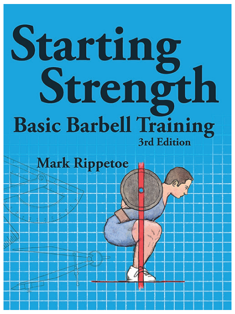
Starting Strength

This is an excerpt from the Deadlift chapter of Starting Strength: Basic Barbell Training, 3rd Edition, available directly from us or through Amazon now. It is the first part of an expanded explanation of some pulling mechanics topics we have been working on for the past few years. The second part will follow shortly.



Pulling Mechanics

First, let's make a few general observations about the behavior of the physical system we're working with here. *Moment*, or rotating force (sometimes the term *torque* is used), is the force applied along a rigid bar that makes an object at the end of the bar turn around an axis. Moment is at its maximum when applied at 90 degrees to the thing being rotated. Think about turning a nut with a wrench; your hand placed at a weird angle to the wrench is not strong, and the strongest position is one in which your hand is at a right angle to the wrench. This is why a mechanic always wants to have enough room to get his arm at right angles to his wrench on a stuck bolt.

Moment also increases with distance away from the thing being turned. A grip on the wrench turns the bolt more easily the farther it is from the bolt. The *moment arm* is the distance between the bolt and your hand on the wrench, measured at right angles between the bolt and the direction you're pulling on the wrench. A longer wrench works better than a shorter one because the longer length creates a longer moment arm if the angle of the pull remains efficient. The moment arm's length

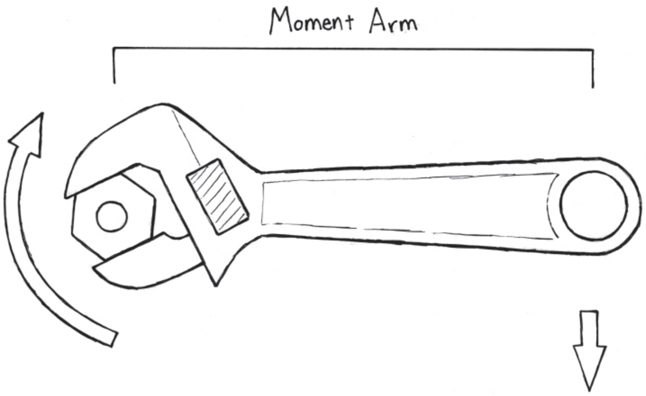


Figure 4-16. The important mechanical concept of the moment arm, as illustrated by the wrench and bolt.

is determined by both the length of the segment and the angle of the pull. A long wrench pulled from an angle that is less than 90 degrees will not turn the bolt well because the horizontal distance between the pull and the bolt is not as long as the wrench; i.e., you have created a short moment arm. Likewise, a short wrench pulled at 90 degrees is not an effective tool for a tight bolt because of the short moment arm.

This fact applies to all situations where a weight is lifted by the back, i.e., pulling or squatting. Gravity operates in a straight vertical line in the direction we call “down.” A bar in the hands always pulls straight down, so the moment arm in this system is always measured from the bar horizontally. A short back at a more horizontal angle might have the same moment arm length as a longer back at a more vertical angle. The best setup would *seem to be* a short back at a vertical angle, but we are, unfortunately, limited by the other physical constraints on the system in our ability to make our pulling mechanics more favorable. If the back is short relative to the legs, making the back vertical will drop the hips, which shoves the knees forward, which inclines the shins, which pushes the bar forward. This sequence puts the bar forward of the mid-foot and puts the shoulders behind the bar, neither of which will work at heavy weights, for reasons we shall soon investigate.

A wrench-and-bolt model works just fine for simply describing a moment arm, but it’s not really an accurate depiction of what happens at the hip joints in a deadlift. There is another way of describing the mechanics of the pull. The hip and the spine held rigid by your trunk muscles form a Class 1 lever. To refresh your memory, a Class 1 lever places the fulcrum between the load and the force that moves it, with the rigid member being the object that transmits the force, like a seesaw (Figure 4-17). The moment arms are the segments of the rigid member on either side of the fulcrum. If they are the same length, the force applied to the load is the same as the weight of the load if the system is in balance, and the distance each side moves is the same. If one side is shorter and the other side longer, the short side moves a shorter distance, more slowly,

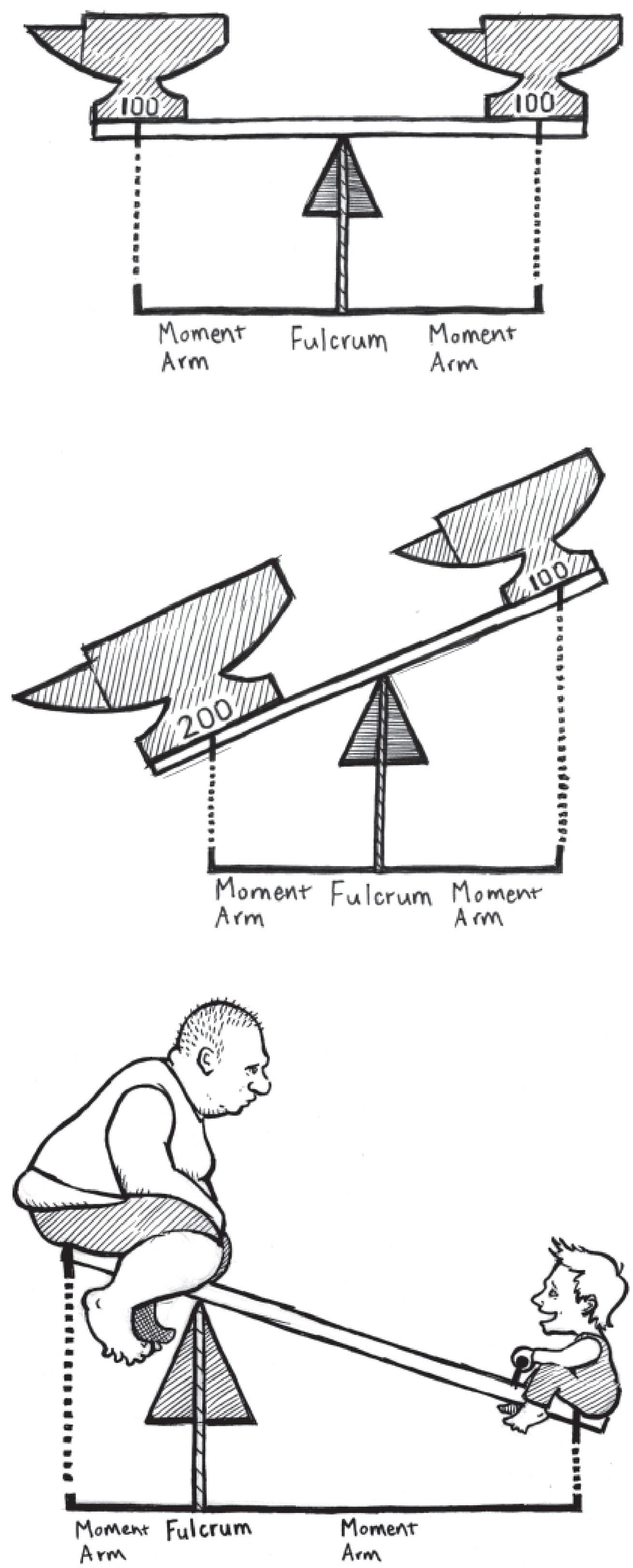


Figure 4-17. The Class 1 lever.

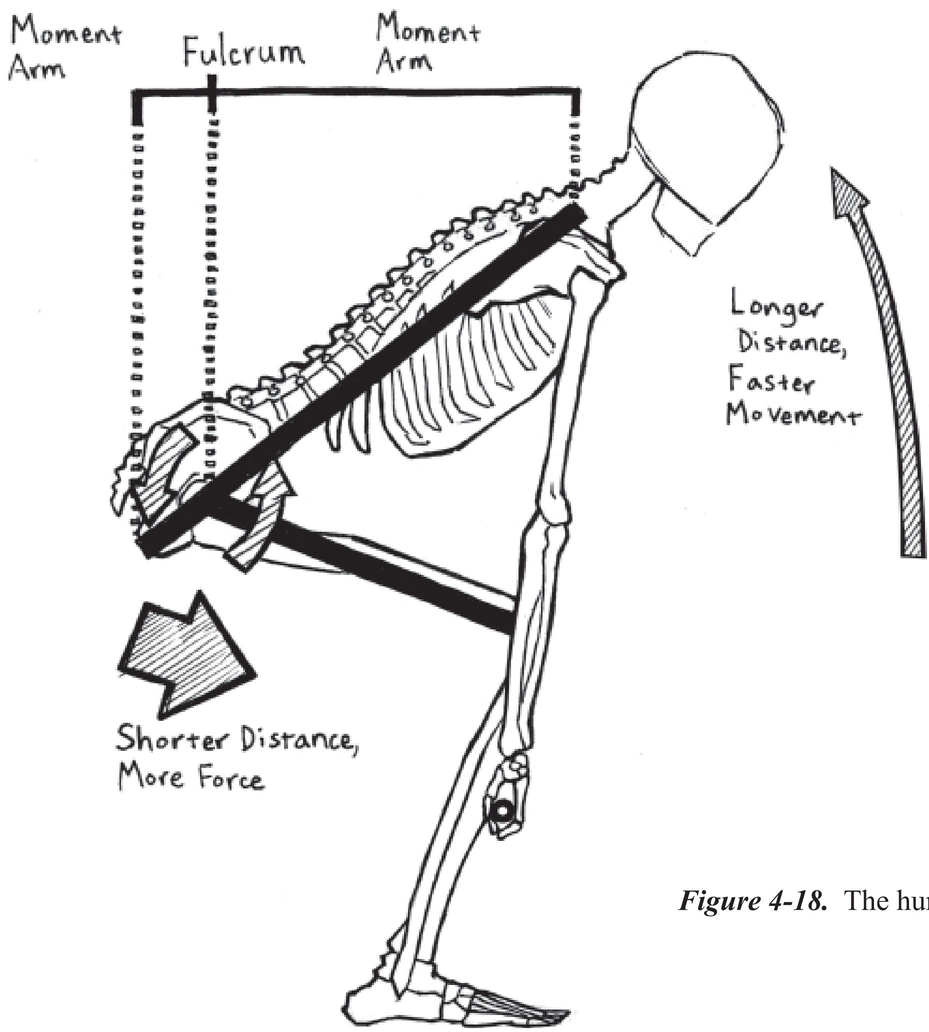


Figure 4-18. The human hip, a Class 1 lever.

while the longer side moves a longer distance more quickly. But the speed at the longer end comes at the expense of higher force at the shorter end, with the force at the short end being multiplied by the length of the bar at the long end. So, a Class 1 lever can move a heavy weight a short distance more slowly if you push (or pull) down on the long side, like a crowbar prying loose a nail. Or it can move a light weight faster if you push (or pull) down hard on the short side, like stepping on a rake and having the handle hit you in the face, or the way a trebuchet worked in the olden days of siege warfare.

The human hip is a Class 1 lever. The back and the pelvis form the rigid segment; the hip joint is the fulcrum; the hamstrings, glutes, and adductors of the posterior chain are the force pulling down behind the hips (the short segment); and the load in your hands is the force pulling down in front of the hips (the long segment) (Figure 4-18). If the force generated by the posterior chain is high enough – if you are strong enough – the short segment behind the hips can lever up the long segment in front, even with a heavy weight. The simultaneously extending knees complicate the system, but not much. If we could design the system to deadlift heavy weights, we'd put the hips closer to the bar. But since we can't, we have to design the pull to make the most of the mechanics we have, and this is why we keep the bar as close to the hips as we can get it. Some advanced lifters use an intentionally rounded upper back to shorten the distance between their hips and the bar. As we'll see, this is properly the job of the lats.

This leverage system operates when you deadlift. But if you're strong enough, the moment arm works the other way, too; the short side moving a short distance with enough force can make the

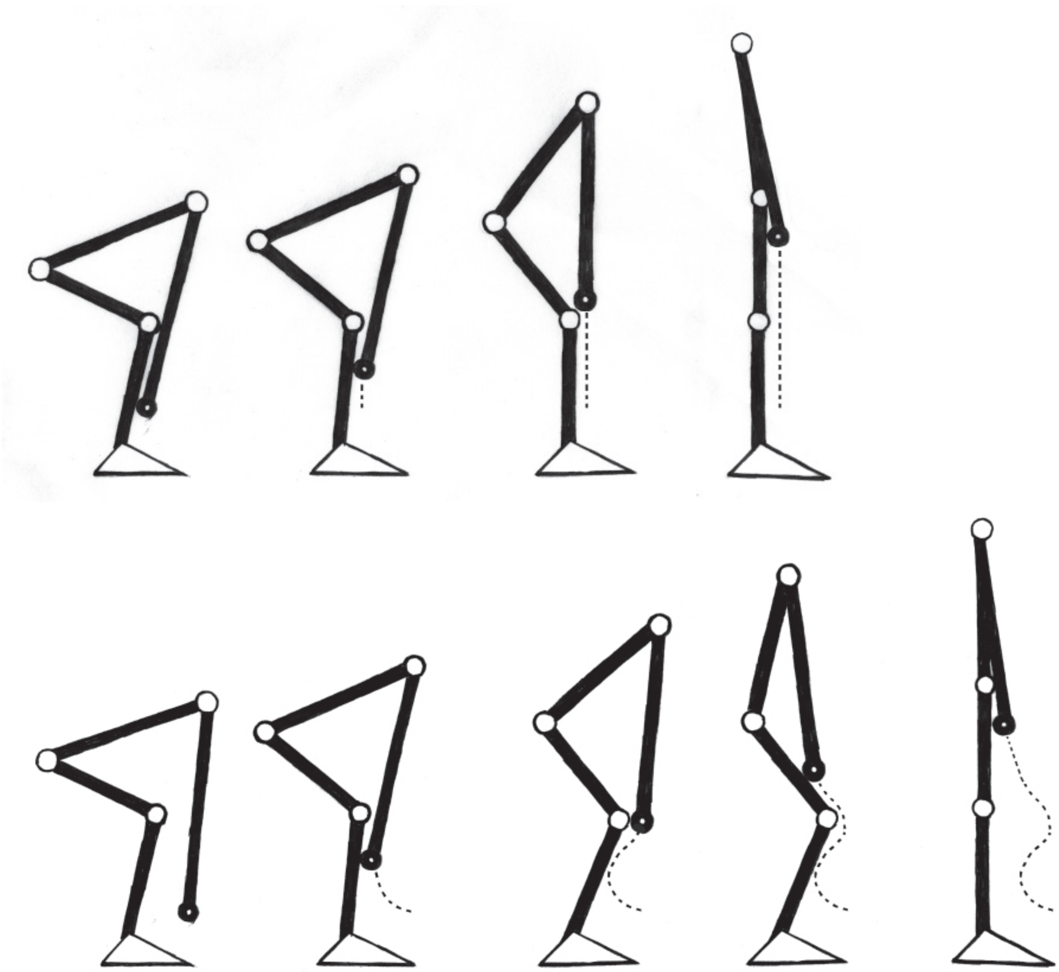


Figure 4-19. The work done against gravity is purely vertical displacement because the force of gravity acts vertically. Any other movement of the bar is horizontal motion that does not represent work done against gravity and is therefore effort spent inefficiently.

long side accelerate its load over a long distance. This is what happens in a clean or snatch.

The bar path in a heavy deadlift should theoretically be straight, because that is the shortest, most efficient way to move an object through space from one point to another, and vertically up, because that is opposite to the direction in which gravity is pulling the barbell. *Work* is defined as force (in the case of work against gravity, the force of gravity acting on the mass of the loaded barbell) multiplied by distance (the measured distance the barbell has to travel), and can therefore be expressed in foot-pounds. Since gravity operates straight down, the only work that can be done *against gravity* is straight up, and any other movement represents energy expended doing something else. Force can be applied to the bar horizontally – in a direction either forward or backward relative to the lifter – and cause the bar to move forward or backward on its way up, but this horizontal force cannot cause work to be done against gravity. In other words, you can walk around the room with the bar if you want to, but the deadlifting part consists of the work done to change the vertical distance between the bar on the floor and the bar in your hands at lockout. The shortest distance a deadlift can travel is a straight vertical line, and a longer bar path is therefore less efficient. Most sports-related movement – think of judo, downhill skiing, or football – is not as simple as a straight vertical line, but the movements involved in lifting barbells can be, so they *should* be.

The deadlift places the bar in front of the legs, creating a different situation than exists in the squat and, to a lesser extent, the press: the bar is not balanced on the shoulders and directly over the mid-foot, with a roughly equal amount of body mass on either side of the bar that can remain in balance during the lift. A deadlift must stay in balance with most of the body behind the bar. This requirement creates a situation in which the center of mass (COM) of the lifter/barbell system must be considered. During the deadlift, this COM will vary slightly, and cleans and snatches are more complicated than deadlifts due to their longer range of motion and increased musculoskeletal complexity. Light deadlifts actually balance differently than heavy deadlifts – the heavier the weight, the closer the loaded barbell approximates the COM of the body/barbell system, and the less important the body mass behind the bar becomes. A light deadlift can therefore leave the ground from a position more forward of the exact middle of the foot than a heavy deadlift can, and the same is true of a snatch or a clean.

It should also be obvious that the closer the barbell is to the body's own COM, the shorter the moment arm will be between them, and the less leverage there will be between the components of the lifter/barbell system. The closer you can get the bar to the body's COM without getting behind the mid-foot, the less leverage between them you must overcome while lifting the load. Any distance between the bar and the balance point at the mid-foot constitutes a moment arm as well, one that has a profound effect on pulling efficiency, as we will see. And as mentioned earlier, the greater the distance between bar and hips, the longer the moment arm is against the hips. So, as is the case with all other barbell exercises that involve standing with the bar in the hands or on the back, leverage is optimal and the bar is in balance when it is right over the middle of the foot. And it should never deviate from this bar path where it is in balance: right over the middle of the foot in a straight vertical line. This bar path should be recognized as the ideal physical model we try to approach; a good deadlifter gets very close.

The deadlift uses force generated by the extension of the knees and hips to drive the bar off the floor to lockout. The force is transmitted along the rigid spine, acting as a moment arm rotating at the hip between the hip extensors and the weight of the bar. This moment force is transmitted to the scapulas (more correctly, *scapulae*) and to the arms, and then down the arms to the bar. The scapula, a flat bone with a comparatively large surface area, interfaces with the rigid back as it lies against the rib cage, and is anchored in place by the extremely strong trapezius as well as by the rhomboid major and minor, the levator scapulae, and other muscles. The trapezius originates at the base of the skull and – by the *nuchal ligament* – all along the spinous processes of the cervical spine to C7, and from the spinous processes of C7 to T12, making this muscle origin the longest one in the human body. All of these fibers have an insertion point on some part of the shoulder: either the long bony ridge that runs down the length of the scapula (this ridge is called the *spine of the scapula*) or the superior aspect of the clavicle. The traps can therefore transfer force from a very long line of attachment on the spine to a very long line of attachment on the shoulders. (This is why the deadlift is such a good builder of traps and why good deadlifters have bigger traps than other athletes.) Although the traps can concentrically shrug the shoulders, adduct the scapulas, and depress the scapulas, their function in the deadlift is isometric – they hold the scapulas in place. When you are in position to pull the bar off the floor, with a back angle of somewhere between 20 and 30 degrees, depending on your anthropometry, the scapulas lie flat against the Valsalva-supported rib cage. They are held in place there by the traps and rhomboids, and are thus in a well-supported position to receive the force coming up the rigid trunk from the extending hips and knees.

The humerus is attached quite thoroughly to the scapula at the *glenoid,* or shoulder joint, by several ligaments, the deltoids, the rotator cuff tendons and musculature, the long head of the triceps, the biceps, and the teres major muscles. The delts have a long origin all along the inferior side of the spine of the scapula, directly across the bone

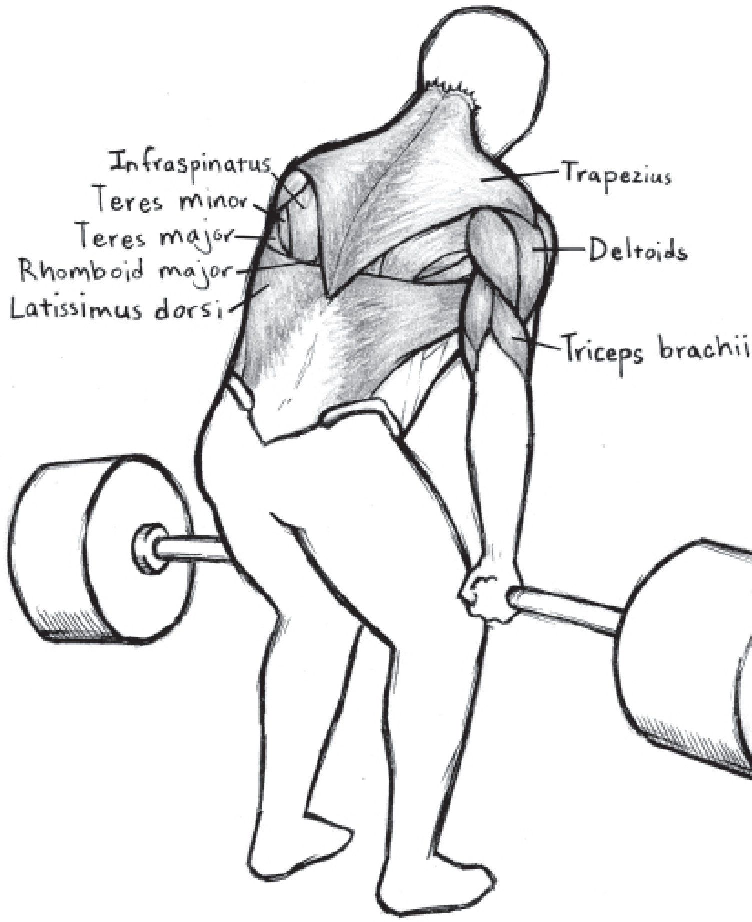


Figure 4-20. Muscles involved in force transfer between the arms and the spine, posterior view.

from the trap attachment, and they wrap around to the front along the acromion and the outside one-third of the clavicle. The delts insert on the *deltoid tuberosity* on the lateral side of the humerus, a large bump almost halfway down the shaft. This assembly – of spine to trapezius to scapula/clavicle to deltoid to humerus – produces a very robust, effective piece of force-transfer architecture. The teres major ties the bottom of the scapula to the front of the humerus, close to the glenoid, adding to the musculature connecting the two bones.

The latissimus dorsi muscles have a very important role to play here, too: they arise from a very broad origin on the lower back, starting for most people (there are variations between individuals) at the T7 spinous process and sweeping down with the *thoracolumbar fascia*, a broad sheet of connective tissue with fibers on the sacrum and the iliac crest of the pelvis. The insertion of the lat is on the front of the humerus at the top, very close to the pectoralis major insertion, so its function is to pull the humerus back; this function is very important to the mechanics of the pull. So the humerus has attachments both from the scapula and directly from the spine, and every spinous process in the spinal column, from skull to sacrum, is connected by either lats or traps to the humerus, with both overlapping from T7 through T12. All of these attachments form a rather thorough and effective connection between the back and the arms.

