Injury Potential and Safety Aspects of Weightlifting Movements

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THE SNATCH AND THE CLEAN and jerk and their derivations (weightlifting movements) (14) can be classified as *explosive exercises.* Explosive exercises have been defined as movements that use maximum or near maximum rates of force development, while maximum or near maximum force production is maintained throughout a specified range of motion in keeping with the exercise technique involved (39, 44).

These explosive weightlifting movements are of obvious importance to weightlifting. Additionally, they can be of considerable use in training for various other sports, particularly strength/power sports such as throwing events, volleyball, and American football. Their use in the training for various sports results from specificity of exercise and training, the bioenergetic and biomechanical similarity of these exercises to many sporting activities (44).

Thus these exercises are used not only by weightlifters but also by athletes in many other sports (21, 31, 36). Some coaches are reluctant to use weightlifting movements, even though they may be useful in the sport they coach. There can be three reasons for this:

1. The coaches do not understand the relationship of weightlifting exercises to training for other sports.
2. The coaches believe these exercises are not safe and may cause excessive injuries.
3. The coaches do not know how to teach their athletes the proper exercise form or technique.

These three factors should be addressed by sport scientists and the coaching community. A better understanding of the biomechanics of weightlifting and the physiological responses to training will foster a greater appreciation of weightlifting as a sport and of the importance of weightlifting movements in the training of various athletes. Additionally, knowledge of proper technique and safety factors associated with weightlifting movements can reduce the risk of injury for weightlifting training as well as for other sports.

Discussion

The first factor has been addressed in several previous articles (3, 13, 14, 39, 44) and will not be discussed here. The second factor, dealing with injury/safety factors, has only recently begun to be studied; few studies have specifically addressed this problem. Injuries can be divided into either acute or chronic types.

Types of Injuries

Acute. Acute injuries include muscle and connective tissue strains and sprains. A strain is a stretch or tear in the muscle or its surrounding tissues (fascia or tendons). Strains can range in severity from the tearing of only a few fibers to complete tendon avulsion and complete muscle rupture. A sprain is the stretching or tearing of stabilizing connective tissue such as ligaments, articular capsule, synovial membranes, and the tendons that cross the joints (18).

Other acute injuries include bone fractures, ruptured disks, and trauma to nerves (10, 18, 25, 28, 40, 41, 45, 46). Acute injuries can occur at various locations including the ankles, knees, hips, back, shoulders, and wrists. The underlying mechanisms and rehabilitation of these injuries has been discussed previously (10, 18, 25, 28, 40, 41, 43, 45, 46, 47).

The causes of acute injuries include barbell or platform defects, poor training hall conditions, improper footwear, collisions with the bar, poor technique, failure to properly warm up, and rapid weight loss (18, 25). Acute injuries typically occur as a result of an athlete losing concentration, attempting to perform beyond his or her capabilities, returning to training before being completely rehabilitated from an injury, or poor coaching (e.g., the coach pushes too hard, picks inappropriate weights, gives inappropriate cues) (18).

Chronic. Chronic injuries include typical overuse injuries such as tendinitis and bursitis as well as chronically recurring injuries that result from returning to training too soon. Firowicz (10) and Herrick and Stoessel (18) state that most weight-room injuries are of the overuse type. The underlying mechanisms and rehabilitation of overuse injuries have been discussed previously (10, 18, 23, 25).

Overuse injuries are typically the result of poor technique, use of high volume or high intensities for too long a period, and poor choice of exercises (one-sided training, not paying enough attention to antagonists) (10, 18, 23, 25).

Recent articles (27, 30) suggest that weightlifting movements are dangerous; these articles indicate that injuries can be excessive if such movements are used in training. The implication is that weightlifting is a dangerous sport and that weightlifting movements should not be used in the training of other athletes. Although no objective data were provided, it was suggested (27, 30) that there is a high injury rate from weightlifting movements resulting from the speed of movement and the uncontrolled manner in which the weights are lifted.

There is little objective information to suggest that the speed of a muscle action alone increases the potential for injury. Evidence does suggest that most injuries to muscle/connective tissue occur during eccentric muscle actions (15). It has been shown that the stress placed on tendons during a maximum isometric contraction is about 30% of the maximum tensile strength of the tissue (20). This leaves a considerable (>200%) safety margin.

During normal daily and athletic activities, both eccentric and concentric muscle actions occur. It has been suggested that about 50% of the safety margin is used during these activities (1). The safety margin increases at high strain rates such as those occurring during intense fast eccentric muscle actions. This larger safety margin is due to intrinsic properties of connective tissue (35). Additionally, most injuries (strains) occur at the myotendinous junction (muscle-tendon interface) and are largely a function of the total energy absorbed regardless of strain rates (15, 38).

An important adaptation to high speed movement is intermuscular coordination. As the speed of movement increases, antagonistic muscle activation (co-

contractions) also increases (3). The major function of co-contraction of the antagonist appears to be joint protection, including augmentation of ligament stability, equalization of pressure across articular surfaces, regulation of joint mechanical impedance, and movement control including control of the duration of acceleration and deceleration and coordination of movement precision (3).

The co-activation response to high speed movements is characterized by specific triphasic electromyographic (EMG) patterns (3). It appears that these EMG patterns must be learned, and this can be accomplished through high speed training.

One possibility for increased injury is that the antagonist will be exposed to eccentric muscle actions that can be of considerable force. However, the potential for injury can be minimized by carefully learning appropriate patterns of co-contractions, that is, proper technique. It is also possible that bar collisions as a result of the snatch and the clean and jerk may increase the potential for injury.

Excessive impact forces as a result of catching the bar could also increase the risk of injury. Burkhardt et al. (4) found that propulsive and impact (catch phase) forces resulting from the power clean (90% 1-RM) were similar to those found for countermovement vertical jumps and drop jumps from 42, 63, and 80 cm. Burkhardt et al. point out that the propulsive and impact forces they observed were made under controlled laboratory conditions and that training and competition could result in higher forces.

Additionally, jumps are often landed on one leg, which would greatly increase stress and shear forces on the joints. It should be noted that the snatch and the clean, when performed properly, are controlled movements and that the catch phase for weightlifting movements would rarely if ever occur on one leg. Thus the forces encountered for the snatch and the clean would likely be less than those resulting from jumping that ends in one-legged landings.

Unpublished data based on questionnaires and athlete interviews (M. Stone, 1980–83, $n = 32$) suggest there may be a relationship between the number of complete squat clean and jerks performed in training and the number of training days missed due to injury. The weightlifters performing more clean and jerks, especially above 90% of 1-RM, missed more days of training. It is possible that as the number of clean and jerks increases in training, so does the number of injuries. There was no evidence of a relationship between missed training days due to injury for squat snatches, power snatches, power cleans, or pulling movements, all of which are high force/high velocity movements.

In an injury assessment of 80 weightlifters, Kulund et al. (28) also concluded that most injuries resulted from the clean and jerk, with the squat snatch a distant second. Pulling and squatting movements produced relatively few injuries. It is possible that heavy squat clean and jerks, and perhaps the squat snatch, may increase the likelihood for catching the bar out of position, which can increase the potential for injury.

Also important are the effects of fatigue. Fatigue results in reduced muscular strength, a decreased isometric rate of force development, and interference with movement patterns, especially during high power movements such as weightlifting (2, 44). This suggests that during high volume training such as the preparation phase, when fatigue levels may be high, the number of technically complex exercises should be limited. Performing these exercises while fatigued can interfere with learning or stabilizing proper technique, may result in diminished adaptations for maximum strength and power gains, and may increase the risk of injury.

Incidence of Injury

Perhaps the best way to determine whether an activity has a high rate of injury is to look at the injury rate data objectively. Several studies have examined injuries to the lower back including spondylolysis (vertebral stress fractures, usually in the 5th lumbar vertebrae). Spondylolysis is sometimes accompanied by spondylolysthesis, a forward sliding of a vertebra.

Kotani et al. (26) studied 26 Japanese weightlifters (*M* age = 21 yrs) for several years and found 24 to have recurrent back pain (unspecified as to severity or cause) and 8 (31%) to have spondylolysis. Dangles and Spencer (8) studied 27 weightlifters and 20 powerlifters (*M* age = 30 yrs) and found that 21 (44%) had spondylolysis. No differences were noted between powerlifters (high force/slow movements) and weightlifters (both high force/slow and fast movements).

From 1962 until 1988, Rossi and Dragoni (37) examined 3,132 athletes in various sports who complained of low back problems; 22 of 97 weightlifters (22.7%) showed clinical evidence of spondylolysis. These data would suggest that weightlifting, along with most other sports (37), produces a high incidence of spondylolysis relative to the general population (4–7% incidence).

However, these studies contain many design deficiencies which bear examination. First, spondylolysis is strongly influenced by heredity (49). No adequate history (X-rays, family history, etc.) was obtained prior to the athletes' involvement in weightlifting. Some of the athletes could have had conditions predisposing them to the development of back problems including spondylolysis.

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Second, the studies did not use a random sample, thereby biasing the results. This is particularly important in the studies of Dangles and Spencer (8) and Rossi and Dragoni (37), since they selected their sample from athletes complaining of back problems. This factor is also important because other sports, particularly diving, wrestling, gymnastics, and American football, are believed to have a very high incidence of low back problems including spondylolysis (9, 32, 37).

Third, and perhaps most important, all three studies used weightlifters who had competed prior to 1972 when the standing press was part of weightlifting competition. The press resulted in considerable hyperextension of the back. The general conclusion of all three studies suggested that it was not the speed of the movement but rather the hyperextension of the back, primarily resulting from overhead lifting, that was the major cause of the back problems among the athletes studied.

Thus, since the press has been eliminated from competition, the incidence of back problems may be lower. Furthermore, spondylolysis (stress fracture) may be an overuse injury that is more likely to be a function of training program design than of the specific exercises used. Considering the design problems associated with these studies, however, we cannot accurately assess the incidence of low back problems resulting from weightlifting movements.

It should also be noted that several studies and observations do not support the contention that weightlifting movements cause excessive low back injuries. Kurachenko (29) studied 20 swimmers and weightlifters, ages 14 to 17 years, for a 2-year period. There was no evidence of spinal or other bone/joint pathology. Kurachenko reported that the bones as well as other tissues of the weightlifters had adapted to the training program by increasing in density and becoming stronger, which helped protect them from damage.

An increase in bone material as a result of weightlifting training has recently been observed in American junior weightlifters (7). Kulund et al. (28) reported a relatively low incidence (10%) of low back pain among 80 weightlifters.

More recently, Granhed and Morelli (16) compared the incidence of low back pain among retired wrestlers, ages 39 to 62; weightlifters, ages 40 to 61; and untrained men, ages 40 to 47. The wrestlers reported an incidence of 59%, the untrained men an incidence of 31%, and the weightlifters reported the lowest incidence at 23%.

. . . the low incidence of back pain and injury among weightlifters was due to increased muscular strength . . .

Kulund et al. (28) have suggested that the low incidence of back pain and injury among weightlifters was due to increased muscular strength and tissue strength, spinal flexibility, and the straight-back lifting style used in weightlifting movements. Low back pain may be associated with a variety of factors. For a discussion of the possible causes and solutions to low back pain, see Garhammer (12) and Chandler and Stone (6).

The knee may also be vulnerable to damage from weightlifting movements. As with the lower back, few studies have specifically assessed the incidence of knee injuries as a result of weightlifting movements.

It is possible that knee damage might be associated with knee instability. Klein (24) suggested that squatting movements in which the thigh moved to a position below parallel with the floor would decrease medial and lateral knee stability.

Several subsequent studies assessing squatting effects on medial and lateral knee stability were unable to confirm Klein's conclusions (33, 34, 48). A comparison of knee stability associated with the anterior and posterior cruciate ligaments (5) found few differences between powerlifters, weightlifters, and untrained controls, although the athletes showed somewhat greater stability. Kulund et al. (28) found no meniscectomies, no minimal chondromalacia-type complaints, and no knee clicks or pops (which may be associated with knee damage) among 80 weightlifters.

Some people believe that weightlifting or using weightlifting movements could be associated with arthritic changes. Fitzgerald and McLatchie (11) found that the incidence of arthritis in several joints including the knee was no higher in weightlifters than in the general population of the same age. Patellar ligament or tendon rupture occurs in both powerlifters (high force/slow movements) and weightlifters (high force/slow and fast movements); this is rare and may be due to overtraining, use of anabolic steroids, or use of corticosteroids (43).

Many knee problems could be associated with other activities. For example, Herrick et al. (19) found that weightlifters and powerlifters who add running to their training program have more knee pain than those who do not run. These data would suggest that weightlifting movements alone do not pose a significant acute threat to the knee. For additional information, see Chandler and Stone (6).

Kulund et al. (28) suggest that most injuries are not severe and do not require extensive rehabilitation or missed days from training. This agrees with more recent observations. For example, among 24 junior weightlifters (ages 14 to 20 yrs) participating in a month-long training camp in the summer of 1990, only 2 experienced an injury requiring time off from training. Both returned to training before the camp was over (unpublished observations). During this camp the athletes trained two to four times a day, 5 to 7 days a week.

When properly taught, even novice weightlifters ($n = >10{,}000$; 6-yr observation) can remain injury free (22). Based on 168,551 hrs of training, the injury rate for weightlifting has been shown to be 0.0017 per 100 hrs (17). This rate is much lower than for most other sports in the U.S., for example basketball (0.03), track and field (0.57), football (0.10), and gymnastics (0.044).

Based on the information above, it appears that the injury rate for weightlifting is not excessive and, furthermore, is generally lower than for sports such as gymnastics, basketball, and American football (17, 19, 42). Also, weightlifters train using heavy, often near maximum complete squat snatches and clean and jerks. Other athletes using weightlifting movements to enhance performance do not necessarily have to perform the squat snatch or clean and jerk. Reducing the number of heavy squat snatches, cleans, and clean and jerks may reduce the potential for injury.

Appropriate Technique

Coaching weightlifting movements. The third factor is most important. Under normal conditions weightlifting movements are explosive but highly controlled exercises, as noted by technique analysis (4, 14); otherwise the injury rate would be much higher and there would be more missed lifts in competition and training (4, 17, 28). It is only under maximum or near maximum conditions that weightlifting movements are typically missed.

Teaching the appropriate technique is of prime importance. Coaches who teach their athletes improper technique may be risking injury from weightlifting movements or any other weight training exercise (6, 44).

Several articles and manuals concerning appropriate technique and safety aspects are available from, for example, the International Weightlifting Federation (IWF), the United States Weightlifting Federation (USWF), and the National Strength & Conditioning Association (NSCA). The USWF publishes a safety manual that includes sections on appropriate spotting techniques for weightlifting and weight training exercises.

The USWF also offers a beginning course for prospective weightlifting coaches that covers proper weightlifting and weight training exercises, how to teach them, and safety measures and standards associated with these exercises. Videos and other instructional materials concerning the proper technique and use of weightlifting and other explosive exercises are available from the USWF and the NSCA.

Summary

Weightlifting movements may cause injury to soft tissue and to the wrists, shoulders, hips, back, knees, and ankles. The injuries that result from weightlifting movements appear to be primarily a function of overuse, poor technique, or excessive collisions with the bar, particularly as a result of heavy clean and jerks. Training strategies that reduce the number of heavy clean and jerks should be considered.

Compared to most other sports, however, the injuries from weightlifting do not appear to be excessive and are rarely serious. Coaches and athletes can minimize the risk of injury by paying attention to facilities, the athletes' footware and clothing, proper training procedures (periodization, appropriate exercises), proper warm-up, and especially proper technique. ▲

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