

What injuries are attributed to the squat?

The squat is a popular weight-training (WT) exercise that can improve the strength and stability of the knees, core, hips, legs, and ankles by activating musculoskeletal (MSK) tissues in the lower body. In certain cases, however, the stress on the knees, hips, and back may lead to injury.¹⁻⁴

Most **squat** injuries are to the **lower body**.¹⁻⁴ Injuries occur either instantly from abrupt high force movements ([acute traumatic injuries](#)) or gradually from repeated lower intensity [overuse injuries](#).^{3,5} Repeated or untreated injuries can lead to chronic MSK conditions.^{3,5}

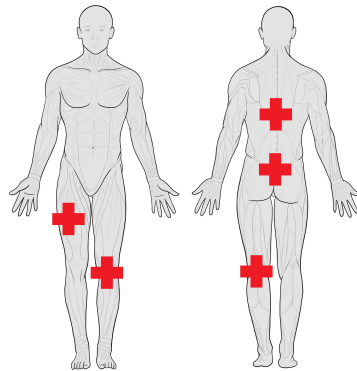
Injuries most commonly attributed to the squat are to the knee, lower back, and hip (including lumbo-pelvic region).¹⁻⁴ Injuries to hamstrings (back of upper leg), and quadriceps (front of upper leg) can also occur. More rarely, fractures to the upper spine, ankle, and lower leg have been reported.¹⁻³

Acute injuries commonly attributed to the squat include:

- Ruptures, tears, strains to leg, knee, hip, groin, back
- Knee sprains
- Herniated disc (back)

Overuse injuries and chronic conditions include:

- Knee, hip, low back pain
- Tendinopathy (hip)
- Bone damage (stress fractures, arthropathy)



Why do squat injuries concern the Army?

Strength training, an important element of a Soldiers' fitness program, involves the use of resistance from the body, machines, bands, or free weights.⁶ Use of free weights on a barbell is a common powerlift squat technique. Though not required by the Army, doctrine⁷ suggests various versions of the squat as a means to improve performance on the dead lift event of the Army Combat Fitness Test (ACFT).

Variations include leg width, the depth buttocks are lowered, and the type and weight of equipment used. To reduce injury risk, Army doctrine advises developing technique prior to adding weights. For example, begin squat training with no weights, a light pole such as a plastic polyvinyl chloride (PVC) pipe, a broom handle, or an empty barbell (approximately 45 pounds). Though certified personal instruction is best to ensure proper form, general guidelines may help reduce risks.

The knee and low back are the most frequently injured body regions among Soldiers.^{8,9} These injuries can require weeks of physical restriction and costly treatment. Though running and foot marching cause about half of the injuries, WT is the third leading cause (5 to 10% of injuries).⁹⁻¹¹ The growing popularity of WT may increase these injuries.



Using a squat rack in place of a spotter; Photo courtesy of APHC

How are squat injuries caused?

During the squat, you place a barbell across the back of your shoulders, crouch into a sitting position with knees bent, and then return to a standing position. Injuries appear to result primarily from a combination of improper form and use of heavy weights. Leaning forward, overarched your back, or allowing your knees to go beyond your toes can place excessive force on the back and knees.¹⁻³ Heavy weights can put tremendous pressure on the quadriceps muscles—fatigue while controlling or lifting these weights can result in leg muscle ruptures or tears.¹ Unless proper form is used, deep squats (when thighs go lower than parallel to the floor) may cause more acute knee sprains and tendinopathy (overuse injury).¹⁻³ Activities such as the squat cause small tears in MSK tissue that must be repaired and remodeled to build strength. Overuse injuries occur when the body has inadequate time to repair this damage.⁵ This results from excessive frequency, duration, weights, and other factors (see below).⁵⁻⁷

What can increase your risk of squat injuries?

Though quantitative evidence is very limited, some observational and descriptive studies¹⁻³ suggest the following may predispose Soldiers to squat injury:

- Inappropriate training principles: Insufficient warm-up, lack of a knowledgeable and physically capable spotter, excessive repetitions/weight.
- Improper technique: Uncontrolled movements, direction of feet not aligned with the knees, knees too far forward or depth too low, bouncing at the bottom of the squat.
- Muscle fatigue: Tends to shorten joint movement reducing the efficiency of the body's movement.
- Imbalanced training: Over-training and building major muscle groups (e.g., quadriceps, glutes, and hamstrings) while under-training stabilizing muscles (e.g., abdominals, erector spinae) can cause spinal instability.
- Anabolic steroid use: Building muscle power beyond the tendon capacity increases susceptibility to tears.
- Equipment: Back and knee braces have not been shown to prevent new WT injuries and may even increase risk.⁴

How can squat injuries be prevented?

Because there are many individual variables associated with weight lifting (e.g., experience, training goals, body build, and prior injuries), there is no single perfect technique or training program that best suits everyone. Additionally, evidence supporting the effectiveness of specific procedures to avoid squat injuries is limited. While general best practices for preventing injuries recommended by medical and fitness professionals are provided below, individuals using free weights are advised to consult with an Army Master Fitness Trainer or Certified Fitness Trainer** for individualized training guidelines and program design.

Guidelines to Avoid Squat Injury

1. Warm-up. At the start of your workout, complete 10 minutes of light cardio and/or dynamic stretches to increase your blood flow and warm up joints. Also incorporate movements similar to the exercises in the planned training session, so complete 1-2 sets of squats with light weights before your training sets.

2. Use safety bars.

Most squat racks come with safety bars on the side that act as “spotters” to prevent the barbell from dropping on you if you are unable to lift the weight back to the starting position. Adjust the safety bars to an appropriate height based on how low you squat. Before setting the safety bars and loading the barbell, complete a few body weight repetitions to determine the appropriate height for the safety bars.

Photo courtesy of APHC



3. Select an appropriate weight. To reduce the risk of injury, begin squat training with no weights, a light bar (e.g., broom stick handle, PVC pipe), or if you are fit an empty barbell (approximately 45 pounds) to develop your squat technique prior to adding weights. When you have developed good form, choose a training weight that you are safely able to lift for the desired number of repetitions and sets. The number of “reps” in each set typically ranges from 6 to 12; the number of “sets” is typically 2 or 3. Use moderate weights with more reps (10 to 12) and sets (3) to improve muscle endurance. Use fewer reps (6 to 8) and sets (2) with heavier weights to increase muscle size and power. Gradually increase weights over time while maintaining good form (e.g., increase weight by 10% once you can safely complete your sets). Always remember the risk of overuse injury from repeated stress on the knees and back from squats and other WT lifts (such as the deadlift) over time.

4. Secure weight on the bar with weight clips or collars. A slight tilt or imbalance from a slipping weight can cause injury, so it is important that the weight plates remain in place. Use clips/collars to prevent weight plates from shifting or slipping off the bar during a lift. These are required by most fitness facilities.

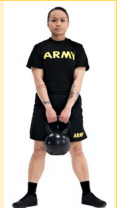
5. Ensure proper technique. There are many variations of the squat using different squat depth, stance width, and barbell position. Some of these variations can increase injury risk but may be recommended for certain people. To determine your best form and technique, obtain face-to-face instruction from a qualified personal trainer.** Some general squat recommendations include:

- Discuss training set with spotter or set up squat rack at the right height for you.
- Stand with feet shoulder-width apart, toes aligned with knees, and activate your abdominal muscles.
- Inhale while slowly sitting back into buttocks, sinking weight back into heels, until thighs are parallel to floor.
- Keep knees from going past the toes and maintain a straight back with eyes on horizon (do not look down).
- Do not bounce at the bottom of the squat – slowly exhale and stand without locking knees at top. Repeat.

6. Allow for muscle recovery. Rest intervals between sets depend on training goals, but it is generally recommended to rest for at least 2–3 minutes between each set. Allow at least 48 hours between weight training sessions for any single muscle group such as those of the knees, hips, and back.

7. Use alternative equipment and/or exercises. Reducing or eliminating weights allows you to focus on good form with less injury risk. Slight adjustments to stance may help. Squats performed with just body weight, empty barbells, or PVC pipe can improve strength in gluteus and leg muscles while reducing injury risk. You can also use dumbbells or kettlebells, typically using lighter weight, and/or changing to a wider stance (sumo squat). Lunges and box step-ups, using just body weight or dumbbells, also work similar muscle groups.

Sumo squat with kettlebell ⁷



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** E.g., ACSM Certified Personal Trainer® (CPT), ACSM Certified Health Fitness SpecialistSM (HFS), ACSM Certified Group Exercise InstructorSM Certified Strength and Conditioning Specialist®, NSCA-Certified Personal Trainer® (NSCA-CPT), NSCA Tactical Strength and Conditioning-Facilitator (TSAC-F).
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