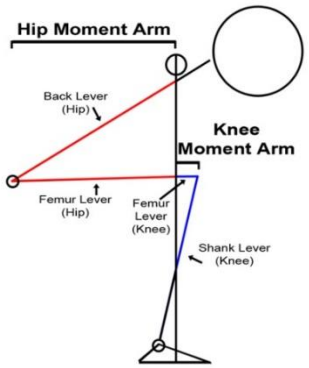
The science behind squatting

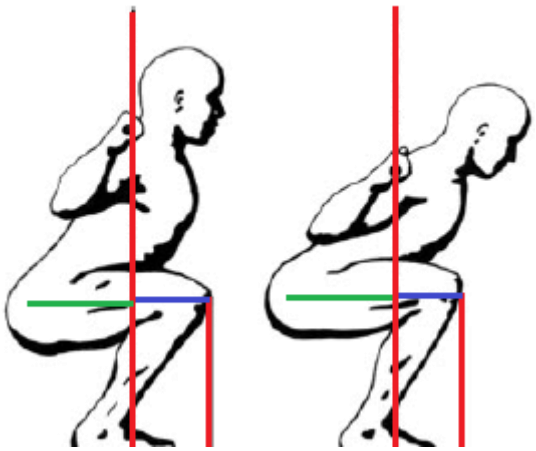


- Squat is a sagittal plane movement
- Triple extension
- Spinal muscles heavily activated
- We need to control abduction/adduction and rotation

The Squat

The back squat is one of the most versatile exercises performed in athletics. The squat is utilized in a wide variety of environments ranging from clinical rehabilitation to formal strength and conditioning to competitive powerlifting.

In competitive powerlifting, it is important to understand that powerlifting rules and guidelines are not based on optimal human mechanics but instead are founded on subjective visual criteria for judging the squat in powerlifting competitions. Many powerlifting organizations require depth that may be considered excessive range of motion. At NorCal Powerlifting, our criteria for a successful powerlifting squat are as close to ideal squat depth with respect to optimal human mechanics. So, what is the optimal squat form for powerlifting? Below I will highlight different components to the squat that I believe should be considered.



High Bar **Low Bar**

How deeply should we squat?

There are varying depths that a squat can be performed -- a partial squat (knee flexion angle of about 40°), sports squat (knee flexion angle of 70 to 100°), and a deep squat (knee flexion angle greater than 100°). When examining joint angles in relation to each other, in a parallel squat (femur parallel to the floor) the knee is roughly 100 to 110^{o} while a 90^{o} squat ends up being above parallel. That said, a proper squat is somewhere between 90^{o} and parallel for the athletic population and roughly 100-110^{o} for a successful lift in NorCal Powerlifting. Basically, the femur must be, at a minimum, parallel to the floor for the lift to be considered “good”.

To summarize, you should consider the demands you are placing on your body when considering squat depth. An individual without any pathology in the hip/knee/ankle may benefit from squatting through their full available range of motion, but this may exacerbate symptoms for individuals with patellofemoral dysfunction, cartilage compromise, or hip/ankle impingement.

Bar Placement

The back squat includes the high and low bar squats. Both back squat positions include forward trunk lean with less anterior knee excursion and an increased moment arm in the hip joint which results in increased demand of the hip musculature. The low bar requires greater forward trunk lean which reduces patellofemoral compression and ACL strain. This more closely mimics the “glute dominant” squat that is more commonly instructed in powerlifting settings.

BAR POSITION

- **High bar squat**
  - Greater knee extensor torque and less hip extensor torque vs. low bar
- **Low bar squat**
  - Greater hip extensor torque and less knee extensor torque vs. high bar

SPINE: FUNCTIONAL ANATOMY

Gliding joint – multiple joints that interact with one another

- 24 vertebrae – 7 cervical, 12 thoracic, 5 lumbar
- Bottom portions consist of sacrum (5 fused vertebra) and coccyx (4 fused vertebrae-tail)
- Vertebrae small on top and gets progressively bigger on bottom
- The spine is susceptible to injury. Thoracic are kyphotic/lumbar are lordotic so they balance each other out

SPINAL FORCES DURING SQUATTING

- Squatting with flexed lumbar spine decreases the moment arm for the lumbar erector spinae muscles, reduces tolerance to compressive load, and results in a transfer of the load from muscles to passive tissues, heightening the risk of disc herniation
- Squatting with 2 degrees increase in extension from neutral position heightens compressive forces in the posterior annulus
- Proper squat technique requires a rigid spine that eliminates any planar motion

SPINAL MUSCULATURE DURING SQUATTING

- The lumbar erector spinae (e.g., iliocostalis, lumborum, etc.) are particularly important during the squat as they help to resist vertebral shear and maintain anteroposterior spinal integrity, providing the greatest contribution to spinal stabilization. Weak erectors can limit squat strength.
- The back squat involves significant static recruitment of the anterior core musculature
- Greater rectus abdominis activity than the traditional plank

SPINE FUNCTION DURING SQUATTING

- Thoracic Position:

Correct thoracic positioning ensures a lifter has the ability to tightly retract the shoulder blades and hold the chest up and open throughout the squat movement to promote ideal thoracic spine support.

- Trunk Position:

Trunk position is primarily focused on not having excessive trunk flexion and/or rounding(kyphosis) of the lumbar spine.

FOOT PLACEMENT

- **Narrow stance** (87 to 118% of shoulder width)
  - Greater gastroc activity
  - Increases forward knee translation resulting in increased knee torque
- **Wide Stance** (158 to 196% of shoulder width)
  - Greater gluteus maximus, hamstring and adductor activity
  - Increases hip compression forces
- **Foot position** (hip/tibial rotation)
  - Greater adductor activation
  - Knees should track in line with toes

HIP JOINT: FUNCTIONAL ANATOMY

- Ball and socket joint
- Freely mobile in all three planes of movement
  - Flexion and extension in the sagittal plane
  - Abduction and adduction in the frontal plane
  - Internal/External rotation and horizontal abduction/adduction in the transverse plane

HIP TORQUE DURING SQUATTING

- Hip torque increases in conjunction w/increases in hip flexion
- Maximal torque occurs near the bottom phase of movement
- Forward lean is positively correlated with increased forces about the hip joint

HIP MUSCULATURE DURING SQUATTING

- Activity of the gluteus maximus exhibits a positive relationship with squat depth
- Hamstrings active during the squat and relatively unaffected by squat depth

DEEP SQUATS: CONTRAINDICATIONS

- Greatest risk of injury is to knee menisci and associated articular cartilage
- Under increased stress at high flexion angles due to greater compression
- May increase susceptibility to patellofemoral degeneration due to stress from contact of underside of the patella with articulating aspect of femur
- Essential to consider an individual's pathologic condition in determining optimal squat depth

HIP FUNCTION DURING SQUATTING

- Hip Position: The hip position criterion focuses on the frontal plane position of the hips.
- Knee Position: Anterior knee excursion allows for a more upright trunk position, inducing less torque at the hip and shear forces at the lumbar spine, but results in increased knee torque.

KNEE PLACEMENT

ANKLE JOINT; FUNCTIONAL ANATOMY

- The ankle is comprised of the talocrural and talocalcaneal joints
- During the squat, the talocrural joint facilitates movement through the actions of dorsi flexion and plantar flexion while the primary action at the subtalar is to maintain postural stability and limit eversion/inversion at the foot.

KNEES OVER TOES

Fry, et al. had 7 recreationally trained males perform three unrestricted squat lifts and three restricted lifts where a wooden dowel was placed immediately in front of both feet so that the knees were prevented from moving forward past the toes

- Knee torque increased in the unrestricted squat
- Hip torque was increased during restricted squatting
- Greater forward lean in restricted squats result in increased shear forces at the lumbar spine

ANKLE/FEET FUNCTION DURING SQUATTING

Ankle Position:

Forward tibial translation must be targeted with the hip.

Foot Position:

Keeping your entire foot grounded, with the big toe down and pressure exerted toward the lateral aspect of the foot, should be done throughout the squat.

GAZE

- Downward gaze has been shown to increase trunk flexion by 4.5 degrees and hip flexion by approximately 8 degrees compared to a straight ahead or upward gaze
- Given that excessive trunk and hip flexion can place excessive torque on the vertebral column, this suggests it is beneficial to maintain either a straight head or upward gaze during the squat

NECK FUNCTION DURING SQUATTING

Head Position:

Neck strength, stability and physiological range of motion are essential to provide support to the cervical vertebrae.

Take Home Points

Consider the individual, specific tasks, and environmental factors as these are important to determine squat prescription prior to labelling movements and positions for “the optimal squat.”