

## Current Concepts

# Upper Extremity Weight-Training Modifications for the Injured Athlete

## A Clinical Perspective

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### ABSTRACT

The ability of the health care professional to make correct decisions about the progression of weight-training is critical to the rehabilitation process. The purpose of this article is to describe our approach to modification of weight-lifting techniques using the injured shoulder as a model. Additionally, the impact of various upper extremity weight-training techniques on healthy athletes is discussed. The effects of grip, hand spacing, bar trajectory, and start and finishing positions on microtraumatic injury and return to weight-training activities after injury are considered. Several weight-training functional progressions for common multijoint exercises (such as bench press, shoulder press, power clean) are presented. Adaptations for periodization are also presented for implementation in the rehabilitation sequence. The weight-training modifications described in this paper will assist the health professional to safely return athletes to the weight room after shoulder injury.

Weight-training programs are an integral part of the rehabilitation of injured athletes. The general population also participates in strength and fitness programs as part of rehabilitation after injury. The sports medicine professional's knowledge of weight room activities is critical to the success of rehabilitation programs and the prevention

of subsequent injuries from weight-training. Encouragement of correct weight-lifting mechanics should reduce the incidence of training-related injuries in patients as well as in uninjured athletes.<sup>34,35</sup> Some modifications of weight-lifting activities for various injuries can be derived from the anatomy, pathomechanics, pathology, and surgical techniques; others are not so straightforward. The gymnasium has its own culture and language that makes translation of theory to practice difficult. The authors, representing several disciplines, have developed a weight-lifting modification approach for common shoulder injuries.

Heavy resistance free-weight exercises are not a component of the rehabilitation and training programs of all athletes (for example, baseball players)<sup>50-52</sup>; however, common lifts like the bench press and squat are the mainstays of contemporary strength and conditioning programs for many athletes. In addition, in those for whom weight lifting itself is a primary sport, shoulder injuries are not uncommon and can be career-threatening.<sup>25,27</sup>

The purpose of this article is to describe our approach to modification of weight-lifting techniques using the injured shoulder as the model. Modifications for patients with shoulder rotator cuff tendinitis or impingement syndrome, acromioclavicular problems (such as distal clavicle osteolysis),<sup>24</sup> shoulder instability,<sup>14</sup> and glenoid labrum and biceps anchor damage (such as superior labrum anteroposterior or SLAP lesions) will be discussed and illustrated. The exercises we focus on are the common multijoint lifts including the bench press, shoulder press, latissimus dorsi pulldown, power clean, and squat. The analysis of each lift will include hand spacing, grip selection, and shoulder range of motion requirements.

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## BENCH PRESS

The bench press is a core exercise for the upper extremity in strength and conditioning programs designed to increase upper extremity strength and power. Awareness by sports medicine professionals of modifications to the bench press for those patients with injured shoulders is imperative because of the popularity of the exercise. A common first question from the athlete after shoulder injury or surgery is "When can I bench press?" Maximum weights for high school males range from 175 to 300 pounds, and for collegiate males the range is 250 to 400 pounds.<sup>54</sup> Exceptional athletes can exceed these levels. At this intensity, the bench press places a tremendous stress on the humeral head stabilizers,<sup>17,34</sup> primarily the rotator cuff and the long head of the biceps brachii muscles.<sup>41</sup> In addition, the biomechanical pattern from horizontal adduction into horizontal abduction and back to horizontal adduction can lead to repetitive compression of the distal clavicle.<sup>5,38,41</sup> The bench press can be modified to allow most athletes with an injured shoulder to perform the lift.<sup>36</sup>

The traditional bench press involves a combination of movements in the sagittal (flexion/extension), coronal (abduction/adduction), and transverse (horizontal adduction) planes. The lifter is in the supine position and the pressing motion starts with hands placed slightly wider than shoulder width (that is, 1.5 to 2 times the biacromial width).<sup>53</sup> The bar is slowly lowered to touch a point on the chest wall 2 to 3 inches superior to the xiphoid process. The bar is then pressed upward as the elbows extend completely and the exercise finishes with the bar in line with the shoulders. The agonist muscles of the bench press are the anterior deltoid, pectoralis major, and triceps brachii.<sup>1,8</sup> The bench press can be performed with the supporting bench at angles other than horizontal (that is, inclined variations from 30° to 45°, declined variations from 18° to 30°) to create a more sport-specific motion and emphasize different muscle groups or portions of a particular muscle group.

The absolute intensity single-repetition maximum (1 RM) can contribute significantly to shoulder lesions, should be avoided, and in most cases should be limited to only 2 to 3 times per year.<sup>37,55</sup> Maximum bench press can, however, be estimated from the weight lifted for multiple repetitions using a standardized table.<sup>2</sup>

### Rotator Cuff Injury and Shoulder Impingement

Athletes with rotator cuff injury and impingement syndrome require modifications to the bench press before it may be used for training. These modifications can also be used by those at risk for developing shoulder abnormalities (for example, athletes who participate in collision sports and who commonly suffer acute or repetitive trauma to the acromioclavicular joint) in an effort to limit

microtraumatic changes to the distal clavicle and slow the degenerative process. Most of the specific modifications are in the hand spacing and grip selection steps.<sup>20,26,47</sup>

Hand spacing should be no wider than 1.5 times the biacromial width (Fig. 1). The narrower hand spacing minimizes the peak shoulder torque in the pressing motion and therefore reduces the anterior and posterior rotator cuff and biceps tendon complex requirements for humeral head stabilization.<sup>11,46,52</sup> The narrower hand spacing also allows the athlete to make adjustments to the component angles of the bench press by maintaining shoulder abduction at less than 45° (Fig. 2) and shoulder extension at less than 15° (Fig. 3). Alteration of the shoulder component angle aligns the clavicular border of the pectoralis major and biceps brachii muscles into a mechanically advantageous position to assist shoulder flexion through the initial and middle range of motion, and decreases the stress on the long head of the biceps muscle at the bicipital groove as the humerus moves into horizontal adduction.<sup>4,18,32,33</sup>

The component angles and shoulder torque are significantly altered with a grip greater than 2 times biacromial width. The wider grip develops shoulder torque 1.5 times greater than with a narrow grip and increases the shoulder abduction above 75°.<sup>11</sup> Although the narrower hand spacing increases horizontal adduction at the shoulder, maintaining shoulder abduction below 45° decreases compressive forces at the distal clavicle.<sup>11</sup> The touch position is also altered by this hand spacing to a point even more superior to the xiphoid process (Fig. 4), decreasing the net torque on the shoulder.<sup>21</sup>

Grip selection also affects the shoulder. The overhand grip (with the hand on top of the bar in a fully pronated position) and the underhand grip (with the hand on the bar in a fully supinated position) affect both the biceps tendon and the supraspinatus muscle portion of the rotator cuff.<sup>13,29</sup> The overhand grip (pronation of the forearm) moves the biceps tendon out from under the acromion by internal rotation of the shoulder.<sup>6</sup> The overhand grip also draws the supraspinatus muscle portion of the rotator cuff beneath the anterior acromion.<sup>6</sup> The underhand grip (su-



**Figure 1.** Hand spacing less than 1.5 times the biacromial width.

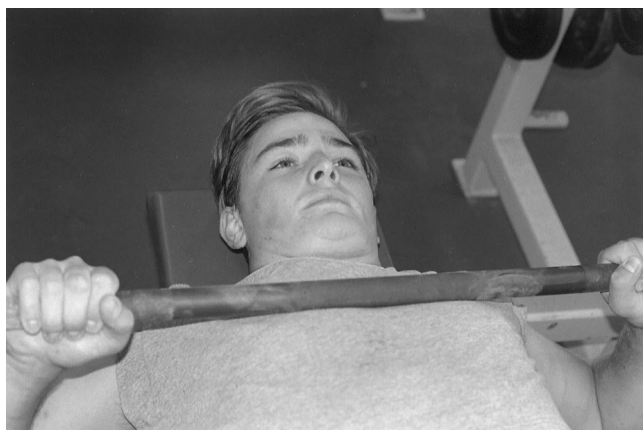
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**Figure 2.** Maintaining shoulder abduction at less than 45°.



**Figure 3.** Maintaining shoulder extension at less than 15°.



**Figure 4.** The touch position is superior to the highest point on the chest.

pination of the forearm) places the long head of the biceps tendon under the acromion during the pressing motion, as the shoulder is externally rotated in this position.<sup>29</sup> In like manner, the supraspinatus muscle is rotated posteriorly by the underhand grip, away from the acromion. This is

particularly important if the athlete has a type III (hooked) acromion that can mechanically abrade underlying structures (for example, the supraspinatus muscle portion of the rotator cuff in an overhand grip and the biceps tendon in an underhand grip).<sup>3,6,9</sup>

As athletes in rehabilitation and training programs advance to weight room exercises, progression should follow a periodized program. Periodization systematically manipulates volume, intensity, and load in resistance training over a period of time to elicit a specific physiologic response (Table 1).<sup>44</sup> Periodization allows easy adaptation to the new technique while providing proper physiologic stimuli to key muscle groups. Criteria for progression from one step of the weight-lifting program to another are provided in Table 2.<sup>7</sup> Guidelines for bench press progression are provided in Table 3. Several important concerns are addressed in the bench press progression including the use of scapular strengthening, use of towels as spacers on the chest to reduce the distance of bar excursion, and the underhand grip to ease the retraining to the new component angle positions and to aid progression from partial to full range of motion.

#### Anterior Shoulder Instability

In designing strength programs for persons with anterior shoulder instability, several exercise modifications should be considered. A mandatory handoff should be used with all bench press activities (Fig. 5).<sup>16,22</sup> The handoff should begin with the first warm-up set and continue throughout the entire session. This eliminates any risk of subluxation or dislocation during the removal or return of the bar back to the rack position. The second modification is the use of a systematic alternation of the flat and decline bench press to decrease microtraumatic injury in the ligaments of the shoulder. The flat and decline bench press exercises offer a significant advantage when coupled with the same hand spacing (less than 1.5 times the biacromial width) and adjustments to component angles (for example, shoulder abduction less than 45°) that were recommended for athletes with rotator cuff or impingement injuries.<sup>10</sup> Because of the flat position or declined angle of these bench

**TABLE 1**  
Periodization Program

1. Base phase
3 to 4 sets of 10 repetitions
Progress to 4 to 5 sets of 10 to 12 repetitions
Low intensity
Stress proper technique
2. Strength phase
3 to 4 sets of 6 to 8 repetitions
Medium intensity
3. Strength/power phase
3 to 4 sets of 4 to 6 repetitions
Medium to high intensity
4. Peaking phase
3 to 4 sets of 6 to 8 repetitions
Increase weight 2.5% per session
Alternate heavy and light sessions



TABLE 2  
Criteria for Progression

Criterion	Action
Soreness during warm-up sets that continues	Take 2 days off and drop down one step
Soreness during warm-up sets that goes away	Continue the program at that step
Soreness during warm-up sets that goes away, but redevelops during workout	Take 2 days off and drop down one step
Soreness the day after lifting	Take 1 day off and stay at that step
No soreness	Advance one step weekly or as instructed

TABLE 3  
Bench Press Progression

Step 1. Scapular protraction Protraction of the scapula with the elbows fully locked Emphasis is on concentric and eccentric scapular protraction Grip is alternated every other set between overhand and underhand positions
Step 2. Partial ROM <sup>a</sup> press/underhand grip 4- to 6-inch thickness of toweling underneath shirt Underhand grip Bar is lowered until it touches the toweling and returns to start position
Step 3. Partial ROM press/overhand grip 4- to 6-inch thickness of toweling underneath shirt Overhand grip Bar is lowered until it touches the toweling and returns to start position
Step 4. Full ROM press/underhand grip Underhand grip Bar is lowered until it touches the chest and returns to start position
Step 5. Full ROM press/overhand grip Overhand grip Bar is lowered until it touches the chest and returns to start position

<sup>a</sup> Range of motion.

press activities, the athlete maintains a conservative shoulder position below 90° of shoulder flexion, 45° of abduction, and neutral external rotation. An athlete with anteroinferior instability, or after anterior shoulder stabilization surgery should eliminate the incline bench press from the strength training program. The incline bench press places the athlete at risk since the "high five" position (that is, 90° of shoulder abduction and 90° of shoulder external rotation) is maintained throughout the entire exercise, increasing strain on the compromised anterior middle and anteroinferior glenohumeral ligaments.<sup>10, 28, 31, 40</sup>

Finally, there should be modifications to the program design because of the inherent laxity of the shoulder complex and stress on the dynamic stabilizers. Program design modifications include a decrease in the total volume (for example, number of repetitions) by alternating the flat and decline bench presses every other training session. Also, intensity of the exercises should be varied within the microcycles (smallest period of time during a



Figure 5. Position for mandatory handoff.

strength training cycle, usually lasting a few days to 1 week) of the strength program. These program design modifications should minimize potential overuse problems that can develop during long-term training.

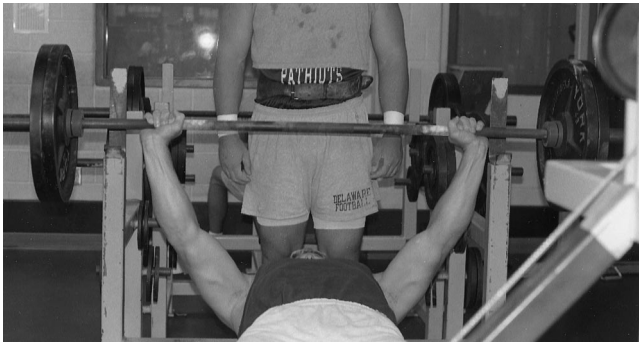
### SLAP Lesions

The modifications for an athlete with a SLAP lesion<sup>42</sup> are identical to modifications for an athlete with anterior instability. The grip should vary between an overhand grip and an underhand grip to decrease the microtraumatic injuries and stress on the long head of the biceps tendon.<sup>7</sup> The overhand grip removes the biceps tendon from beneath the acromion by internally rotating the humerus, but because of the full forearm pronation, it stresses the attachment of the long head of the biceps during exercise. The underhand grip places the long head of the biceps tendon in a preferred position to decrease the stress on the tendon (forearm supination), but places the long head of the biceps tendon beneath the acromion, allowing it to become impinged during the pressing motion if an acromial hook is present. The program should also vary the intensity of the exercise within the microcycles, with each grip variation emphasized on separate days and not combined on the same day.<sup>7</sup>

### Posterior Shoulder Instability

An athlete with posterior shoulder instability should increase the hand spacing to more than 2 times the biacromial width (Fig. 6). The wider hand spacing and resulting component angles allow better structural approximation of the humeral head in the glenoid fossa and decrease the strain on the posterior soft tissue.<sup>12, 43</sup> This hand position allows the athlete to make adjustments to the component angles of the bench press including shoulder abduction greater than 80°, horizontal abduction greater than 15° at the start of the concentric phase of the lift, and horizontal adduction less than 20° in the finishing position at the end of the concentric phase. Again, mandatory handoffs should be used throughout the entire session.

The program design for persons with posterior shoulder



**Figure 6.** Hand spacing more than 2 times the biacromial width.

instability should include only the flat bench press, as well as alternating the intensity of the exercise within microcycles of the strength program. The athlete with posterior shoulder instability should carefully consider whether to use the bench press in a strength program because any bench press puts a posterior force on the shoulder. If the bench press is used, the athlete should begin with the flat bench press to develop the proper skill and motor control. If the athlete can perform the flat bench press without symptoms, then a gradual progression to the decline bench press is possible. Program design modifications are the same as for anterior shoulder instability (that is, alternate flat bench press and decline bench press).

## SHOULDER PRESS

The shoulder press is usually performed from a starting position with the bar behind the neck. The use of the behind-the-neck shoulder press within a strength program is rarely needed and should only be considered when there is a compelling argument for sport or position specificity (for example, Olympic lifting, basketball rebounding, and football defensive backs and wide receivers). Even in these instances, we believe the training can be accomplished without the use of this lift. The physiologic effects of the behind-the-neck press can easily be replaced with specific posterior deltoid muscle exercises such as rear deltoid raises, seated rows, or dumbbell rows.

The behind-the-neck press involves a combination of motions in the sagittal (flexion) and the coronal (abduction/adduction) planes. The primary motion varies as a function of the starting position. The behind-the-neck press starts at the level of the first thoracic vertebra with the bar resting on the trapezius muscles and finishes with the bar straight overhead. The pressing motion involves hand spacing slightly wider than shoulder width and an overhand grip. The lift finishes with the bar pressed overhead, finishing in line with the coronal plane just anterior to the ear. The primary motion in the concentric phase of the exercise is shoulder abduction.<sup>4</sup> The agonist muscles of the behind-the-neck press include posterior deltoid, trapezius, and triceps brachii.<sup>4</sup>

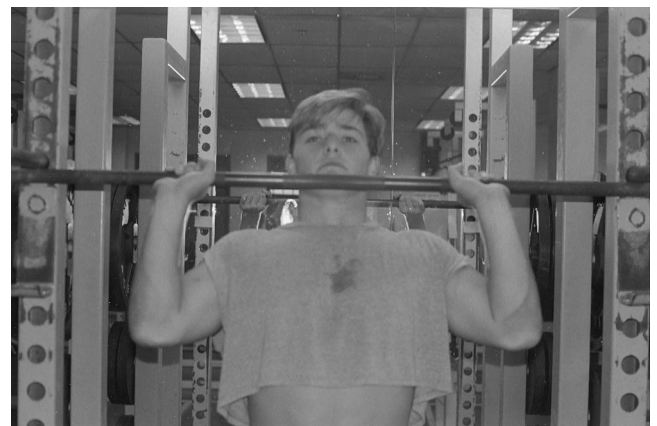
The behind-the-neck press places the athlete into the high five position of abduction and external rotation.<sup>10</sup>

This position creates significant strain on the anteroinferior glenohumeral ligaments.<sup>10</sup> Glenohumeral joint stress is magnified by the torque created from supporting weights in the athlete's hands.<sup>28</sup> The behind-the-neck press also stresses the cervical region by placing the athlete's head into excessive flexion in the overhead finish position.<sup>34,37</sup> In a healthy athlete whose athletic endeavors require power in the behind-the-neck position, a modified behind-the-neck shoulder press can be performed. Concentric motion begins at ear level and finishes in the normal overhead position. This limited range of motion provides significant reduction in strain to the anteroinferior glenohumeral ligaments.<sup>48</sup>

The front shoulder press has many sport-specific applications and is combined with upper and lower extremity exercises (push press, power press, clean and jerk) to teach total body coordination and power. The front shoulder press starts with hand spacing slightly wider than shoulder width and the bar resting on both anterior deltoid muscles and the sternoclavicular joints. The exercises are done in the scapular plane and the final overhead position is identical to that of the front press. This allows the bar and weights to be positioned in the body's center of gravity throughout the lift. The motion is an equal combination of shoulder flexion and abduction during the concentric phase.

The shoulder press can be modified for an athlete with shoulder lesions such as anterior glenohumeral instability, SLAP lesions, or rotator cuff tendinitis or impingement by using functional isometric exercises.<sup>30</sup> The functional isometric program is completed within the confines of a power rack. The goal of the modification is to preserve vertical displacement of the bar while limiting its horizontal translation. The horizontal translation (as the bar moves from anterior to posterior) leads to increased strain on the anteroinferior glenohumeral ligaments and increased risk of glenohumeral subluxation by allowing more external rotation.<sup>23,45,48</sup>

In this exercise, the athlete is seated inside the power rack to perform a shoulder press with the bar placed between two pins on each side of the rack (Fig. 7). One pin



**Figure 7.** The bar is placed between two pins on each side of the power rack for a modified shoulder press.

supports the weight while the second pin limits the range of motion. The pin height is adjusted for a starting angle of approximately 60° of shoulder flexion and progressed to 90° of shoulder flexion and finally to 120° of shoulder flexion. This position provides minimal torque into external rotation and significant glenohumeral joint approximation. The program design follows traditional isometric training: a 5-second hold per repetition and 6 to 10 repetitions at each of the three angles (60°, 90°, 120°). If the athlete needs overhead strengthening, then a progression from isolated dumbbell exercises to pain-free functional isometrics to dynamic shoulder presses should proceed as shown in Table 4.

A final consideration for athletes with shoulder instability is the use of weight machines. Machines must be examined for shoulder positioning requirements, and the machine-mandated biomechanical lifting pattern, to assess the strain on the glenohumeral ligaments. The machines must allow the shoulder to be positioned in internal rotation and allow flexion in a lifting pattern that allows minimal horizontal translation. Examples of machines that allow "safe" positioning include Magnum Shoulder Press (Magnum Fitness Systems, Milwaukee, Wisconsin), Hammer Strength Isolated Shoulder Press (Hammer Strength, Cincinnati, Ohio), and Nautilus Shoulder Press (Nautilus International, Independence, Virginia).

#### LATISSIMUS DORSI PULLDOWN

The latissimus dorsi pulldown is usually performed to a behind-the-neck position. This exercise involves a combination of movements in the sagittal plane (flexion/extension) and the coronal plane (adduction/abduction). The seated behind-the-neck latissimus dorsi pulldown starts with the bar suspended at arms' length above the shoulders in line with the torso. The bar should be lined up in the coronal plane. A comfortable 1.5 to 2 times the biacromial width overhand grip should be used for this exercise. The concentric phase of the exercise is initiated by pulling the bar from overhead to the base of the neck at the first thoracic vertebrae. The eccentric phase involves returning

the bar to the starting position. The primary movement is in the coronal plane. The agonist muscles include the shoulder adductors (latissimus dorsi, teres minor, rhomboids, and trapezius) and elbow flexor muscles (biceps, brachialis, and brachioradialis).

The latissimus dorsi behind-the-neck pulldown or pull-up, while popular in most gymnasiums and health clubs, is an unnecessary component of a strength program and should be avoided. The detrimental effects are the same as those of the behind-the-neck shoulder press and include placing the athlete into the high five position of abduction and external rotation,<sup>10</sup> stressing the rotator cuff through the impingement mechanism, and risking injury to the cervical region by placing the athlete into an excessive forward head tilt position.<sup>34,37</sup> In addition, transient upper extremity paralysis after completion of behind-the-neck latissimus dorsi pulldown has been reported in the literature.<sup>39</sup> It is hypothesized that increased forward head position combined with the repetitive motion can produce transient brachial plexus nerve injury.<sup>39</sup>

The front latissimus dorsi pulldown has many sport-specific applications, but should be performed in a modified position. The modified, seated, front latissimus dorsi pulldown exercise starts with the torso reclined in 30° of

TABLE 4  
Front shoulder press progression

Step 1. Isolated motions
Shoulder flexion below 90° (front deltoid raises)
Shoulder abduction below 90° (lateral raises)
Step 2. Multiangle isometrics
Isometrics at 60°, 90°, and 120° of shoulder flexion
Step 3. Partial ROM <sup>a</sup> front shoulder press
Bar is lowered to the height of the forehead and returns to start position
Step 4. Shoulder press lockout
Bar inside power rack, 3 to 6 inches below elbow lockout position
Bar is pressed from front press position
Step 5. Full ROM front shoulder press
Bar is lowered until it touches the chest and returns to start position

<sup>a</sup> Range of motion.



Figure 8. The torso in reclined 30° of trunk extension.



trunk extension (Fig. 8). Therefore, the bar is suspended at arms' length in line with the xiphoid process. The grip should be a comfortable 1.25 to 1.5 times the biacromial width grip. The concentric phase of the exercise is initiated by pulling the bar from overhead to slightly above the xiphoid process. The eccentric phase involves slowly returning the bar to the starting position. The exercise takes place in the sagittal and coronal planes. The agonist muscles are similar to those used in the behind-the-neck latissimus dorsi pulldown, but a greater emphasis is placed on the scapular retractor and latissimus dorsi muscles in this position.

The front latissimus dorsi pulldown offers some distinct advantages over the behind-the-neck version of the exercise. There is a significant difference in muscle group emphasis in the latissimus dorsi pulldown exercises. The front version accentuates the shoulder adductor and scapular retractor muscles to a much greater extent than the behind-the-neck form. In contrast, the behind-the-neck latissimus dorsi pulldown places more stress on the elbow flexor complex. Electromyographic studies have been performed on several latissimus dorsi pulldown positions. The optimum position for latissimus dorsi and scapular retractor muscle involvement was the recommended modified position: reclined 30° trunk extension with the chest touch position proximal to the xiphoid process. This position creates a greater mechanical advantage for the latissimus muscle insertion on the anterior surface of the humerus at the bicipital groove (T. M. McLaughlin, personal communication, 1989). The front latissimus dorsi pulldown exercise eliminates injury risk for shoulder instability. First, pulling from the anterior position negates the stress on the anteroinferior glenohumeral ligament by not placing the athlete in the high five position.<sup>10</sup> Second,

as previously discussed, the front latissimus dorsi pull-down exercise increases the activation of the shoulder adductor and scapular retractor muscles that assists in stabilizing the humeral head during the exercise (T. M. McLaughlin, personal communication, 1989). The front latissimus dorsi pulldown exercise progression is provided in Table 5.

## POWER CLEAN

The power clean is a total body movement involving both the upper and lower extremities. The power clean involves a combination of motions in the sagittal (flexion) and coronal (adduction/abduction) planes. The final pulling phase of the power clean entails a series of closely timed movements: first, shoulder shrugging, then elbow flexion, and finally shoulder abduction. This series of muscle contractions places the bar into position to be "racked" by the upper extremity. The "racking" position occurs through shoulder flexion and scapular retraction and allows the bar to rest across the shoulder complex with minimal effort (Fig. 9). The pulling and racking phases take place in less than a second and require motor patterns that have been taught and are well ingrained for the exercise to be performed safely.

The speed of motion and the technical aspect of the

TABLE 5  
Front Latissimus Dorsi Pulldown Progression

Step 1. Shrug/underhand grip
Scapular retraction and shoulder extension with elbows fully locked
Forearm supinated, underhand grip
Step 2. Shrug/overhand grip
Scapular retraction and shoulder extension with elbows fully locked
Forearm pronated, overhand grip
Step 3. Partial ROM <sup>a</sup> latissimus dorsi muscle pulldown/underhand grip
4- to 6-inch thickness of towel placed underneath shirt
Forearm supinated, underhand grip
Bar is lowered until it touches the toweling and returns to start position
Step 4. Partial ROM latissimus dorsi muscle pulldown/overhand grip
4- to 6-inch thickness of towel placed underneath shirt
Forearm pronated, overhand grip
Bar is lowered until it touches the toweling and returns to start position
Step 5. Full ROM latissimus dorsi muscle pulldown with Overhand grip
Bar is lowered until it touches the chest and returns to start position

<sup>a</sup> Range of motion.

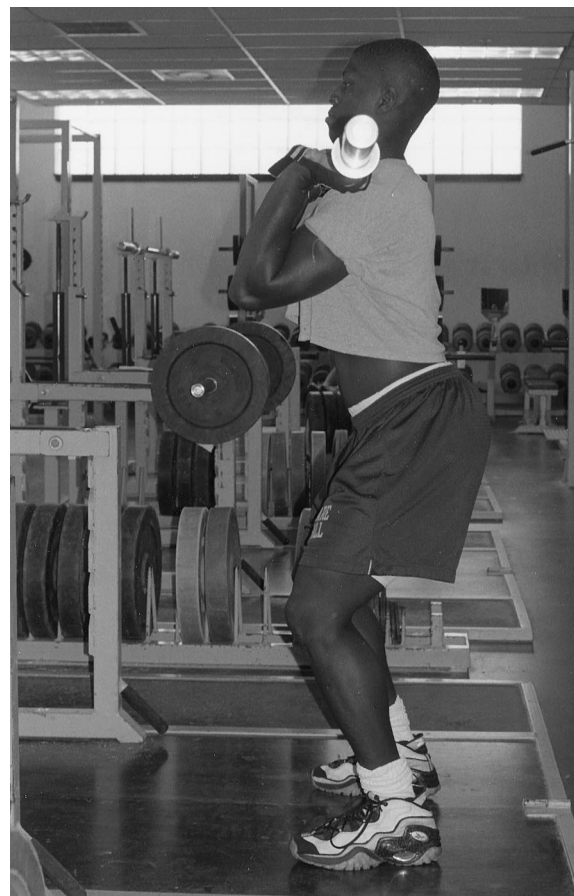
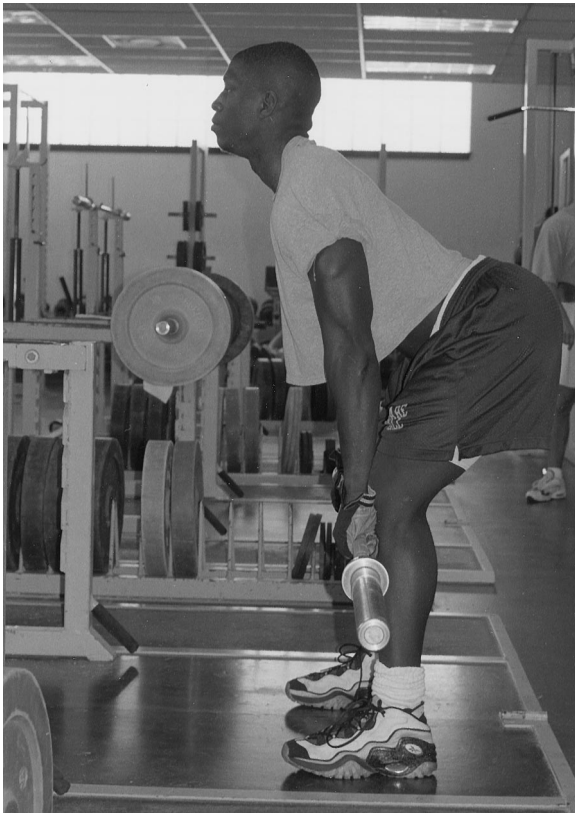


Figure 9. The racking position for the power clean exercise.

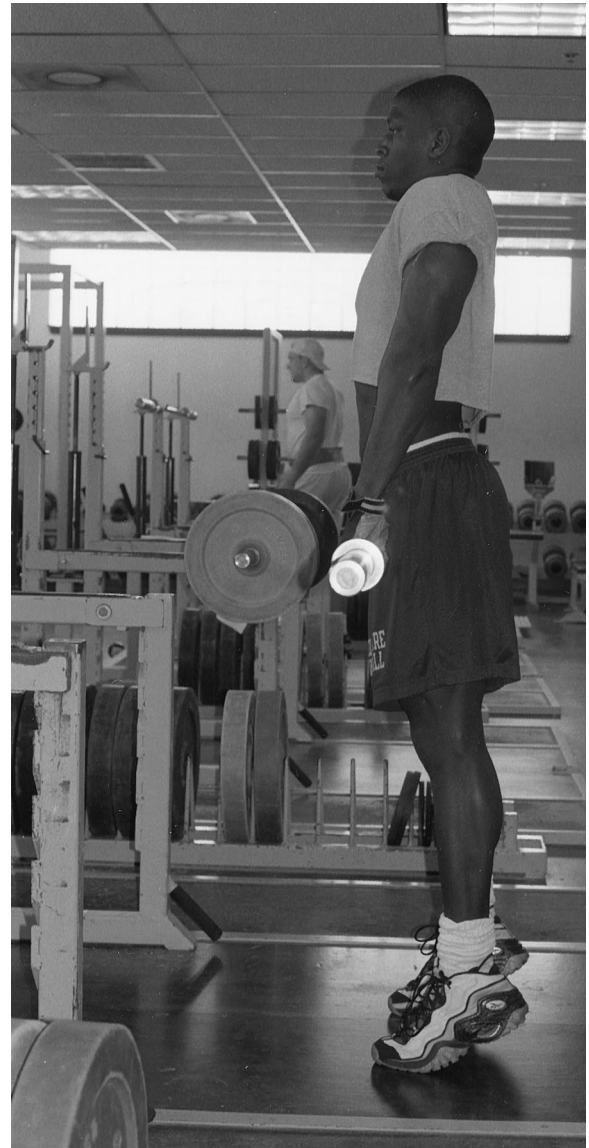


**Figure 10.** Starting position for the power clean high pull or power pull exercise.

power clean places a pathologic distal clavicle<sup>5</sup> and wrist joint at risk. As described in the United States Weightlifting Association Coaching Accreditation Course, "The lifter extends the body upward in a violent movement . . . shrugging . . . and rising on the balls of the feet [and] . . . from this position [moves] up and under the bar."<sup>15</sup> Even with correct performance of the power clean, repetitive microtrauma occurs to these areas. Athletes who participate in collision sports such as football or lacrosse suffer repetitive macrotrauma to these areas during the season and are particularly susceptible to injury when participating in off-season conditioning programs.<sup>5</sup>

Repetitive microtrauma from the power clean can be addressed in two ways. If the athlete has an injured acromioclavicular joint or sustains a wrist sprain or strain during the competitive season, the power clean should be modified to allow only the pulling portion of the lift without racking the bar. This exercise is termed a "power clean high pull" or "power pull" (Figs. 10 and 11). The key to the exercise modification is that the athlete still derives the benefit of lower extremity power output, but the wrist is held in a neutral position to avoid the extended position normally associated with the rack position. In addition, the athlete does not rack the bar and avoids additional trauma to the acromioclavicular joint that can be associated with a mistimed lift.

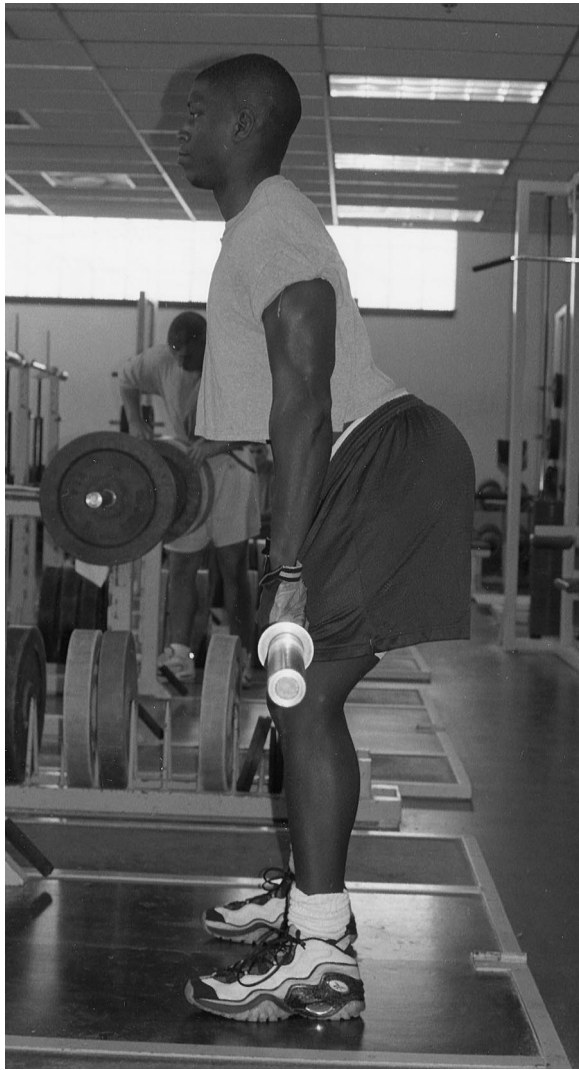
An athlete with a SLAP lesion is at risk during the



**Figure 11.** Finish position for the power clean high pull or power pull exercise.

acceleration phase and deceleration phase of the power clean.<sup>42,49</sup> Therefore, modification should be directed at the starting position and repositioning after a repetition is completed. First, the power clean should begin from the start position above the knees (Fig. 12), as opposed to picking up the weight from the floor, and continue with the normal high pulling motion. The start position above the knees is commonly referred to as the "hang" position and decreases the overall stress on the shoulder during the acceleration phase of the power clean. The rationale for this higher position is that the athlete minimizes the total time during the acceleration phase when performing from the hang position. In addition, the scapular stabilizer and erector spinae muscle groups are at the mechanically advantageous position during the hang power clean exercises as opposed to starting from the floor. The second





**Figure 12.** Above-the-knee starting position for the power clean exercise.

consideration is the use of bumper plates so the athlete may freely drop the weights to the platform without having to decelerate the bar. The deceleration phase, which involves an eccentric contraction of the biceps and puts the athlete with a SLAP lesion at risk for further injury, is eliminated.<sup>42,49</sup>

## SQUAT

The squat is a total body movement exercise involving both the upper and lower extremities. It is traditionally performed with the bar across the upper back. In fact, this lift is also known as the “back squat.” The upper extremity phase of the squat involves a combination of motions in the transverse (external rotation) and coronal (abduction) planes. The upper extremity is positioned to support the bar on the back while performing a squatting motion. The position is initiated by placing the hands at slightly wider than shoulder width and then stepping under the bar. The

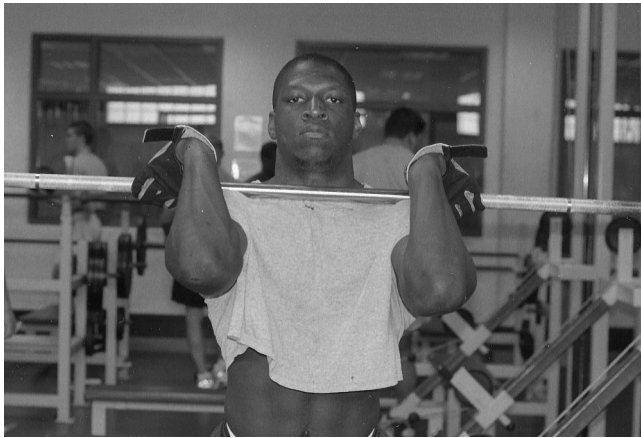
athlete positions the bar comfortably on the upper trapezius muscle when performing “high bar” squats and lower on the trapezius muscle while performing “low bar” squats.

This exercise targets the lower extremity and hip muscles and is considered, along with the power clean, to be an essential exercise for lower extremity and hip strengthening. Common maximum weights for healthy male athletes range from 250 to 400 pounds. Exceptional athletes can lift 400 to 550 pounds in a squat. This intensity creates huge stresses on the glenohumeral complex. An athlete with an unstable shoulder may have an additional problem with back squatting because the high five position is a critical component of the lift.<sup>10</sup>

There are two exercise modifications for back squatting. The first involves the use of a special bar with a modified center of mass.<sup>20</sup> The athlete holds the bar with the shoulders in an adducted and internally rotated position (Fig. 13). The modified center of mass allows the bar to rest on the shoulders without sliding off the back. If this equipment is not accessible, a front squat is used as a replacement exercise. The front squat shifts the center of gravity from the back to the front as the bar rests on the anterior deltoid and sternoclavicular joints and is balanced by the hands (Fig. 14). The exercise still stresses the lower extremity and hip muscles, but the athlete holds the bar in 80° to 90° of shoulder flexion, less than 15° of external



**Figure 13.** The center of mass bar is held with the shoulders in an adducted and internally rotated position.



**Figure 14.** The bar rests on the anterior deltoid and sternoclavicular joints and is balanced by the hands.

rotation, and neutral abduction, a bar position that is much safer for an injured shoulder. As with the bar with a modified center of mass, this position minimizes the stress of the middle and inferior glenohumeral ligaments.<sup>19</sup> The technique is reinforced if the athlete is instructed to maintain scapular elevation and retraction throughout the squatting motion.<sup>15</sup>

Proper front squatting technique places maximal stress on the deltoid and sternoclavicular joint and minimal stress on the wrist joint.<sup>15</sup> This emphasizes the concept of using the wrist to provide the balance rather than the support for the bar. This position avoids abduction and external rotation and forces the athlete to contract the internal rotator muscles to stabilize the bar.<sup>10</sup> These components provide a safe exercise modification while still emphasizing lower extremity strength. Initially, the athlete can expect to exercise at approximately 60% of the back squat 1 RM, but after achieving good technique with the lift, the exercise intensity will approach 80%.

## SUMMARY

The health care professional's knowledge of exercise technique is necessary to help injured athletes make informed choices about weight-lifting activities. The information in this article helps the caregiver to alter weight-lifting programs so as to provide protection for joints, tendons, and muscles while enhancing physical performance. Modifications of hand spacing, grip selection, and start and finish positions used in common upper extremity lifts (bench press, shoulder press, and latissimus dorsi pulldown exercises) decrease microtrauma to the joints of the shoulder and reduce the strain on passive and active shoulder stabilizers. Exercises whose risk-to-benefit ratios are high (such as behind-the-neck latissimus dorsi pulldowns) should be eliminated from all programs, while the behind-the-neck press should be modified and only used for limited, sport-specific training. Lower extremity exercises that involve the upper extremity (such as the power clean and squat) can easily be modified to minimize wrist and

clavicular microtrauma and reduce strain on the shoulder ligaments.

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#### ERRATUM

Please note that one of our authors' names was misspelled in the May/June 1998 issue. In the article entitled "The Deltoid Muscle Origin. Histologic Characteristics and Effects of Subacromial Decompression" on pages 379 to 383, Michael Wang, MD, should be Michael Weng, MD. We regret any inconvenience this may cause to Dr. Weng.