

Safety of the Squat Exercise

The squat is typically a barbell exercise where the individual starts in a standing position with the barbell on the back, and bends the knees to squat down until the thighs are parallel with the floor. It has been the subject of some controversy in exercise prescription, primarily related to the belief that it causes knee or low back pain or injury. However, when examining the safety of the squat, it is appropriate to review the history, science, and practical application of this activity.

Any resistance exercise improperly performed may result in injury. Such injury may occur due to excessive volume of training, excessive resistance, or use of improper form in performing the exercise. Thus, exercise technique is paramount.

Historical Perspective

Scientific evidence that squatting movements could be detrimental to the knee came from work reported in the 1960s. The squat exercise, properly done, reportedly stretched the knee ligaments in both medial/lateral and posterior/anterior directions. Based on this work, some military services in the United States ceased using squatting movements (specifically jump squats without resistance) in their training programs.

Possible flaws regarding this research include choice of subjects and investigators' bias. Subjects in one of the studies were parachute jumpers. Medial/lateral knee ligament injuries are common in this group, because 1) the legs are often caught in parachute lines as it opens, and 2) parachutists place excessive force on the knee joint when landing.

Recent Scientific Evidence-the Knee

Since work from the 1960s, several research studies have expanded our knowledge and understanding in this area. These include studies made on athletes, animals and individuals who have been through injury rehabilitation. One study used an instrument to measure anterior/posterior displacement of the tibia relative to the femur. Subjects performed varying depths of squats over an eight-week period. Additional data were collected on groups of weightlifters, power lifters, and age-matched controls. Over the eight-week period, there was no increased instability created relative to depth of the squat. Thus, squats do not negatively affect knee stability. Using the same instrument, another group of researchers determined that acute bouts of exercise using a variety of activities (including squats) decreased stability of the knee joint, possibly due to muscle fatigue or elevated body temperature. Therefore, knee instability is not necessarily due to one specific exercise movement such as the squat. However, many exercises can cause acute instability due to other factors.

Various forms of exercise have been shown to increase ligament strength. In animal studies, endurance exercise has been shown to increase the strength of the ligament-bone attachment, as well as increasing the diameter and collagen content of ligaments. When bone-ligament preparations are tested at high speeds, they fail at a higher maximum load. In athletes rehabilitating injured knees, closed-chain exercises such as the squat are currently used because in the squat, the hamstrings co-contract with other leg muscles to increase the stability of the knee, thus putting less stress on the anterior cruciate ligament.

There are certainly times in the healing of injuries where the squat, and other exercises that stress the knee, should be avoided. However, once soft tissues have healed, exercises should be chosen that are the most effective at improving strength to protect the knee joint from further injury.

The Stress of Squats on the Back

Another area of concern for safety in the squat exercise is the low back. If the lift is not properly performed, the forces at the low back maybe intense enough to cause injury.



The most common errors that may lead to back problems include 1) lifting excessive weight and 2) leaning over too far so the weight is lifted by the back and not the legs and hips. Squatting with resistance placed on the upper back across the shoulders does increase the compressive forces on the spine. Maintaining an erect posture helps to evenly distribute the forces on the spine, and to decrease the chance of injury. Forces at the lumbar spine on half-squats with a loaded barbell were determined to be six to ten times the body weight. To reduce both spinal compressive forces and shear forces, the athlete should have the necessary flexibility of the knee, hip and spine to maintain an upright posture during the squat.

Abdominal strength is also important to protect the spine. During a heavy lift, lifters hold their breath during the effort portion of the lift. This increases intra-abdominal pressure and helps stabilize the spine. Wearing a weight belt may also help the athlete exert intra-abdominal pressure. While there is some controversy about the use of weight belts, they probably should be used during heavy squat lifts.

Stress fractures of the vertebra (spondylolysis) and forward slippage of one vertebra over another (spondylolisthesis) do occur in athletes. Because athletes are generally active in a variety of ways, including resistance training, it is difficult to determine whether resistance training is a possible cause of these conditions. Maintaining strong torso musculature is essential in protecting the spine during the squatting movement. The squat program should be modified for athletes with back problems.

Back pain is a common complaint associated by some with the squat exercise. Sprains and strains may occur with a variety of athletic activities and are more likely to occur with sudden movements involving spinal extension and rotation. Properly performed, the squat exercise does not fit into this category. In one study, weightlifters had a relatively low incidence of back pain (eight of 80 lifters). This study indicates that spinal flexibility, lifting with a straight back, and strong paravertebral muscles protect the lifter from back pain. In former lifters, the incidence of low back pain was less than in the general population.

Proper Use of Squats in a Training Program

As mentioned earlier, any exercise can be performed improperly. Athletes enter training programs with different strength levels and past injuries. All of these factors must be considered when developing a strength program. Proper technique taught by qualified personnel is important to the safety of the squat exercise. The depth of the squat is generally recommended to the point where the tops of the thighs are parallel with the floor. With proper form and progression, certain athletes may be able to descend lower. The value of deep squats for improving athletic performance continues to be a debated topic. In general, if the athlete is required to perform from a deep squat position, such as in weightlifting, that athlete should gradually progress to the deep squat position.

Training while overly fatigued or training to failure with squats may place the athlete at risk of losing control of the squat and therefore losing control of the weight, allowing a twisting motion at the knee, increasing the potential for meniscal injuries to the knee. Time for adequate recovery should be allowed (both within the exercise session and from one exercise session to the next), and the resistance and repetitions should be adjusted appropriately.

Proper Form

1. Use an approximate shoulder-width foot stance.
2. Descend in a controlled manner.
3. Ascend at a variety of speeds, including fast but controlled speeds.
4. Exhale after the major effort on the ascent.
5. Avoid bouncing or twisting in the bottom position.
6. Maintain a normal lordotic posture with an erect spine.
7. Descend to the point where the tops of the thighs are parallel to the floor.
8. Keep feet flat on the floor.
9. In general, be sure knees do not go beyond the toes.
10. Keep progression of both resistance and depth of the squat gradual, and do not exceed the body's capacity to adapt to the imposed demands. Warning symptoms for progressing too fast include back pain, knee pain, and other symptoms of overtraining.
11. Consider fatigue to be a risk factor in squatting.
12. Maintain proper form, or stop performing the exercise.

Summary

In summary, the squat exercise is important to many athletes because of its functionality and similarity to athletic movements. If appropriate guidelines are followed, the squat is a safe exercise for individuals without a previous history of injuries. The squat is a large-muscle-mass exercise and has excellent potential for adding lean muscle mass with properly prescribed exercise.

The squat trains a high number of muscles, focusing on the lower body and back. Individuals with prior injury or special considerations (e.g. pregnant women) need to consult their physician before starting any exercise program.

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