



The general set-up position for an air squat as demonstrated by CrossFit Inc. Seminar Staff.

The squat is an essential movement pattern, but many lose the ability to perform a proper squat over time, and the movement must be retrained to allow them to perform daily activities such as standing from a seated position.

In the world of athletic development, the squat is the most important exercise for developing powerful hip extension, and thus it is one of the best exercises for improving athleticism. In the CrossFit Level 1 Certificate Course, the air squat is the foundation on which the squat is developed into higher-level training tools such as the back squat, front squat and overhead squat, with the latter two variations key to the Olympic lifts.

Performing a proper squat requires significant mobility throughout the body, but the ability to move all the involved joints through their available ranges of motion does not necessarily ensure a perfect squat. The squat also requires considerable motor control, meaning the athlete must be able to efficiently utilize his or her available motion through proper muscle activation. While mobility is often blamed for poor movement, motor control is just as important. A thorough understanding of the mobility and motor-control needs of the squat will help athletes and coaches choose the best corrective exercises to optimize performance of this essential functional movement.

Points of Performance

The CrossFit Level 1 Certificate Course provides the superior framework for learning the instruction and performance of the squat through both lectures and hands-on group coaching. The points of performance taught in the course ensure that athletes perform the squat with sound mechanics.

In the set-up, the athlete should have a shoulder width-stance with knees and hips fully extended and his or her weight on the heels. The athlete maintains a braced core with the chest up to position the spine in neutral. To execute the movement, the athlete begins by moving his or her hips down and back (versus moving the knees forward). The athlete descends until the hip crease is below the kneecap while keeping the knees over the feet and the spine in a neutral position. The movement is finished when the athlete returns to the full upright position with the hips and knees extended (3).

Common faults during the squat include loss of neutral spine, shifting of weight onto the toes, loss of contact between heels and ground, outward rotation of the feet during performance of the squat, lack of squat depth and improper lateral tracking of



A solid air squat provides the foundation for variations including the back squat, front squat and overhead squat.

the knee (3). The "CrossFit Level 1 Training Guide" provides multiple corrective exercises and cues for improving these faults.

Mobility Requirements for the Squat

When determining whether performance is limited by mobility or motor-control issues, begin by analyzing mobility. If adequate mobility is present in all necessary joints but movement quality is below standards, motor-control imbalances are to blame.

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The first place to start when analyzing mobility for the squat is the ankle. Lack of ankle dorsiflexion is one of the most common range-of-motion limitations seen in athletes and can cause all the faults listed above. Limited ankle dorsiflexion has been shown in multiple research studies to cause movement faults during other activities such as jumping. This research has also correlated limited ankle mobility with a variety of lower-extremity injuries (2,4,5). Thus, addressing ankle mobility is necessary for optimizing movement quality.

To test ankle mobility, position the big toe of the ankle to be tested one hand width away from a wall with the foot pointed forward. On average, the foot tends to be approximately 4 inches from the wall. While barefoot in the bottom position of a lunge, the athlete should be able to touch the kneecap to the wall without the heel's rising off the ground. If the athlete cannot do so, ankle dorsiflexion is limited.

To assess if sufficient knee flexion is present to squat to depth, the athlete should lie on his or her back and bend the knee to the point where the calf muscles make contact with the posterior thigh. Hip-flexion is tested in the same position as the athlete pulls the thigh toward the chest. If the front of the thigh contacts the stomach, adequate hip flexion is present (1).

If these three tests are passed, the athlete has sufficient lowerbody range of motion to perform a squat while maintaining all points of performance outlined in the "CrossFit Level 1 Training Guide." While other mobility testing will be proposed, the vast majority of athletes who have passed these first three tests but demonstrate improper squat form do so because of motorcontrol dysfunctions rather than mobility restrictions. Interventions such as "squat therapy"—as proposed in the "Training Guide" and discussed below—will help these athletes improve their mechanics.

To assess hip rotation, the athlete should sit on a box with an upright torso. A partner rotates one leg so the foot goes inward for external rotation and outward for internal rotation. The partner must also ensure that the thigh remains pointed directly forward and that motion is stopped before the pelvis begins to shift. Normal range of motion for both internal and external rotation should be approximately 40 degrees.

Limitations in either direction of hip rotation will result in a variety of compensations during the squat and other athletic movements. Common squat compensations include outward turning of the feet during execution of the squat, loss of neutral spinal positioning, and excessive outward movement of the knees beyond the width of the feet. Therefore, optimizing hip mobility is necessary in developing overall athleticism.

It is important to note that hip anatomy varies greatly in individuals. For some, this suggested hip-rotation mobility may not be possible, but even small improvements can have significant effects on improving performance and function. For an in-depth look at hip anatomy and function during athletics, read the CrossFit Journal article "The Hip and Athletic tPerformance."

When mobility restrictions are present, a variety of techniques can be employed to improve range of motion, including stretching, myofascial release, joint mobilizations and manual therapy performed by trained professionals. Mobility improvement is a broad topic, with individual response varying greatly. Recommended resources for potential mobility exercises can be found at the end of this article.

To assess range of motion in lumbar-spine extension, have the athlete lie prone. The athlete should then prop the upper body onto his or her forearms. Uniform extension through the lumbar spine should be seen with the athlete's hips flat on the ground. In those with dysfunctional lumbar-spine extension, the hips will rise off the ground or the athlete will be seen exhibiting excessive extension at one spinal segment (often at the junction between the lumbar and thoracic spine).





Thoracic-spine extension and shoulder mobility have been previously discussed in "Analyzing the Handstand Position." Thoracic-spine extension is important in all squat variations, and shoulder mobility and stability become increasingly important in the overhead squat. To better understand the demands on the shoulder in CrossFit, see "The Optimal Shoulder" in the CrossFit Journal.

Motor Control of the Squat

As previously discussed, when an athlete has proper mobility but squat performance is dysfunctional, motor-control issues are present: that is, the individual is unable to properly coordinate muscle activation to control movement through the available ranges of motion to properly perform a squat. Verbal, visual and tactile cues should be employed to improve mechanics in athletes whose squat mechanics are limited by motor control.

While it's common for athletes to believe their squat errors are solely related to range-of-motion issues, many errors are caused by motor control. Trainers will often present a cue only to have an athlete say "I can't" before he or she details a perceived range-of-motion issue. In some cases, range of motion is indeed limited, but in other cases the faults are caused by motor control. Either way, relentless trainers can almost always make smaller improvements in the short term simply by using creative cues to improve motor control.

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Inward tracking of the knees is one of the most common movement faults that results from a lack of motor control. While the fault might be caused by limited ankle mobility, it is usually the result of a lack of activation of the gluteal muscles to control lateral movement of the knee. Verbal cues such as "push the knees out" or "spread the ground with you feet" can be employed to remedy this fault.

In others cases, an external target such as a coach's hand near the athlete's knee will produce better results (3). A resistance band around the athlete's knees can also make for a great



external cue for use in correcting the knees-in fault. The band should be of light resistance, as it is used as a device to improve gluteal activation rather than to improve strength via loading (1). A great combined approach to this problem would be having the athlete perform squats with a resistance band during warm-up, with the coach cueing for correction during workouts.

A second common motor-control dysfunction is loss of neutral spinal positioning into lumbar flexion. This can often be corrected by cueing the athlete to lift the chest or raise the arms during descent into the squat (3).

For others, their static positioning during the set-up of the squat will put them in a disadvantageous position for maintaining proper spinal alignment. If an athlete begins with the lumbar spine overextended, the pelvis will be tilted anteriorly, decreasing the hip-socket range of motion available for the hip to move into flexion. As the athlete descends, the lumbar spine will have to move into flexion to allow for depth to be reached. This is commonly referred to as a "butt wink" when seen while squatting. Some athletes with sufficient hip mobility are fooled into thinking range of motion is lacking simply due to poor set-up in the squat. These athletes should be instructed in proper positioning before descending into the squat. Cues such as "keep your ribcage down" will often get the athlete to engage the abdominals and glutes to assume a more neutral position.

Similarly, many athletes initially struggle with balance during a squat, resulting in faults such as loss of neutral spine, weight shift onto the toes, excessive anterior knee movement and lack of depth during the squat. Much like a building, the weight must be distributed properly in the foundation or errors appear above. As with poor pelvic orientation in the set-up, poor weight distribution places athletes in positions that appear to be caused by limited mobility.

For some, a cue to push the hips down and back while keeping weight on the heels will assist in correction. For others, the use of a weight to provide a counterbalance will help the athlete learn proper positioning. This can be performed by holding a kettlebell in a goblet-squat position or by holding a light plate out in front of the chest. As the athlete learns proper positioning, the weight can be reduced or eliminated entirely to provide less counterbalance assistance. The weight will allow the quadriceps-dominant athlete to send the hips back—rather than the knees forward—to better load the hips without loss of balance.

Unlike mobility issues, motor-control issues can often be quickly remedied with proper corrective strategies and cues.

The squat-therapy corrective exercise taught in the CrossFit Level 1 Certificate Course is a fantastic tool for addressing all the most common mechanical errors, and it's a great starting point for an athlete who demonstrates multiple squat faults. To perform squat therapy, the athlete stands facing a wall in a proper set-up position. He or she then squats to a 10-inch box or other low target such as a medicine ball. The squat is performed slowly with the coach carefully watching and providing appropriate cueing throughout the movement (3).

The box provides a tactile target to ensure proper depth. Additionally, the wall forces the athlete to avoid excessive forward movement of the knees and trunk. Drastic mechanical improvements are often seen when a coach's cueing is combined with an athlete's conscious effort to keep the weight on the heels and the chest upright.

Unlike mobility issues, motor-control issues can often be quickly remedied with proper corrective strategies and cues. With consistent practice of movements using proper technique, these corrected patterns will ultimately become an athlete's default mechanics. As an athlete's motor control improves, his or her ability to properly load joints and muscles will be enhanced, and more efficient movement patterns will translate into improved performance during other athletic movements.

Evaluate and Improve

The squat is a fundamental movement pattern required for remaining functionally independent as one ages and for developing athleticism. Determining if squat dysfunctions come from range-of-motion or motor-control imbalances will help coaches and athletes find better corrective cues and exercises to more quickly optimize the athlete's performance and ensure safety.



Squat therapy is a powerful coaching tool for improving squat mechanics in an athlete with multiple faults.

Resources for the Fitness Athlete

Fitness Pain Free
The Hybrid Perspective
The Barbell Physio
Mobility 101
The Movement Fix
MobilityWod
The Wod Doc

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