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Low-Bar vs. High-Bar Squats

Mark Rippetoe

I learned to squat a long time ago. It was 1977, and I had just been in a little altercation that convinced me that I might need to be in a little better shape than I was. I was an Early Adopter of soccer in high school (Texas, 1973-74, nobody knew what the hell we were doing, we had to buy the balls through the mail, football coaches thought we were girls, our soccer coach didn't know what he was doing, etc.) and had continued playing intramural in college. I was in decent "shape" in the sense that I wasn't fat, but considering myself then with 30 years of experience now, I can understand why I decided I need to train. I was a *soccer player*, for God's sake. I was not very strong. And although my little brush with violence had left me mostly intact, I was unhappy with the outcome. I decided the same thing young men have been deciding since there have been young men: I was going to get stronger.

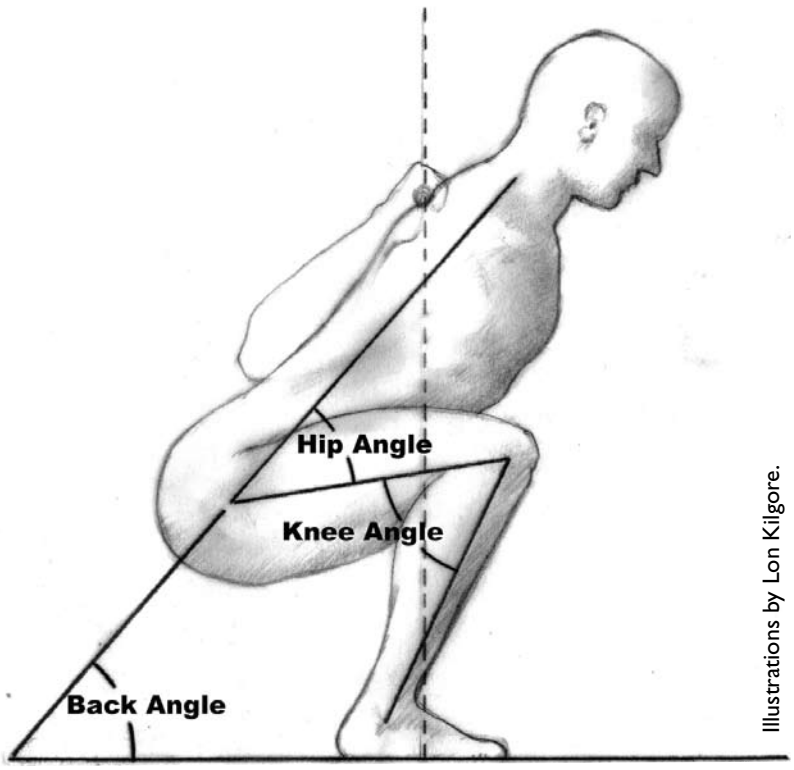

Figure 1. Relevant body angles for the squat.

A lack of strength had not been a major factor in the affair. The guy only hit me once—a sucker punch, really and actually—and I was not completely inexperienced in these matters. But I failed to whip his ass, and failures of this type usually demand a response. Being a relatively civilized individual, my response was not to drive by and shoot him, as the pussies of today seem prone to do. It was to begin a systematic overhaul of the person responsible for my failure to whip his ass: me. And usually these types of overhauls involve a realization that you're not as strong as a guy ought to be. Such epiphanies have for many decades been an important part of the gym business.

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So I wandered into the area that passed for the gym at Midwestern University with the idea that I'd lift some weights and get stronger. It was up two sets of stairs on the second floor of the PE building, the facility that housed the basketball coliseum, and it consisted of two small, dirty rooms that were obviously on page three of the two-page maintenance list. They were the kind of rooms you see in schools that appear to hold all the pipes for the other rooms in the building. The MU weight room was open just a few hours a day, maybe four, and was "supervised" as an afterthought by the intramural staff located downstairs on the other side of the building. This was actually fortunate, since they didn't know any more about this than I did, and their advice would not have been helpful. Their primary function was to make sure the weight room was locked at least three hours before all home basketball games—for no apparent reason, since the ticket gates were also on the other side of the building, all the students could go free anyway, and capacity crowds had never exactly been a problem for the MU Indians. But it was air conditioned, a little anyway, in stark contrast to the downtown Y, and it was free with tuition. This was where I started training in 1977. I don't miss it at all.

This was also where I met my buddy Phil, who still trains with me today. We didn't have any classes together, just a common interest in training. And we drank a lot of beer together, since this is what college guys do. Phil was a lot like a dog in that he vomited in such a casual way. He'd be standing there by the bar talking to you in a perfectly normal tone of voice, excuse himself, and then turn his head and puke in the trash can. No drama, no retching, just a simple purging of the gut like I blow my nose. He claims that this was to keep from getting too drunk, but I didn't notice that it worked too well. We were both young and stupid, but we trained harder than most people, even before we knew what we were doing. We still do.

Phil and I started training together in the afternoon after class. He knew more about lifting weights than I did, having been in a big high school in San Antonio, having hung around in the weight room a little with the football players (he was actually a tennis player in high school, a pretty good one who had made it to the Texas state tournament in doubles), and probably having read a few muscle magazines, which I had not yet discovered. As a result, Phil had a general idea about what was supposed to happen in the weight room. But he really didn't know much, and he was limited in what he could teach me. I knew some bodyweight exercises, like dips, push-ups, sit-ups, and chins, which I would do at home or at work (I was actually a disc jockey on the weekends, when the radio station office was closed, and I sometimes did dips on the chairs between songs), but up until then my exercise had consisted primarily of running. We meant well, but so did Mussolini.

Everybody in the MU weight room was doing the Universal machine, an old-style Gladiator with five stations, and it was always busy. But there was an old York power rack in the second room of this silly little facility, and nobody was ever using it, so we messed around with the bar that was on it, doing half squats, presses, and curls. We managed to get sweaty and sore, kind of felt like we were getting something accomplished, and started going three or four days a week.

On one occasion there was an older guy there—obviously not a student, and probably from out of town—who seemed to know what he was doing. I had never seen him there before, and I never saw him again. This guy had a *book* he was consulting between sets, writing stuff down like an accountant. He had on a pair of lace-up 6-inch-high boots that had a strap across the instep. He carried a bag that contained some hand chalk, a belt of some sort, some sweats, and some straps that looked like they might be for his wrists. There was none of the purposeless wandering around that characterized my time spent in the weight room; this guy knew what was going to happen next. He was lean, hairy, muscular, and very serious. And he spent all his time in the room with the bar and rack.

I noticed the guy doing an exercise I'd never seen anybody else do. He took the bar out of the rack on his back and squatted *all the way down* and back up with it for several reps. He did this quite a few times, adding plates to the bar between each set. I walked around the room, trying to maintain low profile, curling, doing the occasional leg press when I could get on the machine, and watching from the other room as this older, more experienced guy did what was obviously a more serious version of weight room activity than I was familiar with.

Phil and I started trying to squat the way we'd seen him do it. It made us both stronger, and we eventually both competed in powerlifting for many years. We both deadlifted in the lower 600s several times, but I was a

better squatter at 611 than Phil's 589. The interesting thing is that when we copied that squat the first day we tried it, we both put the bar on top of our traps when we took it out of the rack. Phil still does it this way, and it took me years to figure out that I liked it better in the low-bar position, just below my scapular spine on top of my contracted posterior delts. But we weren't too different from most people about where we put the bar when they start squatting. It seemed to fit up there on the traps so securely, and it was the logical place for it on first inspection. And, really, it's probably where the hairy guy had it too, although at this point of rather extreme remove from the event, I don't remember exactly.

The fact is that most people want to squat with the bar on their traps and not down lower on the back, especially if they have had no one suggest otherwise. And that would be fine, except that it doesn't work as well.

Hip drive and the posterior chain

The back squat is literally the only exercise in the entire repertoire of weighted human movement that allows the direct training of the complex movement pattern known as *hip drive*. "Posterior chain" is a term that refers to the muscles that produce hip extension—i.e., straightening out of the hip joint from its flexed (or bent) position in the bottom of the squat. The muscles that accomplish hip extension are the hamstrings, the glutes, and the adductors or groin muscles, and together these are referred to as the posterior chain. The initial movement up out of the bottom of a full squat is hip drive, and is best thought of as a shoving-up of the sacral area of the lower back, the area right above your butt. This is the hardest thing to teach in my method of squatting, and by far the most important.

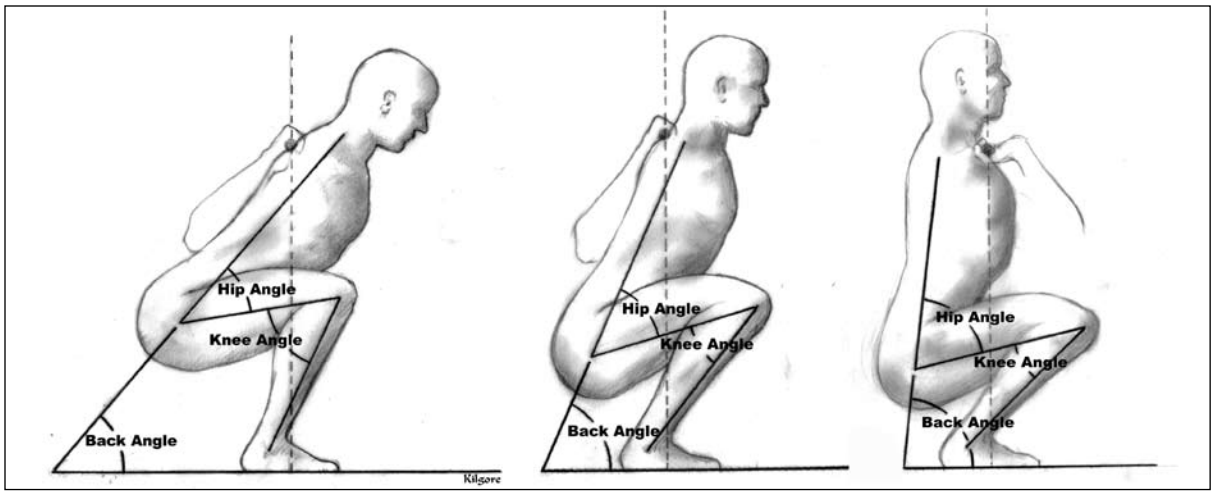
This is because the squat is the only exercise in the weight room that trains the recruitment of the entire posterior chain in a way that is progressively improvable, and that is one of the things that makes the squat the best exercise you can do with barbells and, by extension, the best strength exercise there is. These important muscles contribute to jumping, pulling, pushing, and anything else involving the lower body. The squat trains the posterior chain more effectively than any other movement that uses those muscles because none of the other movements involve enough range of motion to use them all at the same time, and none of them work this long range of motion by preceding their contraction with an eccentric lowering, which produces a stretch-shortening cycle or *stretch reflex*.

The stretch reflex produces a much harder contraction than would be possible without it, one that recruits many more motor units than would be available without the loaded pre-stretch provided by the lowering phase of the lift. The conventional deadlift, for example, uses the hamstrings and glutes, leaves out the adductors, and starts with a concentric contraction at a position that places the hips well above the level of a deep squat. No bounce, no adductors, shorter range of motion, but very hard anyway—harder, in fact, than squatting, due to the comparatively inefficient nature of starting from a dead stop—yet not as useful to overall strength development. Plyometric jumps may be deep enough if they're done that way, and they may employ the requisite stretch reflex provided by the drop, but they are not incrementally increasable the way a loaded barbell exercise can be, they can be damned tough on the feet and knees for novices, and they are not weight-bearing in the sense that the whole skeleton is loaded with a bar on the shoulders. In contrast, the squat uses all the posterior chain muscles, requires the full range of motion of the hips and knees, engages the stretch-shortening cycle inherent in the movement, and can be performed by anybody who can stand up from a chair, because we have very light bars that can be increased by very small increments.

Why bar position matters

But what earthly thing could the position of the bar on the back have to do with this? We know that the bar/lifter system will be in balance when the bar is directly over the middle of the foot, and the heavier the bar, the more precisely this position must be kept. We know this because everybody who has ever violated this particular squatting law has fallen over on either their ass or their face, unless the weight was very light. And even if the weight was light enough to do wrong, energy was being expended to keep the falling-over part from happening, energy that could otherwise have contributed to making the bar go up.

Now, if the bar is on the front of the shoulders as in the front squat, a very vertical back angle will be required if the bar is to be kept over the mid-foot, as Figure 2 illustrates. Notice the knee angle made necessary by this position: it is very acute. And notice the hip angle: it is way more open than it would be with a more horizontal back angle. In this position, the hamstrings are in a



Illustrations by Lon Kilgore.

Figure 2. Note the difference in body angles in low-bar, high-bar and front squats.

contracted position because their attachments at the pelvis (on the ischial tuberosity) and at the knee (on the tibial tuberosity) are as close together as they can be at the bottom of a squat, and nearly as close as they can get anyway. (The only way the hamstring can be in a shorter position is if you are standing up and you touch your heel to your butt.) In the bottom position of the front squat, then, the hamstrings can't really contract much more than they already have; they are functioning isometrically to hold up the torso in the nearly vertical position required of the front squat, but there is not enough contractile capacity left to contribute much to hip extension. To say it again, even more simply, the hamstrings are already fully contracted in the bottom of the front squat and can't contract much more. This leaves the glutes and adductors on their own to produce hip extension, and this is why your ass gets so sore when you front squat heavy: it's having to do all the work that the hamstrings normally help with pretty much all by itself, the poor little thing. You might notice Olympic lifters squeezing their knees closer together, sometimes repeatedly, on the way up out of a limit squat clean. This is an attempt (maybe conscious, maybe not) to use their adductors to help with hip extension, since the hamstrings can't.

The upshot of this is that the drive out of the bottom of the front squat essentially leaves out the hamstrings, and we'd like to use them when we squat so that we can get them strong. So this makes the front squat a poor choice for training the posterior chain. The squat form we'd have to use to recruit the most hamstring would be a style that produces a more acute hip angle, so the hamstrings would be placed in a stretched-out position at the bottom to contribute the most they could to the hip extension. This means that we need to use a form with a much more horizontal back angle, since the back angle largely determines the hip angle, and that means that the bar must be placed in a position on the back where the bar will be over the middle of the foot at that more horizontal back angle. This means the bar should be in the lowest secure position it can get on the back, right below the spine of the scapula—that bump on your shoulder blade you can feel when you reach across and touch the back of your shoulder. And if the adductors got their share of the work too, that would be nice; a moderate stance of shoulder-width heels with toes pointing out about 30 degrees makes the femurs stretch out the groin muscles as the hips are lowered, and if the muscles are stretched out they are in the position they must be in to contract and contribute force to the hip extension. This position is what we refer to as the low-bar squat.

This is not the same form used by powerlifters, who are trying to use absolutely as much hip-angle acuity as they can get for another reason entirely: they are trying to get the most out of their squat suit, an expensive, very tight singlet that is designed to resist hip flexion and store elastic energy in the eccentric phase, and therefore aid hip extension. To this end they use a very wide stance that moves the thighs out of the way of the belly and permits a really horizontal back angle, and as vertical a shin position as they can obtain. Vertical shins open the knee angle and close the hip angle, thus minimizing quadriceps involvement and permitting the more effective use of the suit/hip extension. Knee wraps are

additionally used, to resist knee flexion and, like the squat suit, store elastic energy during the eccentric phase. Our stance is not nearly as wide, a position which permits more forward travel of the knee and more use of the quadriceps. In fact, every aspect of the technique used in this type of squat maximizes the amount of muscle and the range of motion used in the exercise.

If the bar is placed high on the back—on top of the traps, where Phil still carries it and where most people start off carrying it because it's easier and more obviously a nice place for a bar—the back angle must accommodate the higher position by becoming more vertical to keep the bar over the mid-foot. But that's not all that changes: the hip angle must become more open if the back angle is more vertical, and the knee angle must become more acute if the hip angle is more open, because the knees get shoved forward when the hip opens up (Figure 2 again). In other words, the high-bar squat makes the back squat more like the front squat, and we don't want to front squat for general strength because it leaves out the hamstrings.

Lots of people will defend the use of the high-bar position, often known as the Olympic squat because it is usually the style used by Olympic weightlifters. They will say that it's more like the front squat part of the clean, so it is better for strengthening the clean. But they're already doing front squats anyway, both as an assistance exercise and every time they clean (not to mention overhead squats they do every time they snatch, which have physiological mechanics similar to the front squat). The high-bar squat is a stronger squat than a front squat, but not as strong as a low-bar squat, because the more horizontal back angle means that more muscle gets used. I think many Olympic lifters do high-bar squats mainly because Tommy Kono did them that way. But as great an athlete as Kono was, that is not really a reason to do them. In fact, the vast, overwhelming majority of the strongest weightlifters in the world squat with the bar on their traps, because that's the way it's been done throughout the history of the sport of Olympic weightlifting, but that is also no reason to do them that way. That's actually not *reasoning* at all.

Nuts and bolts

In contrast, let's try to *think* our way through this material, at least to the point at which boredom limits our attention span (you may already be there). One line of reasoning that can be applied to this analysis is the consideration of lever arms, and the relationship of leverage to back position. A lever arm (or moment arm) is the distance between a point of rotation and the point at which the force to rotate it is applied. It is the distance between your hand on the handle of a wrench and the nut you're trying to turn at the business end of the wrench (Figure 3). In our squat model, there are two ways to think about lever arms and their relationship to the bar/lifter system: first, the distance between the bar and the hip—the horizontal distance along which the force of the bar acts on the hip—and, second, the distance between the hip and the bar along the length of the back.

Now, before those of you enrolled this semester in Mechanics 2743 have a chance to point this out, I am aware that the length of a lever arm is in fact measured only at 90 degrees to the point of rotation. If the bar is sitting on the shoulders directly above the hips, the force is all compression and the lever arm length is zero, no matter how tall you are or how long your back is; if the bar is on the shoulders and the back is horizontal, as in a good morning, rotational force against the hips is as high as it can be, and the length of the lever arm is the whole distance between the bar and the hips along the back.

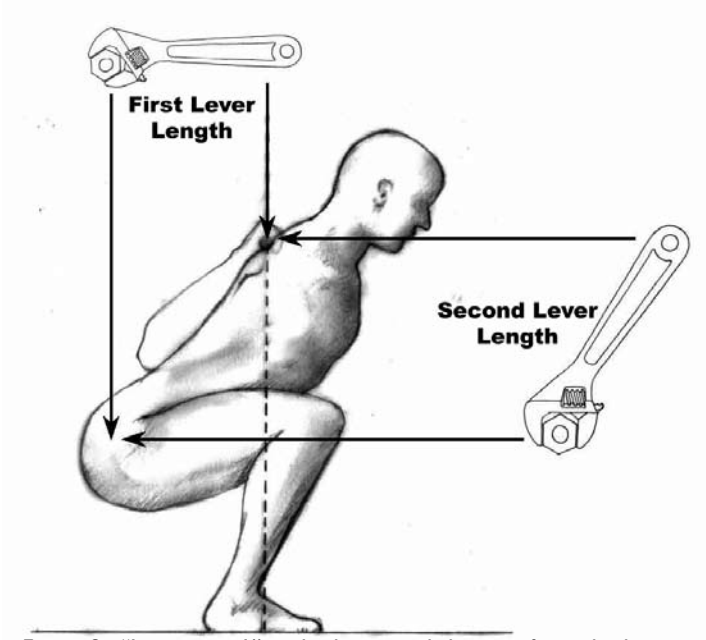


Figure 3. "Lever arm 1" is the horizontal distance from the bar to the hip. "Lever arm 2" is the distance between the bar and the hip along the back.

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Which means that the only lever arm in this system is really the horizontal distance between the hip and the bar, our first example. But the thing we're calling the "second lever arm," the distance along the back from the bar to the sacrum, is very useful for illustrating the potential for the first lever arm, the real one, to get longer or shorter with a change in back angle.

The back squat is the only exercise in the weight room that trains the recruitment of the entire posterior chain in a way that is progressively improvable, and that is one of the things that makes the squat the best exercise you can do with barbells and, by extension, the best strength exercise there is.

The back angle is maintained by the hip extensors—a.k.a. the posterior chain. And the net effect of maintaining the back angle is to keep the bar directly over the middle of the foot where the system is in balance. A vertical back, necessary for a proper front squat, reduces the first lever arm to about zero. But the length of the "second lever arm," the one between the bar and the hip along the back, makes keeping the first lever arm short potentially a lot of work. All of the little perturbations and wiggles that normally occur during a squat make the effects of a long back significant.

The effects of the two are interrelated, and they can be better understood by looking at people of different anthropometry: a guy with a short back relative to his legs will have a shorter "second lever arm" at any back angle than someone with a long back and short legs, and will have an advantage there because this translates into a shorter first lever arm. But since his legs are longer he won't be able to maintain as vertical a back angle, and therefore he will have a longer first lever arm. The opposite case, a gal with a long torso and short legs, will have a short first lever arm due to the fact that short legs and a long back produce a more vertical back angle, and this vertical back is easier to maintain due to this short lever. For a short-torso guy, lots of back work occurs every time he squats due to his more horizontal back angle and longer first lever arm. For her, since there is not as much back work involved in holding her more vertical position, deadlifts become very important to strengthen the back against the inevitable loss of good position inherent in doing heavy squats. His back always has to work hard to maintain his less-than-perfect position, while her job is easy until she gets out of her normal vertical position, at which time it becomes harder than his. There is a potentially very long wrench against her hips.

It is a significant observation that most record squats have been done with the bar in the low-back position. Those of us who are not competitive powerlifters are not particularly concerned with how much absolute weight we can squat; we are trying, rather, to see how strong we can get using the squat. But it is still relevant that more weight can be lifted in the low-bar position; the more weight we squat, the more force we must produce using all the involved muscle mass to produce it, and the stronger we get. In addition, the peripheral effects of moving heavier weights are important to long-term performance adaptation. Bone density, tendon and ligament integrity, hormone response, and the psychological aspects of handling heavier rather than lighter weights all make low-bar squats the best way to squat for the general purpose of getting strong.

The conventional wisdom holds that a more vertical torso is better for both squats and deadlifts. (The conventional wisdom, being very conventional after all, does not much concern itself with cleans and snatches, but they are often taught this way too.) The supposed primary benefit of a vertical torso is a reduction in shear force on the spine. *Shear* is the sliding-across force applied to the back at non-vertical angles, and increases with horizontality. *Shearing* would be the sliding movement between adjacent vertebrae if the back muscles were to fail in their job of holding them in position. The rigidity of the spinal column is maintained by the erectors and trunk muscles in isometric contraction, and the back angle is maintained by the hip extensors. If the trunk muscles and erectors do their anatomically correct and important job of preventing intervertebral movement (i.e., any change in the spatial relationship between each

of the vertebrae) shearing cannot take place. So, when *shear force* is successfully overcome by the trunk muscles, *shearing* does not take place.

(Actually, really and truly, if the back muscles were to fail to do their job, shearing does not take place—rotation does: when the back rounds during a squat or pull, the intervertebral movement, because of the ligamentous support between the vertebral bodies, occurs as rotation. The intervertebral space opens in the back and closes in the front, and the net movement has occurred around the center of the disc space. Actual shearing will take place only if there is a spondylolisthesis, or if you have a bad car wreck with your wonderful seat belt on.)

So the maintenance of intervertebral stability is the job of the trunk musculature, and heavy squats and deadlifts are effective back muscle exercises because no other exercises, and certainly none done on machines, can duplicate this function. The conventional exercise certification industry's call for more verticality in squat and deadlift technique ignores this fact. And this is why the stress on the back produced by the first lever arm is a useful part of the exercise.

But this is beside the primary point of my argument, which is that high-bar squats have limited usefulness. There are several reasons for this. As we discussed earlier, the low-bar squat is the primary exercise for developing hip drive—the active and powerful recruitment of the muscles of the posterior chain. The hamstrings, adductors, and glutes in a low-bar squat act directly to open the hip angle out of the bottom. In a front squat, the hamstrings are shortened by the acute knee angle and open hip angle into a position of almost complete contraction, and cannot be used to make the hips extend, since they are already contracted. The extremely vertical back angle is maintained by the glutes and the contracted hamstrings, and the glutes and adductors function as the primary extensors of the hip in the absence of hamstring involvement. This means that there is little hamstring in a front squat and lots of hamstring in a low-bar back squat. And a high-bar back squat is intermediate between the two. I specifically want there to be lots of hamstring involvement in the squat, especially for Olympic weightlifters, most of whom either will not—or are not allowed to—deadlift heavy and thereby get their hamstring work. If all your squat work—front squats in cleans and out of the rack, and high-bar back squats—omits effective hamstring involvement, your posterior chain gets inadequate training. And this can be costly on a third-attempt clean. If we're front squatting when we clean and when we front squat, what earthly reason would there be to make our back squats more like an exercise we're already doing plenty of, an exercise that leaves out a muscle group that is very important when we pull?

Olympic weightlifters and squats

My argument is that Olympic weightlifters and everybody else who squats to get as much muscle as strong as possible should use the low-bar position to do it most effectively. It affects more muscle mass, it allows the lifting of heavier weights, and it therefore gets us stronger. And stronger is why we squat. Strength is a general characteristic, one that is *trained* as opposed to a specific skill that is *practiced*. Therefore strength can and should be developed in as general a way as possible, because greater strength can be better produced by as many muscles working together as possible. Skill practice and development takes that strength and applies it through the specific motor pathways used in the skill. The low-bar back squat is a perfect example of a way to develop general strength, through training, which can then be applied to a specific skill like a squat clean, through practice. If we rely only on the clean itself and the front squat to develop strength for the clean, we lose the opportunity to develop greater strength with an exercise more capable of allowing more of our bodies to lift more weight and thus become stronger more generally. The front squat is specific to Olympic weightlifting; the low-bar back squat produces posterior chain development and greater strength. Choosing to squat with a high-bar position is choosing to train less, rather than more, muscle mass.

An argument has also been made that the high-bar squat is better than the low-bar position because a longer second lever arm causes the first lever arm to be volitional—it makes the lifter consciously control the back angle. This line of reasoning is sometimes used by weightlifting coaches as evidence that the high-bar position is better because you can't control your back angle by merely leaning into your tightened hamstrings. But again, we are squatting for strength, not squat-control practice. If you want to squat with a form that requires a lot of attention paid to back angle, you front squat. A correct front squat requires a chest-up/elbows-up position that requires a lot of concentration to maintain,

and it emphasizes the upper back while the low-bar back squat works the lower lumbar muscles more, as discussed earlier. In fact, front squats work the upper back so well that lots of people doing barbell rows would be better off with rock-solid front squats. But I really can't see an argument for the use of an intermediate technique that essentially bastardizes both of the other two. Either you want to do a squat with lighter weights that forces you to hold a position used in weightlifting and usefully focuses on upper-back strength, in which case you front squat, or you want to squat with heavy weights to get as many muscles as strong as possible, in which case you low-bar back squat.

So, I want there to be shear stress on the back so that the muscles that control intervertebral position get strong. I want active use of the hamstrings, so that they get strong too. I want the heaviest weight on my back that I can move through a full range of motion. And this is why I like the low-bar back squat. I just can't get Phil to listen to me. He's stronger than I am, and he always has been, so he's going to be hard to convince. After all, the boy did both Steinborn and Zercher lifts with 500 pounds at a body weight of 198—not wise, perhaps, but still a record today, I believe.

But I've still got him on the squat.

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Mark Rippetoe and his buddy Phil do most of their squatting at his gym, Wichita Falls Athletic Club/CrossFit Wichita Falls. Rip has 30 years of experience in the fitness industry and 10 years as a competitive powerlifter. He has published articles in the *Strength and Conditioning Journal*, is a regular contributor to the *CrossFit Journal*, and is the author of the books *Starting Strength: Basic Barbell Training*, *Practical Programming for Strength Training*, and *Strong Enough: Thoughts from Thirty Years of Barbell Training*.