Deep Squats

By

Jason Shea PICP III, MS, C.S.C.S,

A#$ to the grass. Below parallel. Hamstrings resting on calves. All synonymous with deep squatting. A study performed by Caterisano et al 2002 provides valuable insight into squat depth and muscle activation. In this study, the researchers found glute activation during full squats to be greater than twice that of partial squats (35.4% compared to 16.9%), hamstring activation to be similar, while quadriceps activation dominated during the partial squats only. Understanding that the glutes and hamstrings (and to some extent the adductors) are the primary hip extensors during sprinting/accelerating, the take home message from this and other studies (Robertson et al 2008), could completely change the way athlete's prepare for and perform on the field..

From his book Strong Enough, Dr. Mark Rippetoe states "the fundamental misunderstanding here is about what we're trying to accomplish when we squat. The quadriceps are not the only muscles that are supposed to be involved in the exercise. The hamstring muscles on the back of the thigh attach at the front of the tibia, at the bottom of the knee, wrap around it on both sides and pull back on the knee from below it as they get tight. The adductors connect the groin area of the pelvis to the medial (inside) aspect of the femur, and these muscles also pull back on the knee when they tighten, but from above the knee and toward the inside. Both of these muscle groups tighten from behind the knee as the torso leans forward, the knees travel out to stay parallel to the feet, and the hips reach back of correct depth, balancing the forward pulling stress from the quadriceps and the patellar tendon around the front of the knee. But they only exert this balancing pull ***when they are stretched***, in the full squat position (6)."

"At the bottom of the squat, where the hamstrings and adductors are fully stretched, there is as much pull on the knee from the posterior as form the anterior. In this position, the quadriceps' knee extension force is balanced by the hamstrings' knee flexion force. At the same time, the adductors have stretched too, and if the knees stay parallel to the feet, as they should, the adductors will get tight and pull on the femurs. This "knee out" position anchors the femur so that adductor contractions and hamstring contractions produce hip extension, which is apparent when sore adductors show up the day after a heavy squat workout (6)."

"Because the hamstrings attach to the pelvis at the ischial tuberosity, any forward tilting of the top of the pelvis will stretch the hamstrings away from their insertion points at the knees. When the pelvis and the back are properly locked in a flat rigid unit by the back muscles, the forward angle of the torso and pelvis tightens up the hamstrings. At the same time, if the knees are shoved out to the sides at the bottom of the squat, the adductors are tightened. If this is done correctly, there is a slight "bounce" or muscular rebound off the hamstrings and adductors at the bottom of the squat, which initiates the upward drive out of the hole. This hip extension is accomplished much more efficiently and much, much more safely for the knee when it occurs from this correct position- ***the position that cannot be achieved unless the squat is deep (6)***."

With regard to half squats, Rippetoe goes on to state "the only muscles under any stress are the quads, since the hamstrings, glutes, and adductors are not involved due to the limited range of motion. The spine is invariably loaded too heavily, since it is incredibly easy to "squat" big weights if you only have to move them a few inches. The knees are disproportionately subjected to anterior stress, since the lack of depth does not engage the hamstrings and activate their posterior balancing effect. The lower back muscles, used in the full squat to maintain spinal alignment and the back and pelvis angle, get little work in the half squat because it is not deep enough to ever put the low back at much of an angle (6)."

In their study examining squat depth and lower extremity muscle function Robertson et al showed similar findings. "During the ascent phase, the hip extensor moments of force produced the largest powers followed by the ankle plantar flexors and then the knee extensors. The hip and knee extensors provided the initial bursts of power during ascent with the ankle extensors and especially a second burst from the hip extensors adding power during the latter half of the ascent (7)."

So where did the myths about half squats being better for the knees come from? Starr states “In the early sixties, Dr. Karl Klein of the University of Texas, published a piece of research which concluded that full squats loosened the knee joint and, therefore, the exercise was harmful to the knees, especially to those engaged in contact sports such as football. As a result, coaches across the nation forbid their players from doing full squats. Some states, such a New Jersey, even outlawed full squats in secondary schools. If coaches allowed their athletes to squat at all, they only gave the OK to half or quarter squat (8).”

“Dr. Klein tested a group of 128 competitive weightlifters who had done full squats against 360 college students who had no such experience. He concluded that the weightlifting group had unstable collateral and anterior cruciate ligaments as a result of the squatting and advised against performing the full range movement (8).”

“Dr. Klein used an aluminum gadget for his test which covered the upper and lower leg much like a leg cast. He exerted pressure from each side of the knee and took a reading on a dial similar to a blood pressure gauge. Dr. Klein always inquired whether the subject did full squats before he conducted the test (8).” Below is the study.

- Klein K. **The deep squat exercise as utilized in weight training for athletes and its effects on the ligaments of the knee**. *J Assoc Phys Ment Rehabil*. 15; Pp 6-11. 1961.

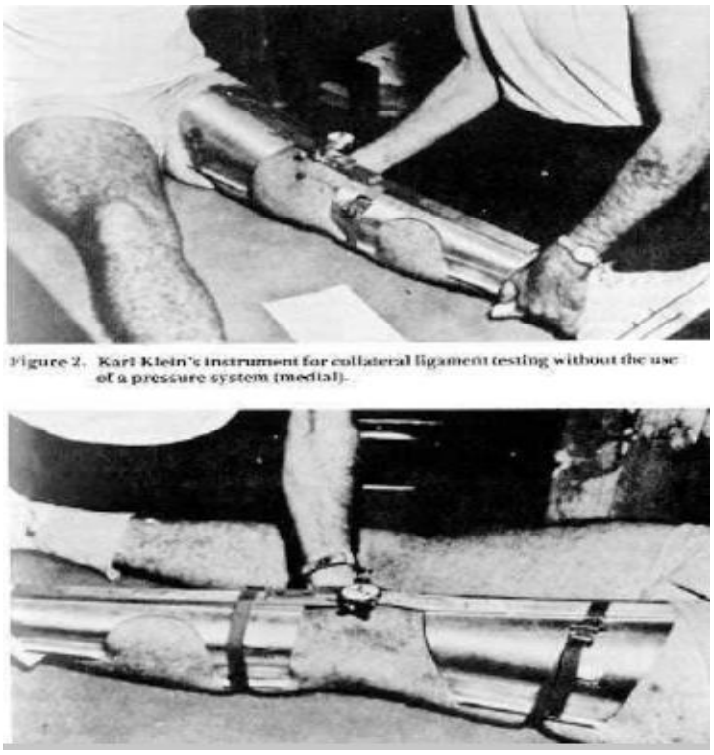

Figure 2. Karl Klein's instrument for collateral ligament testing without the use of a pressure system (medial).

The device created by Dr. Klein to measure collateral ligament laxity. Not to be confused with a certain $6 million dollar surgery performed by the Office of Scientific Intelligence circa 1973. "We can rebuild him…….we have the technology."

Starr had disputes on two main objections. "One, the applying of the pressure was far too subjective. The tester could push harder and harder on the knee joint and secure a pre-determined reading. Many athletes complained that the tester actually hurt their knees because he pushed so hard. Did he push equally hard on each subject? Two, the tester always had the subject classified as a squatter or non-squatter before he tested him, rather than after. This certainly gave the tester the opportunity to have a built in prejudice and eliminate the testing procedure form the pure, controlled category (8)."

"By applying the same testing procedure, another researcher, with an eye to reversing the findings, could quite easily do so. A pure piece of research should not have this wide margin of testing subjectivity unless it is specifically spelled out in the conclusion, which it definitely was not in this case (8)."

With regard to this controversial study, Rippetoe goes on to state "Dr. Karl Klein's study at the University of Texas in 1961, a poorly designed and badly conducted mess that has never been replicated and has been successfully rebutted many times. Klein concluded that below parallel squats produced "loose" knees, although no other training protocol was evaluated for comparison, no other tester administered the measurements, and all the data was biased by pre-test questioning of the subjects (6)."

Other studies have disproven Klein's findings as well. For instance, 10 years after Klein's study, Meyers et al reproduced the study using the same mediolateral collateral ligament testing instrument to measure collateral ligament stability with completely different findings. In this 8 week study, sixty-nine subjects were randomly assigned different groups involving variations of the deep and parallel squat. The researchers found no significant differences in collateral ligament instability and knee joint flexibility within any of the treatment groups. Contradictory to Klein's oft-referred study, the study by Meyers et al found that **both the deep squat** and parallel squat **were not detrimental to knee stability (4)**. Other studies have shown similar findings:

1. Steiner M, Grana W, Chilag K, Schelberg-Karnes E. **The effect of exercise on anterior-posterior knee laxity.** *American Journal of Sports Medicine.* 14(1); Pp 24-29. 1986.

   Study compared the post exercise knee laxity of Squat Powerlifters to college basketball players and 10km recreational runners. The researchers found "basketball players and distance runners experienced a transient increase in anterior and posterior laxity during exercise, whereas the Squat powerlifters did not demonstrate a significant change in laxity ()."

   From this the researchers concluded that "repetitive physiologic stresses as a high strain rate produce significant ligamentous laxity, while a relatively few large stresses a low strain rate do not ()."

2. Chandler T, Wilson G, Stone M. The **effect of the squat exercise on knee stability.** *Med Sci Sports Exerc.* 21(3). Pp 299-303. 1989.

   Knee stability of weightlifter and powerlifters was compared to that of 100 college student subjects. Over 8 weeks the researchers found the powerlifters to be "significantly tighter than

the controls on the anterior drawer at 90 degrees of knee flexion. Also, both the powerlifters and weightlifters were significantly tighter than the controls on the quadriceps active drawer at 90 degrees of knee flexion."

3. Panariello R, Backus S, Parker J. **The effect of the squat exercise on anterior-posterior knee translation in professional football players.** *American Journal of Sports Medicine*. 22(6); Pp 768-773. 1994

   32 healthy subjects participated in a 21 week off-season training program utilizing squats at 130%-200% body weight 2X/week. The researchers concluded "no significant increases in anterior-posterior tibiofemoral translation occurred in athletes using the squat exercise as a part of their off-season training program ()."

Contradictory to popular belief, research clearly shows that properly executed deep squats (for those with good lower extremity health) do not increase knee laxity/instability, but can actually increase muscle recruitment, which can lead to increased performance on the field. So, if deep squats don't cause knee instability than who could be the culprits. A study by Johannsen et al (1989) may have found one of the culprits.

Johannsen H, Lind T, Jakobsen B, Kroner K. **Exercise-induced knee joint laxity in distance runners.** *British Journal of Sports Medicine*. 23(3); Pp 165-168. 1989

20 recreational long distance runners had their knee laxity tested before and after running. The researchers found an 18 percent increase in total anterior-posterior post-exercise laxity during the eccentric quadriceps activity. They conclude that "the laxity increase is caused in part by a true ligamentous laxity increase and in part by a decreased resting tone of the fatigued muscles ()."

In conclusion, Starr points out the immense benefits of deep squatting by stating "it is equally recognized that full range movements build more strength in the muscles and tendons simply because more fibers become involved. It logically follows that full squats work more muscles than do half squats, just as a full range curling motion brings into play more muscles of the upper arm than does a partial curling movement (3)."

REFERENCES

1. Caterisano A, Moss R, Pellinger T, Woodruff K, Lewis V, Booth W, Khadra T. **The effect of back squat depth on the EMG activity of 4 superficial hip and thigh muscles.** *Journal of Strength and Conditioning Research.* 16(3); Pp 428-432. 2002

2. Chandler T, Wilson G, Stone M. The **effect of the squat exercise on knee stability.** *Med Sci Sports Exerc.* 21(3). Pp 299-303. 1989.

3. Johannsen H, Lind T, Jakobsen B, Kroner K. **Exercise-induced knee joint laxity in distance runners.** *British Journal of Sports Medicine*. 23(3); Pp 165-168. 1989

4. Meyers E. Effect **of selected exercise variables on ligament stability and flexibility of the knee.** *Research Q*. 42(4); Pp 411-422. 1971

5. Panariello R, Backus S, Parker J. **The effect of the squat exercise on anterior-posterior knee translation in professional football players.** *American Journal of Sports Medicine*. 22(6); Pp 768-773. 1994

6. Rippetoe M. *Strong Enough: Thoughts from thirty years of barbell training.* Pp. 66-69. The Aasgarard Company, Wichita Falls TX. 2007

7. Robertson D, Wilson J, St Pierre T. **Lower extremity muscle functions during full squats.** *Journal of Applied Biomechanics*. 24(4); Pp 333-339. 2008

8. Starr B. *The Strongest Shall Survive: Strength training for football.* Pp 39-40. Fredericksburg, Va. 1976, 2003.

9. Steiner M, Grana W, Chilag K, Schelberg-Karnes E. **The effect of exercise on anterior-posterior knee laxity.** *American Journal of Sports Medicine.* 14(1); Pp 24-29. 1986.