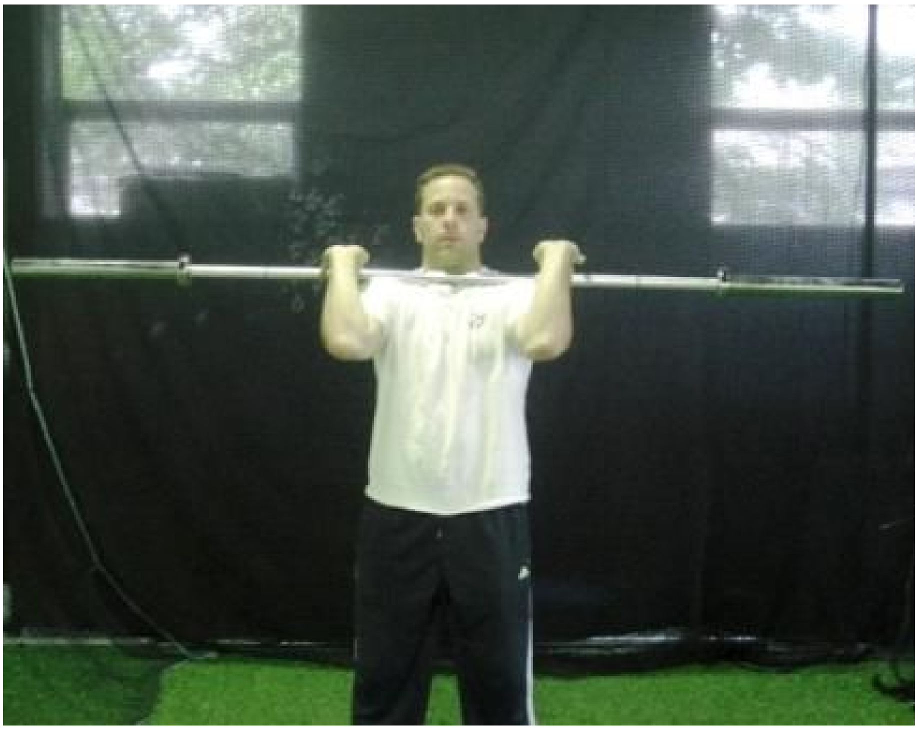

Figure 2 The Starting “Rack” Position

The Performance of the Overhead Weight Lifting Movement

The performance of overhead weight lifting exercises, whenever possible, should be performed in the standing position with the exercise initiated by the legs (i.e. push press). Success in athletics requires the athlete to generate high amounts of force into the ground surface area. This is most effectively achieved with the athlete in the standing position as there is contribution from the entire body. When initiating an overhead lift with the legs, the athlete is utilizing their total body during exercise performance. The force generated by the legs is transferred through the body to the bar as the lift is completed to the overhead extended arm position. With the barbell held in this overhead position, the center of gravity of the body is raised vertically, requiring additional CORE strength for stability. Athletic performance occurs with the athlete on their feet and throwing (pitching) is no exception. Forces generated from the legs are transferred through the body, shoulder, and hand, to propel an object (i.e. baseball) to an intended target. It is documented that the legs contribute up to 60% of the throwing velocity, so why would an athlete not train on their feet, including overhead lifting, whenever possible?

Upper Extremity Position and Bar Pathway

When performing overhead strength training exercises the athlete should start the exercise with the weight (i.e. barbell) to be lifted placed on their shoulders. The bar should follow an overhead arced pathway that allows the bar to travel from a position anterior to the body, to conclude with the arms fully extended directly overhead, and in line with the athlete’s ear (Figure 3). At times an athlete will conclude this overhead lift with their extended arms and hands positioned anterior to the head/body. This improper bar position will place undue stress on the shoulders and may result in lift failure and possible injury when attempting repetitive lifts and/or heavier weight.

Figure 3 Completion of the Overhead Lift

Muscle Activity during Overhead Press Performance

Dr. Hal Townsend and Dr. Frank Jobe performed a study which demonstrated high EMG rotator cuff and deltoid muscle activity during military press exercise (1). In fact the supraspinatus demonstrated a very high EMG activity as it contracted at a significant peak activity of 80% its maximum pretest strength during exercise performance. The authors also found significant EMG activity of the anterior and middle deltoids during performance of the military press exercise. Interestingly, it was reported that “light weights” were used in this study. It would be logical to assume, though not proven in this study, that if heavier weights were utilized, these heavier weights would require even greater muscle activity for successful exercise performance. This would result in increased EMG recordings, greater than the significantly high deltoid and rotator cuff muscle activity initially reported. If true, this would result in increased deltoid and more specifically, rotator cuff activity, (proven through EMG in this study) the same muscle group of concern utilizing overhead strength training.

Incidence of Scapula Compression during Exercise

Another very important benefit of the standing overhead strength exercise is that this type of training allows for normal glenohumeral-scapulothoracic rhythm to occur during exercise performance. The concept of “Closed Kinetic Chain” (CKC) type exercise is based on the premise that a distal portion of an extremity is “fixed” during exercise performance. The “fixation” of the distal segment provides stability at a joint(s) via the compressive forces that occur due to weight bearing forces that are applied to the joint(s) during exercise performance (i.e. the knee during the squat exercise). Applying the same CKC concept, when utilizing a bench to perform such exercises as the bench press, inclined press, seated military press, etc… compression forces due to both body and bar weight, are now applied to the scapula as it is positioned between the bench and the thorax of the body. These compressive forces result in “fixation” and increased scapula “stability” which may limit the required glenohumeral-scapulothoracic “rhythm” of the shoulder for safe exercise performance. This increased scapula stability (or lack of scapula mobility) may place the athlete at risk of possible injury that may occur with high repetitive exercise volume performed over time. Though we are aware of this scenario, the training of our athletes does include the bench press exercise. However, we pay special attention to bench press volume, so that it may not become too excessive, thus placing the athlete at possible risk of injury. We do not utilize a bench for any overhead strength exercise activity.

When Does Overhead Strength Training Become Dangerous?

The question may then be asked if the rotator cuff/deltoid force couple function is normal, thus maintaining the head of the humerous in its proper position in the glenoid, what is the danger of performing strength training activities overhead? Like any strength or power exercise there are conditions that may preclude the athlete to overhead exercise induced injury.

Dr. Thomas Wickiewicz, an orthopedic surgeon at the Hospital for Special Surgery in New York City performed a very interesting shoulder study (2). He compared the superior migration of the head of the humerous due to exercise fatigue vs. the superior humeral head migration found in individuals with rotator cuff tears. He had subjects without history of shoulder pathology and normal shoulder anatomy; exercise their rotator cuff muscles to fatigue. Once fatigued, immediate multiple x-rays of each subjects glenohumeral joint were taken at separate increasing angles as the subjects raised their arms, concluding overhead.

Dr. Wickiewicz found that the effect of exercise fatigue in individuals with "normal" rotator cuff musculature will cause the humeral head to superiorly migrate in the glenoid during overhead motion, mimicking the same superior humeral head migration that occurs in individuals with rotator cuff pathology. The fatigued rotator cuff could not "offset" the strong pull of the deltoid musculature previously described, resulting in a superior migration of the humeral head on the glenoid during overhead ROM.

In my experience, problems and pathologies that occur with "normal" athletic shoulders that train overhead are not due to the exercises performed, but to the excessive overhead exercise volume performed. Rotator cuff muscle fatigue results in a change in overhead shoulder kinematics placing the rotator cuff at increased risk of injury. It is very important to monitor overhead exercise volume, as excessive exercise volume may lead to possible injury to the shoulder anatomy.

A Final Thought……

Many star high school or college quarterbacks and football players train in the weight room to enhance their on field performance. It would not be unusual if their off-season and in-season strength and conditioning programs included the performance of overhead strength exercises. Often these same players are also pitchers on their respective high school or college baseball teams. Occasionally, these athletes receive college scholarships, or are drafted to play professional baseball as they have demonstrated, based on their pitching success, that they may possibly flourish at the "next level" of play. So where has the utilization of overhead weight lifting exercises been a detriment to the success of these athletes? It appears that successful athletes such as quarterbacks, volleyball and basketball players, track and field athletes, etc… commonly utilize the overhead lifts to ensure their athletic success. Perhaps the baseball coach and athlete should recognize the same. If the presentation of the baseball athlete is without abnormal shoulder pathology, their rotator cuff and scapular musculature are "normal", scapulothoracic and glenohumeral kinematics are functioning properly, and the athlete's program design does not place them at risk of injury, overhead weight lifting is a safe and beneficial exercise for the baseball and "overhead" athlete.

References

1. Townsend H, Jobe FW, Pink M, and Perry J: Electromyographic analysis of the glenohumeral muscles during a baseball rehabilitation program. Am J Sports Med 19:264-269, 1991

2. Wickiewicz TH, Chen SK, Otis JC, and Warren RF: Glenohumeral kinematics in a muscle fatigue model: A radiographic study. Presented at the 1994 Specialty Day meeting. American Orthopaedic Society for Sports Medicine, New Orleans, LA, February 1994.