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A New, Rather Long Analysis of the Deadlift

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Many years ago I was strong. Well, relative to what I am now, I was strong. It is a rather dim memory, but I have pictures and trophies that I am told are mine. At the time, I was a decent deadlifter, usually among the last few even in our state-level meets to open, usually with something close to 600 lbs. My PR was 633, done on two separate occasions at a bodyweight of 220. The deadlift was really the only thing I did well, at least on the platform. My training buddies and I trained it hard, probably twice as much as other lifters spent on the lift.

In the early 1980s there were no deadlift "suits"; we wore plain wrestling singlets. Wrestling shoes had just become popular, the reasoning being that the shorter heel decreased the distance that the bar had to be pulled. I found that I could pull better in my squat shoes, with the heel helping me more effectively push the bar away from the floor using my quads in the initial knee extension. We were doing an exercise called halting deadlifts that involves only this initial push off the floor. Haltings start from the same position as the deadlift, with the back locked and the shoulders in front of the bar, and come up to a point right above the kneecap. The keys to the halting are the push of the feet against the floor—the knee extension—and keeping the shoulders out in front of the bar, which, when done correctly, can be felt in the lats almost as much as chin-ups. This is important, although at the time I didn't know why.

We also began using another exercise we called the rack pull. Haltings work from the floor up, and rack pulls fill in the top part of the pull. They start from pins set inside the power rack right below the level of the knee, at about the tibial tuberosity, and move up through lockout, finishing in the same position as the deadlift. The emphasis in the rack pull was the locked back and the hip extension, with an attempt to actively exclude any knee extension from the movement. The start position for the rack pull is also puts the

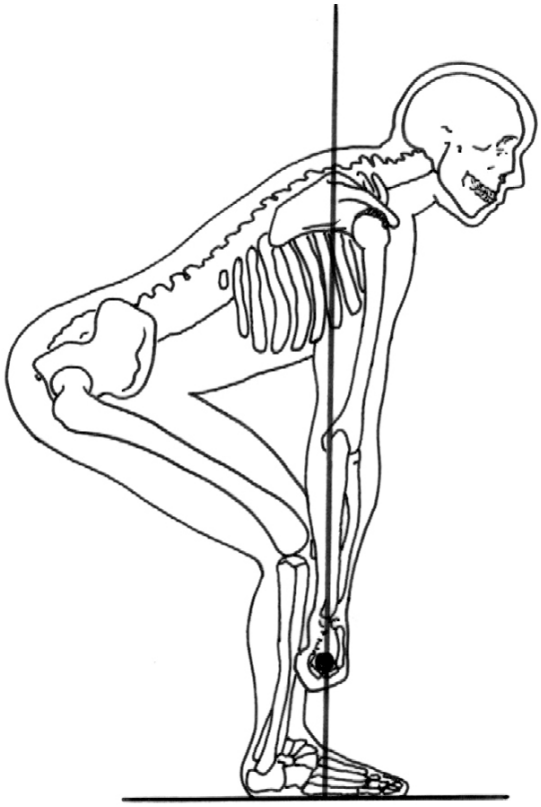

Figure 1 The relationship of the scapula and the bar in the deadlift starting position.
(All illustrations in this article courtesy of Lon Kilgore.)

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shoulders out over the bar, but when the bar comes up past the knees, the chest comes up as the hips begin to bring the back into the vertical finish position. The overlap between the two movements at the knee ensured that there was no "hole" in the training of the full deadlift with these two partial exercises. We didn't feel the rack pull in our lats that much, with me again not knowing why, or even thinking about it.

But two very good questions can be asked here. In both exercises, the start position involves the shoulders being in front of the bar, which is to say, on the other side of the bar from the rest of the body. The interesting thing about this position is that when you're in it, your arms are straight but not actually vertical. They are at about a 10-degree angle from vertical, because the shoulders in front of the bar have them reaching back to the bar at this angle. But it sure seems as though they would almost *have* to be vertical since a damned heavy weight is hanging from them. Shouldn't they hang straight down?

And another thing: shouldn't the back be as vertical as possible, since vertical is easier on the back? If the shoulders are out in front of the bar, the back will most assuredly not be very vertical. It might even be nearly horizontal, almost parallel to the floor, if you have short arms or long legs. But vertical is easier, because the more vertical the back is, the less torque, the rotational force applied against the lower back, will be produced. In a system in which mean old Mr. Gravity provides the force directly downward, the closer to vertical the force is applied, the less the force is converted to torque. Torque is 100% of the force when applied at 90 degrees—i.e., with your back bent over parallel to the floor. And there is no torque when the force is applied parallel to the lever arm, when the back is vertical, where all the force is simply compression. The closer to vertical the back is, the smaller the effects of the lever arm formed by the rigid back with a weight hanging from the top of it.

The answer to both is no. The arms cannot hang straight down; they must be at an angle from the shoulders back to the bar, and the back cannot be vertical if the shoulders are in that position. But why is this true?

This has bothered me for years in a very quiet little squeaky way, the question usually behaving itself and not demanding an analysis. Recently I have been dragged to the board and forced to think about it more thoroughly.

The force that is transferred from the back to the bar doesn't just leap over to the arms through the air. It is transferred to the arms through the shoulder *blades*, and it just so happens that when the correct deadlift position is assumed, the shoulder blades—not the front of the deltoids—are in fact directly over the bar in a line perfectly plumb and vertical to the bar. Let's review the basic force-generation mechanics of the deadlift and see if this makes any sense.

The force that makes the bar go up is generated by the muscles that extend the knees and the hips, and this force is transferred up the rigid spine, across the scapulas to the arms and down to the bar. The weight leaves the floor when the quadriceps extend the knees, but for this to happen the hamstrings and glutes must anchor the hip angle in its position. The hamstrings pull down on the pelvis from below, and the glutes hold it from the top of the iliac crest; if the back stays flat this allows the force to travel up the rigid back held at a constant angle while the quads push the floor. This knee extension can then provide the initial drive

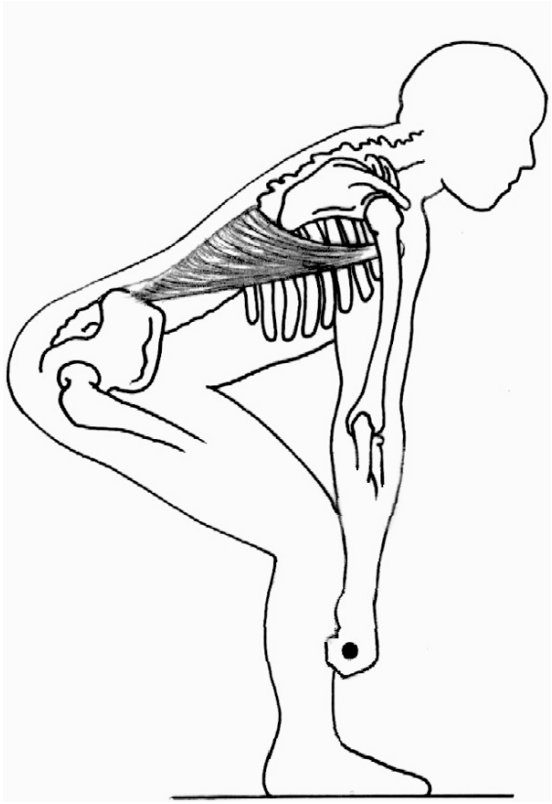

Figure 3 Anatomy of the lat, and its position at the start of the deadlift.

off the ground. If the hamstrings and glutes fail to hold their position during this initial push, the quads don't contribute to the movement of the weight since they straightened out the knee without any movement of the load. When this happens, you just shove your butt up in the air without the quads lifting any of the weight. When the lift is done correctly, though, the hip angle opens only very slightly as the bar rises to the knees, and the back angle—the angle the torso makes with the floor—stays constant. During this process, the quads move the weight, the glutes and hamstrings hold the hips down, and the flat back transfers this force up to the shoulder blades and down the arms to the bar. If the knees extend without moving the bar (pushing the hips up into the air), the movement becomes a stiff-legged deadlift, with the glutes and hamstrings doing the work without the help of the quads.

At this point, the bar must be as close as possible to the middle of the foot (with the feet flat and heels down, of course) where the force acts against the ground: it must be in contact with the shin. In fact, it must stay in contact with the legs all the way up to lockout, since the farther away from the knee and hip joints it is, the longer the lever arm—the back—is, producing more torque against the hips. The correct starting position for any pull from the floor is *always* one in which the bar is in contact with the shins. This is another problem with raising the butt up without moving the bar: the knees pull back as the butt raises, pulling the shins away from the bar and leaving it too far away from the point of ground reaction.

In the correct starting position, the scapulas are directly over the bar. This is because the force transferred up the spine is distributed to the scapulas from the ribs against which they lie flat, sprung from their posterior attachments against the spine and supported through their curvature around to their anterior attachments on the sternum. They are held fast by the trapezius muscles, which attach the spine of the scapula—the long bony ridge extending down the length of this otherwise broad, flat bone—to the vertebral processes along a broad origin that extends from the top of the neck well down the middle of the back, and by the rhomboideus muscles, which form a narrower attachment between the medial edge of the scapula and the spine. The scapulas have only a muscular attachment to the back; they float within their muscular base to allow a range of shoulder position. The retracted position, the one in which they are pulled closest to the spine, is the position of maximum muscular tension, and maximum support from the traps and rhomboids. It is the position in which they can most effectively receive the force from the back for transfer to the arms. At the start position the inferior part of the muscle, the part farthest down the back, is the main contributor to the retraction of the scapulas (the upper part becomes important at the top of the deadlift).

The shoulder blades are the skeletal components that receive the force from the back and change the direction of the force from parallel to the back angle to one that connects with the bar. So they are the components that conduct the pulling force of the lifter to the gravitational force that the deadlift must overcome. Gravity acts perpendicular to the floor, so the scapulas must be perpendicular to the bar, because the weight actually hangs from the scapulas.

Of course, this position is ultimately dependent on the ability to keep the spine in rigid extension during this process. If the muscles that keep the spine rigid are not contracted properly or are overcome by the load and

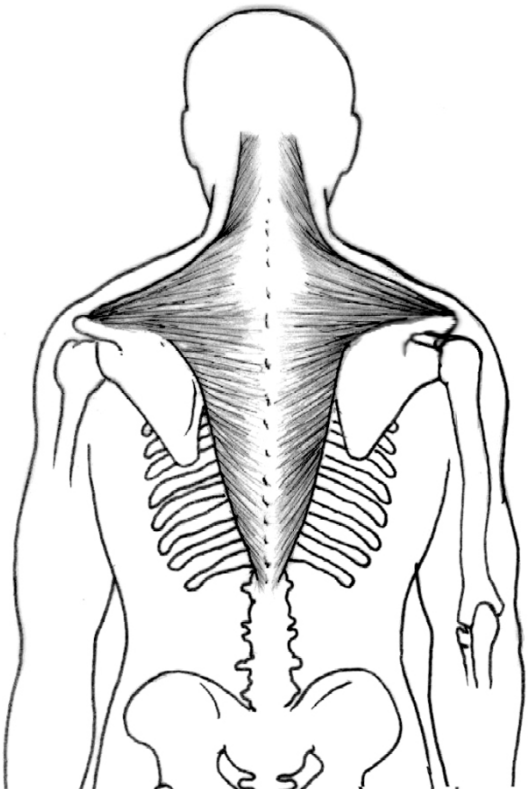

Figure 2 Trapezius anatomy.

pulled into a position where the spine is rounded, two problems result. First, the intervertebral discs are not designed to bear weight effectively anyway. This bipedal stance we occupy is rather poorly thought out, and discs are better at just separating bones than forming a weight-bearing surface between them. They only bear weight well when they are in the correct position, where the surfaces of the vertebrae they separate are oriented in the way the disc is shaped for them. This position is achieved when the back is in extension, both lumbar and thoracic. This is the normal anatomical position for the back, and the one in which the spine must be maintained by the back muscles during a deadlift or any other lift involving force transfer up the spine. Maintaining this position prevents injuries.

Second, if the back fails to maintain extension during the deadlift, some of the force that would have gotten to the bar gets absorbed in the lengthening muscles, and lifting efficiency is reduced. If the back rounds enough, an erect position cannot be attained at the finish, since the function of the spinal erector muscles is to maintain rigid extension, not to actively extend under a load. So, the correct starting *and* maintaining position for the back is *always* one of spinal extension for the whole back. There is shearing force applied to the spine during the deadlift, and it is overcome by the isometric contraction of the spinal erector muscles working with the intrathoracic and intra-abdominal pressure generated by the anterior trunk muscles. This is why the deadlift is regarded as the best back exercise in existence.

In their retracted position, the scapulas lie at an angle that puts the glenoid—the socket that articulates with the ball of the humerus—slightly forward of the spine of the scapula. This means that in the deadlift starting position, the top of the arm at the shoulder will be slightly forward of the scapula. If the scapulas are directly over the bar and the shoulders are slightly forward of it, there is a slight angle from the shoulder to the bar, and the arms will not be vertical. This is where the lats become important. If the shoulders are in front of the bar, the back is flat, and the bar is touching the shins, this angle is inherent in the position. Tension from the lats keeps the bar from swinging away from the shins into a difficult pulling position. The lats keep the bar vertically under the scapulas so that force can transfer to the bar in an anatomically efficient way, and so that the distance between the bar and the point of ground reaction is the shortest.

The lats are good at this. They attach near the top of the humerus along a broad, flat insertion, and in the starting deadlift position the most lateral fibers of the muscle are at about 90 degrees to the bone. This is a very efficient position for maintaining tension on the bone. If you tie a long rope between a tree and a car, you can pull the car by pulling on the rope at a right angle—90 degrees—to the rope. This works best if you are in the middle of the rope, but we are not trying to actually *move* the bar back, just keep it against the shin until the bar is above the knees. The halting deadlift, since it works the part of the motion that involves this lat function, has a profound effect on lat strength and development when done with heavy weights.

Once the bar passes the knees, the knee angle has opened up quite a bit and the hip angle begins to open as the function of the hamstrings and glutes changes. As the bar rises above the knees, the torso becomes more and more vertical as the lift gets closer to the finish position. The hamstrings and glutes begin to actively extend, or open, the hips, changing both the hip angle and the back angle. At this point, most of the knee extension is finished and the hips are catching up. During this phase the scapulas rotate back to a position behind the arms as the chest comes up. They have moved from directly over the bar to behind it as the torso becomes vertical, and the traps change their support from the inferior portion of the muscle to the superior, the part visible above the shoulder. The lats

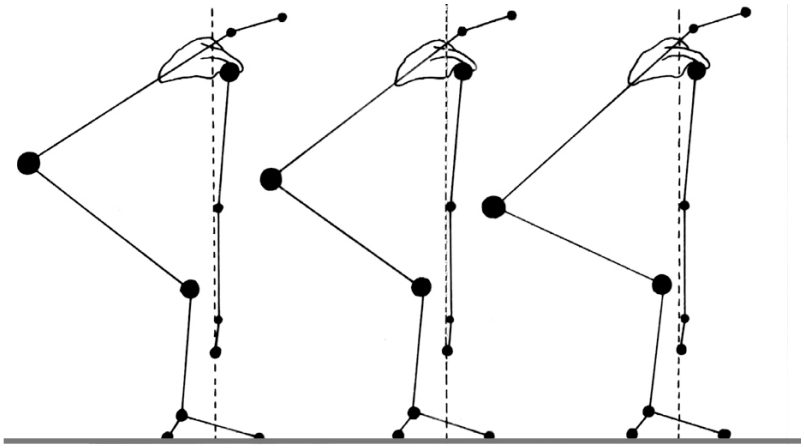

Figure 4 The effect of different variations of back/femur dimensions on back angle in the deadlift starting position.

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drop out of active participation in the lift since they are no longer required to keep the arms from swinging away forward. As the lockout portion of the lift is approached, the knees and hips have both moved through the hard part of their respective ranges of motion, a little more being left for the hips to do than the knees. Their final lockout will occur simultaneously. At lockout, the shoulders are back, the knees and hips are extended, the spine is in normal anatomical position with chest up, face straight forward, lower back locked, and everything stable.

What this boils down to is that there are exactly three criteria for a correct starting position for the deadlift:

1) The back must be locked in extension.

2) The bar must be touching the shins, with the feet flat on the floor.

3) The shoulders must be out in front of the bar so that the shoulder *blades* are directly above the bar.

It doesn't matter what the individual looks like in this position as long as these three criteria are satisfied. Legs may be long or short, the back may be long or short relative to the legs, arms may be long or short, a kyphosis may be present, and these factors will all influence the appearance of the starting position, primarily in terms of varying the angle the back makes with the floor. But as long as all three of the criteria are satisfied, the starting position is correct. As a coach, you should become familiar with the effects of the anthropometric variables on starting position, and learn to tell wrong from merely weird.

In both the halting deadlift and the rack pull, the shoulders start out in front of the bar, because both exercises start with the bar below the knees, when the scapulas are still over the bar. The halting stays in that position all the way up and down, whereas the rack pull rotates out of it shortly after the knee is cleared. And now I know why. And I'm as sorry as you are that it took so long to explain.

Mark Rippetoe is the owner of Wichita Falls Athletic Club and CrossFit Wichita Falls. He has 28 years experience in the fitness industry and 10 years as a competitive powerlifter. He has been certified as an NSCA Certified Strength and Conditioning Specialist since 1985 and is a USA Weightlifting Level III Coach and Senior Coach, as well as a USA Track and Field Level I Coach. He has published articles in the *Strength and Conditioning Journal*, is a regular contributor to the CrossFit Journal, and is the author of the book *Starting Strength: A Simple and Practical Guide for Coaching Beginners* and the forthcoming *Practical Programming for Strength Training.*

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