Journal of Coaching Education

CRITICAL REVIEW ARTICLE

Sports Medicine Knowledge for Coaches: Keeping the Shoulder Healthy in the Weight Room

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ABSTRACT
Weight training is an excellent example of where coaches need to have acquired knowledge and skills in the realms of sports medicine, strength and conditioning, and risk management for safety and injury prevention. There are several exercises and lifting techniques that may increase the risk of shoulder injuries. This article will focus on the prevalence of injuries from weight training, a brief discussion of shoulder anatomy, three of the more common shoulder pathologies, and weight training modifications to assist in the prevention of these shoulder pathologies.

Key Words: National Standards, Safety and Injury Prevention, Physical Conditioning

A publication from the National Association for Sport and Physical Education (NASPE), an association
in the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD)
1900 Association Drive • Reston, Virginia • 20191 • www.NASPEinfo.org • 703.476.3410

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Sports Medicine Knowledge for Coaches: Keeping the Shoulder Healthy in the Weight Room

Coaches play an integral role when it comes to the health and well-being of their athletes. Some coaches have the opportunity to work closely with athletic trainers, strength-and-conditioning specialists, physicians, and other members of a comprehensive sports medicine team to fulfill these responsibilities, while other coaches are forced to take on these roles and responsibilities independently. Weight training is an excellent example of where coaches need to have acquired knowledge and skills in the realms of sports medicine, strength and conditioning, and risk management for safety and injury prevention. Weight training is beneficial to athletic performance and injury prevention. However, there are several exercises and lifting techniques that may increase the risk of shoulder injuries if not modified. With a greater understanding of the modifications for specific weightlifting techniques, the coach can assist in keeping the shoulder healthy in the weight room. This article will focus on a discussion of the prevalence of injuries from weight training, a brief discussion of shoulder anatomy, three of the more common shoulder pathologies, and weight training modifications to assist in the prevention of these shoulder pathologies.

The National Standards for Sport Coaches identify two domains (Domain 2: Safety and Injury Prevention and Domain 3: Physical Conditioning) as knowledge and skill areas needed for coaching competency and professional accountability (National Association for Sport and Physical Education [NASPE], 2006). Standards 8 and 10 in Domain 2 warrant that coaches need to have the knowledge and understanding of injuries and basic treatment protocols in order to appropriately modify drills and exercises (NASPE, 2006; Stone & Gray, 2010). Standards 12 and 15 of Domain 3 establish benchmarks for coaches to design and plan conditioning programs that use sound biomechanical principles, ensure the safety of all athletes, and promote successful return to full participation following an injury (NASPE, 2006). This article provides coaches with information regarding safety in the weight room through the modification of shoulder exercises to assist in meeting these standards.

Injuries from Weight Training

From 1990 through 2007, United States emergency departments saw an estimated 970,800 weight training related injuries (Kerr, Collins, & Comstock, 2010). The Center for Injury Research and Policy of the Research Institute at Nationwide Children's Hospital (2010) has estimated that approximately 150 weight training related injuries were treated in US emergency departments each day. Ninety percent of these injuries occurred in persons using free weights rather than machines, with the highest number of injuries occurring in persons 13 to18 years old (Kerr et al., 2010).

In addition to traditional weight training routines, power lifting is increasing in popularity among athletes and coaches all over the world (Siewe et al., 2011). Examination of competitive power lifters' pain and injury incidents identified the shoulder as one of the most commonly affected body regions (Raske & Norlin, 2002; Siewe et al., 2011). Overall, upper extremity pain

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is the most common problem associated with power lifting, constituting 29% of athletes' complaints (Siewe et al., 2011).

The Shoulder Complex

The shoulder is a unique joint in that it relies heavily on the muscles around it for stability rather than on ligamentous and bony structures as seen in other joints. The shoulder's overall structure and dependence on its surrounding musculature allows a large amount of mobility; however, there is notably less joint stability at the shoulder when compared to other, less mobile joints (Starkey, Brown, & Ryan, 2010). By enhancing coaches' knowledge of shoulder anatomy and associated weightlifting modifications, the authors hope to assist coaches in keeping the shoulder healthy in the weight room.

Anatomy of the Shoulder

The bones, articulations, stabilizing ligaments, and musculature of the shoulder are complex in nature but dynamic in the degree of mobility they allow the shoulder. The shoulder is made up of three bones: the clavicle, scapula, and humerus (Levangie & Norkin, 2011). These three bones join to make up the articulations of the sternoclavicular joint (SC joint), acromioclavicular joint (AC joint), glenohumeral joint (GH joint), and scapulothoracic joint (ST joint). The SC, AC, and GH joints are considered "true" anatomical bony joints, because two bones join together at their respective points (Prentice, 2013). The GH joint is identified as a ball-and-socket joint because the round humeral head (ball) fits into the glenoid cavity (socket) of the scapula (Prentice, 2013). The GH joint is more commonly referred to as the "true" shoulder joint (Prentice, 2013). The ST joint is not a "true" anatomical joint because the scapula rests on the thorax but does not join together with it (Levangie & Norkin, 2011). The ST joint is considered a "functional" joint and is important in the biomechanics of the upper extremity and in injury prevention (Prentice, 2013).

Each articulation has ligaments to assist in providing stability to the shoulder. The glenohumeral ligaments (superior, middle, and inferior) reinforce the capsule to assist with the stability of the joint (Lavangie & Norkin, 2011). The sternoclavicular ligament anchors the clavicle to the sternum. The acromioclavicular ligament and coracoacromial ligament attach the clavicle to the scapula. The coracoacromial ligament also forms the coracoacromial arch to protect the underlying structures (i.e., the rotator cuff tendons, long head of the biceps tendon, and subacromial bursa) from trauma directed to the top of the shoulder (Lavangie & Norkin, 2011). Since the ST joint is not a true joint, it is primarily stabilized by the scapular muscles (trapezius, rhomboid, levator scapulae, and serratus anterior) that attach the scapula to the thoracic wall (Kibler, 1998). The scapula attaches to the clavicle through the acromioclavicular and coracoclavicular ligaments (Lavangie & Norkin, 2011).

According to Prentice (2013), there are three major groups of muscles that act on the GH joint to allow the movements of flexion, extension, abduction, adduction, external rotation, and internal rotation. The first group of muscles includes the pectoralis major and the latissimus dorsi. The second group includes the deltoid, teres major, and the rotator cuff (subscapularis,

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supraspinatus, infraspinatus, and teres minor) muscles. The third group includes the trapezius, rhomboid, levator scapulae, and serratus anterior muscles. The overarching effect of these muscles is to provide dynamic stabilization and functional movement patterns at the GH joint of the shoulder.

These three muscle groups have different actions in both shoulder movement and injury, so the overall function needs to be understood in both cases (Kibler, 1998); however, greater importance must be placed on the role of the rotator cuff and scapular muscles (Kibler, 1998). In the authors' opinion, weight training activities too often focus on the prime movers (i.e., bicep, deltoid, latissimus dorsi, and pectoralis major muscles) of the upper extremity and overlook the rotator cuff. The importance of the rotator cuff muscles is to control the position of the humeral head in the glenoid fossa of the scapula (Higgins, 2011). The supraspinatus specifically acts as a humeral head depressor during shoulder elevation (deltoid activity). A weak or imbalanced rotator cuff causes an inability for the rotator cuff to counteract the pull of the deltoid, thus leading to humeral head elevation and impingement of the tendons under the coracoacromial arch (Higgins, 2011).

Comparatively, the scapular muscles (trapezius, rhomboid, levator scapulae, and serratus anterior) function to control scapular movement that is important to scapulohumeral rhythm. Scapulohumeral rhythm is a coordinated movement between the scapula and the humerus during arm elevation (Higgins, 2011). Normal scapulohumeral rhythm consists of an initial 30–60° of humeral elevation with 0° of scapular rotation. As the GH joint continues through the range of humeral elevation (30–180°), the scapulohumeral motion is approximately 2° of humeral elevation to 1° of scapular rotation (Kibler & McMullen, 2003). Normal scapulohumeral motion is critical to shoulder joint stability, smooth coordinated actions, proper shoulder function, and the prevention of shoulder impingement (Higgins, 2011).

Understanding Shoulder Injuries

Impingement

Shoulder impingement is a common pathology associated with participation in repetitive overhead or throwing activities. Impingement often manifests itself as pain in the anterior shoulder that occurs around midrange (~60–120°) of shoulder abduction and flexion (Prentice, 2004). Often the external rotator cuff muscles (infraspinatus and teres minor) of the shoulder are weaker than the internal rotator cuff (subscapularis) muscle, and tightness is noted in the posterior-inferior joint capsule (Kibler, 1998; Prentice, 2013). Other signs and symptoms include night pain when lying or rolling onto the involved shoulder, difficulty dressing when putting a shirt on overhead, and repetitive shoulder motions involving pushing, pulling, or swinging (Kisner & Colby, 2012).

Impingement is caused by an encroachment of the subacromial space under the coracoacromial arch of the shoulder (Prentice, 2004). Impingement occurs when the humeral head migrates superiorly, causing compression of the supraspinatus tendon, the long head of the biceps tendon, and the subacromial bursa between the coracoacromial arch and the humerus

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(Higgins, 2011). The migration of the humeral head is most commonly due to dysfunctional scapulohumeral rhythm and weakened rotator cuff muscles (Kibler, 1998). In a small number of cases, nerve injury that inhibits the muscles that stabilize the scapula can also contribute to impingement-like symptoms (Kibler, 1998).

The subacromial space is an area below the distal shoulder where the supraspinatus tendon, the long head of the biceps tendon, and the subacromial bursa reside. Anatomical structures of the shoulder, like the acromion process (the tip of the shoulder), may infringe upon the subacromial space and cause a pinching of the structures below the process when the arm is raised above the height of the shoulder (Starkey et al., 2010). Normally, the acromion process is flat in nature and angled slightly upward in relation to the subacromial space (Starkey et al., 2010). Impingement can occur if the acromion process is angled or hooked downward toward the subacromial space (Starkey et al., 2010). Repeated movement of the arm above shoulder height causes repeated pinching at the acromion that may lead to the development of bone spurs on the undersurface of the acromion (Starkey et al., 2010). This may also cause repetitive compression of the long head of the biceps tendon, the supraspinatus tendon, and/or the subacromial bursa that reside in the subacromial space. The repetitive compression leads to irritation and inflammation of the shoulder structures (Starkey et al., 2010).

Posture can also play a role in the narrowing of the subacromial space associated with impingement. This is most often seen with the forward head and rounded shoulder appearance. Forward head posture occurs when there is anterior displacement of the head relative to the thorax and is often associated with neck muscle fatigue and rounded shoulders (Starkey et al., 2010). Rounded shoulders often result from tight anterior chest muscles and weak posterior upper back/neck muscles or from assuming a slouched posture (Starkey et al., 2010). Together, forward head and rounded shoulders cause anterior displacement of the acromion process that narrows the subacromial space and contributes to impingement (Kibler, 1998).

Tightness and/or weakness in various muscle groups are also commonly identified as contributing factors for impingement. For example, weakness of the scapular stabilizers allow for what is commonly referred to as winging of the scapula (Higgins, 2011; Kibler, 1998). Winging scapula is caused by weak serratus anterior and middle and lower trapezius muscles that are unable to hold the scapula flat against the thorax, thus allowing the inside border of the shoulder blade to project off the back (Starkey et al., 2010). This abduction and elevation of the scapula causes a change in position of the acromion, which can affect the condition of impingement.

Anterior instability

Shoulder instability often results from ligamentous stretching or muscular weakness that causes laxity (looseness) and displacement (unwanted movement) of the humerus in the shoulder joint (Starkey et al., 2010). Anterior shoulder instability is common in athletes and often causes pain with weightlifting activities that bring the arm into a forced abducted and externally rotated position known as the “high 5” position (Gross, Brenner, Esformes, & Sonzogni, 1993). Serious precautions should be taken if an athlete reports one or more episodes of his or her shoulder coming out of place (subluxation/dislocation). In cases like this, the authors strongly recommend

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that coaches make certain that the athlete has sought appropriate medical care before performing any weight training activities.

Acromioclavicular joint conditions

The acromioclavicular (AC) joint is frequently injured in overhead strength-training activities (Higgins, 2011). Commonly called a "separated shoulder," this condition indicates an overstretching or tearing of the AC ligament or one of the surrounding ligaments attaching the clavicle to either the first rib or to the scapula (Starkey et al., 2010). Overuse, repetitive-stress mechanisms are often the cause of AC ligament injuries in weightlifting activities (Higgins, 2011). The athlete will complain of pain on the top of the shoulder that increases with overhead activity, horizontal adduction, and/or distraction (Starkey et al., 2010).

There is also a phenomenon known as weightlifter's shoulder (Professional Baseball Athletic Training Society [PBATS], 2010). This is where the repetitive trauma of lifting weights, as in a bench press, military press, or dumbbell fly, causes small fractures at the distal clavicle near the AC joint because of the traction forces of horizontal abduction and adduction (PBATS, 2010). The medical term for this condition is distal clavicle osteolysis (PBATS, 2010). The athlete will often complain of an ache or tenderness at the AC joint and experience weakness in the shoulder and an inability to sleep on the affected side. Other problems may show up from this condition, including difficulty and pain when attempting exercises such as push-ups, bench press, power clean, and dips (PBATS, 2010).

Weight Training Exercises that May Contribute to Developing Shoulder Pain

If the head of the humerus is internally rotated during a weight training activity (e.g., performing a lateral dumbbell raise with thumbs pointed down), the greater tubercle on the humerus is put into alignment to bump up against the acromion process, thus causing a pinching of the structures and initiation of impingement-like symptoms (Kisner & Colby, 2012; Logan, 2004). Common weight training exercises that require internal rotation of the humerus to perform the lifts include lateral dumbbell raises and empty can exercises (Kisner & Colby, 2012; Logan, 2004). Traditionally, lateral dumbbell raises are performed by holding dumbbells in each hand with the thumbs pointed to the floor (Kinakin, 2009). The dumbbells are then raised to shoulder height by lifting the arms out away from the body in an abducted and elevated direction. Similarly, the empty can exercise involves positioning the arms in abduction, approximately 30° of forward or horizontal flexion, and pointing the thumbs to the floor as though emptying a can of soup (Kisner & Colby, 2012). With the thumbs pointing down, the athlete uses a light dumbbell weight in each hand and raises both arms up to just shy of 90° or equivalent to the height of the shoulders. The concern with these exercises revolves around the position of the thumb (Kinakin, 2009; Logan, 2004). Pointing the thumbs to the floor causes internal rotation of the humerus and the opportunity for the greater tubercle to bump up against the acromion process, pinching the structures between these two bony structures and thus contributing to impingement (Logan, 2004).

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Additional weight training activities that warrant caution due to the internal rotation of the humerus include upright rows and pull-ups with the palms facing away from the body (Logan, 2004). The upright row is often performed with the athlete holding a barbell in front of his or her body with arms extended toward the floor and the palms facing the body. While keeping the back straight, the athlete lifts the weight straight up to just below shoulder height and then back down to the starting position. As the weight is lifted, the upright row brings the humerus into the subacromial space, while the upper arm is internally rotated. Pull-ups with the palms facing away from the body also place the upper arms into internal rotation and can create the impingement position at the shoulder (Logan, 2004).

Another concern that could produce shoulder pain while performing weight training exercises is moving the upper arm repeatedly in a range that is at the height of the shoulder, or above 90° of abduction or flexion (Logan, 2004). This repeated action is sometimes seen with the military press or overhead press exercises. During these lifts, decreased muscle strength and/or fatigue often cause an increase in humeral head elevation as the humerus is brought into overhead positions, causing impingement of the structures (Starkey et al., 2010).

A third concern involves the shoulder's scapulohumeral rhythm. This movement pattern is important for the shoulder joint to move uninhibited. For the first 30° of humeral movement, the scapula should not move at all. At 30–60° of humeral movement, the scapula moves at a 2:1 ratio, and above 60° it is a 1:1 ratio of humeral to scapular movement (Higgins, 2011). In weight training activities (i.e. the bench press), the scapulohumeral rhythm can become inhibited due to the equipment used to perform the lift (Panariello, 2011). For example, the bench used in the bench press interferes with the normal movement of the scapula and will not allow the athlete's scapulohumeral rhythm to move efficiently. The problem comes from the athlete lying on the bench with his or her body weight creating the inability for the scapula to move in proper sequence with the humerus (Panariello, 2011). When the scapular movement is limited, it changes the scapulohumeral rhythm, which may lead to symptoms of impingement.

A fourth concern is the "high 5" position in which the upper arm is in an abducted, extended, and externally rotated position (Fees, Decker, Snyder-Mackler, & Axe, 1998). The "high 5" position is the most vulnerable one for a weak shoulder, but it is required to perform weight training movement patterns in the traditional exercises of the full bench press, racking the bar from the back squat, shoulder press, and behind-the-neck lat pull-downs (Prentice, 2004; Fees et al., 1998). This position places a high amount of stress on the shoulder muscles, ligaments, and capsule.

A final concern is protection of the acromion process and AC joint. A weak base of muscular support around the shoulder can cause the humerus to bang into the inferior surface of the acromion process (tip of shoulder) when the athlete raises the arms overhead or when moving the arms repeatedly in the directions of horizontal abduction and adduction, as seen in the weight training exercises of the bench press, push-ups, and dips (Panariello, 2011; PBATS, 2010). In addition, a weak base of support, the speed of movement, and poor technique make the shoulder vulnerable to AC joint injuries during exercises such as the upright row or the pull phase of the power clean (Fees et al., 1998).

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Weightlifting Modifications

To prevent shoulder pain, the athlete must build a sound base of strength below the height of the shoulder and use the scapular plane (raising the arm 30–45° toward the front of the body) as much as possible when performing lifts (Kisner & Colby, 2012). The scapular plane (Figures 1a & 1b) is the angle that is most functional and safe for the shoulder joint during movement (Starkey, 2004). Exercises should be performed to just slightly below 90° of shoulder abduction and flexion (height of the shoulder) to avoid creating shoulder pain. Once a good base of strength is built, crossing the height of the shoulder can be incorporated by using dumbbell weights with the palms turned up or the thumbs facing the ceiling as appropriate for the exercise. By positioning the thumbs toward the ceiling or the palms turned up, the subacromial area has the greatest space available, thereby decreasing the chances of irritating the associated structures (Kisner & Colby, 2012).

Figure 1a

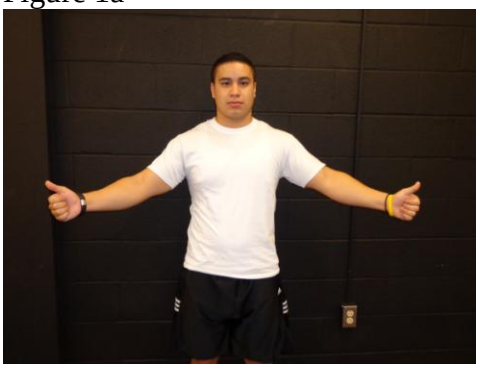
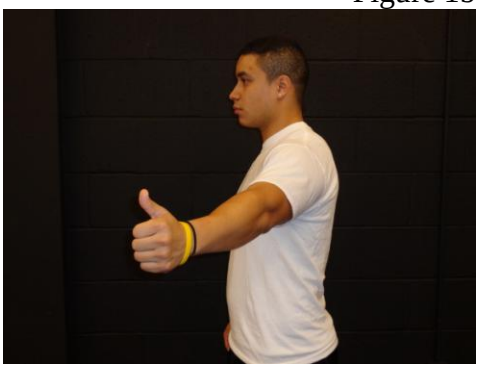


Figure 1b



Lateral dumbbell raises and empty can exercises. Specific weight training exercises (i.e. lateral dumbbell raises, empty can exercises) that traditionally require internal rotation of the humerus can be modified to prevent shoulder pain. Lateral dumbbell raises should be performed using the "thumb up" grip (Kinakin, 2009). With the thumb pointed to the ceiling, the humerus is externally rotated, thus causing the greater tubercle not to align with the acromion process (Figure 2) and therefore improving the biomechanical movement pattern of the shoulder joint (Logan, 2004).

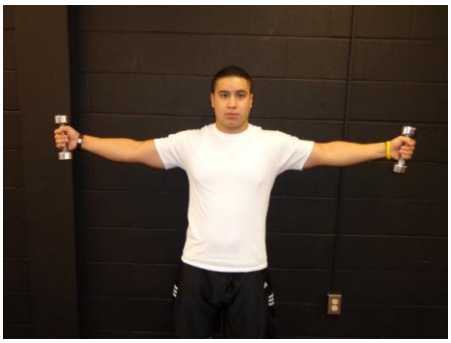


Figure 2

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Empty can exercises should be modified to the full can position (Kisner & Colby, 2012). In the empty can exercise the thumbs point to the floor, whereas in the full can the thumbs point to the ceiling. The full can position, with the thumbs pointing to the ceiling (Figure 3a & 3b), allows for greater space in the subacromial space by rotating the greater tubercle outward to prevent bumping against the undersurface of the acromion process (Kisner & Colby, 2012). The full can exercise has been shown to produce the same muscle activation of the rotator cuff with a safer movement pattern than that of the empty can exercise (Higgins, 2011).

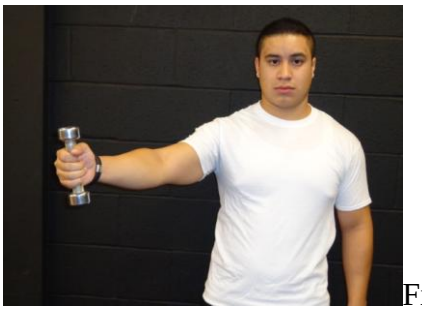
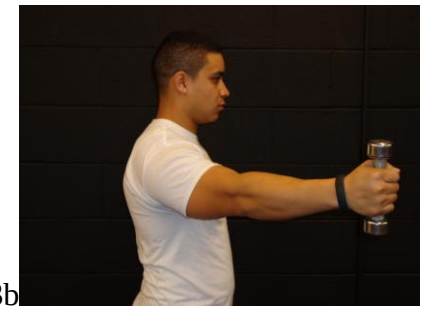


Figure 3a

Figure 3b 

Overhead weight- training exercises. In weight training activities above shoulder height (i.e. military press, overhead press), the weight should only be lowered to the height of the shoulder to help prevent impingement (Logan, 2004). Based on this concept, the authors recommend that after the initial movement to get the weight above 90° of shoulder abduction, the athlete should be instructed to use short arcs of movement from 90° to 180° then back to 90° of shoulder abduction (Figure 4a & 4b). Keeping the upper arm from continually crossing the height of the shoulder diminishes the chance of causing shoulder impingement.

Figure 4a

Figure 4b 

Bench press. A bench press modification to protect the shoulder involves shortening the range of motion so the bar does not touch the chest (Fees et al., 1998). This modification can decrease the excessive load on the anterior shoulder when the athlete fully lowers the bar to touch the chest in a traditional bench press exercise. Shortened range of motion can be accomplished through the use of the towel bench press (Fees et al., 1998). The towel bench press is performed by placing a small stack of towels on the athlete's chest at the place where the bar would touch (Figure 5). This allows the athlete to touch the towel stack with the bar during the lowering phase of the bench press and then push the bar back up in order to avoid full range of motion. Using the stack of towels protects the shoulder by avoiding excessive loading to the anterior shoulder and limiting the "high 5" position (Fees et al., 1998). The towel bench

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modification will also protect the AC joint to prevent the potential for weightlifter's shoulder by limiting the elbows from dropping below or behind the midline of the body during the bench press (Figure 6), thus causing a traction force at the joint (Higgins, 2011; PBATS, 2010).

Figure 5

Figure 6

Rowing exercises. The athlete has several options to choose from when performing rowing exercises for strength training. A seated rowing weight machine, cables, or dumbbells are examples of equipment options. No matter which rowing option is used, the coach should monitor the athlete for any pain throughout the range of movement. If pain develops, the authors recommend that a suitable modification is to stop the arm extension at midline of the body before choosing to discontinue this exercise. Other considerations include keeping the palms facing the body to prevent internal rotation of the humerus and narrowing of the subacromial space (Logan, 2004).

Back squats. Even though squats are considered a lower-extremity strengthening exercise, the shoulder is stressed when managing the weight of the bar. The back squat, where the bar rests behind the neck, places the arms in the "high 5" position (Figure 7) and increases the strain to the shoulder during racking of the bar (Fees et al., 1998). This exercise can be modified to a front squat (Figure 8), where the bar sits across the anterior deltoid muscles and the clavicles (Logan, 2004). Although this modification takes the shoulder out of the "high 5" position, coaches should be cautious regarding placement of the bar, so that it does not place stress on the clavicles and acromion processes.

Other considerable modifications include equipment to eliminate the self-racking of the bar and the associated "high 5" position (Fees et al., 1998). The use of a Smith machine or other athletes as spotters to rack the bar can accomplish this modification (Logan, 2004). A safety squat bar, a bar with a padded yoke that allows the bar to rest on the shoulders without the arms in the "high 5" position, is another recommended equipment modification for the back squat (Fees et al., 1998).

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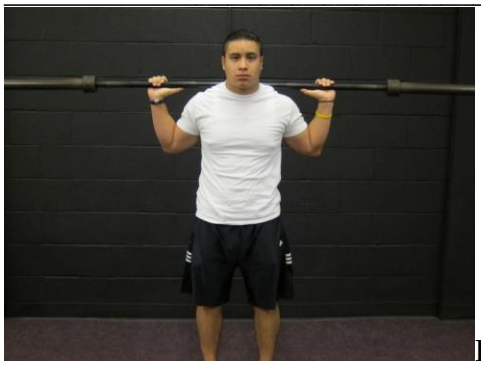

Figure 7

Figure 8

Recommended Modified Shoulder Exercises

In review, shoulder impingement is a common pathology that can result from repeated movement of the arm above shoulder height, poor scapulohumeral rhythm, and a weak rotator cuff that allows for narrowing of the subacromial space. Exercises commonly seen in the weight room that often initiate or develop impingement in the shoulder include the empty can exercise, the lateral dumbbell raise, rowing, and the military press. The weight training modifications recommended to assist in preventing shoulder impingement include the full can exercise, the lateral dumbbell raise with the thumbs facing the ceiling, rowing with the palms facing the body and not extending the arms past the midline of the body, and the military press with the palms facing the body while only working 90°–180°.

Anterior instability is joint laxity that is exacerbated by the arm being placed in the "high 5" position. Exercises commonly seen in the weight room that contribute to this condition include the bench press and back squat. Recommended weight training modifications include the towel bench, front squat, or the use of a safety squat bar.

Acromioclavicular joint conditions, including weightlifter's shoulder, are often caused by repetitive trauma to the AC ligament. The bench press and military press are two of the most common exercises performed in the weight room that can contribute to these conditions. Weight training modifications include the towel bench, exercises that avoid crossing the height of the shoulder, and the military press with the palms facing the body while only working 90°–180°.

Summary

Coaches are to be commended for training athletes in the weight room as part of an overall conditioning program. Due to the prevalent nature of injuries that occur in the weight room, it is suggested that coaches should incorporate weightlifting modifications into their strengthening programs as a way to prevent injuries. Coaches should consider teaching athletes weightlifting modifications that can be used as normal practice for the avoidance of injury or when returning to full participation following an injury.

Consistent with Domain 2 and Domain 3 of the National Standards for Sport Coaches, these modifications and the coach's knowledge of the relationship between lifting techniques and

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potential shoulder injuries can help educate athletes about safe weightlifting activities. By incorporating these weightlifting modifications, the coach can provide the athlete with valuable knowledge and skills to help keep the shoulder healthy in the weight room by preventing or minimizing shoulder injuries. More importantly, the coach's ability to instruct the athlete in weightlifting modifications as a preventive measure will build a knowledge base that the athlete can call upon to make informed decisions about weightlifting activities throughout his or her lifetime.

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