Analysis of the deadlift

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The deadlift is one of the best pure tests of overall body strength, and has been used for training purposes by many coaches for many years. The deadlift is the last of the three lifts tested in powerlifting competition, making it the supreme test, the one that determines placement position in competition.

The standard form deadlift is a simple lift to perform, which is a large factor in why this lift has been used so readily for testing purposes. With such simple biomechanics involved, testing reliability has been easily obtained as compared to the squat or power clean with their more complex biomechanics.

Regular stance deadlift

An athlete preparing to deadlift using the regular stance form addresses the bar (that is on a platform or floor, the bar being an Olympic genre bar, the widest plates being of 90 pounds or 45 kilograms) with the front of the quadriceps lined up with the inside of the bar. The feet are spaced at about shoulder width or a bit narrower, and are externally rotated 45° or slightly less. This position may be varied slightly due to individual differences in torso and leg length.

From this address position, the athlete flexes at the knees and hips and grips the bar about 2" outside the lateral point of each ankle. An alternating grip is used, which means that one hand is supinated, the other pronated, and the bar gripped with palms from opposing directions. The head is lowered while the athlete observes grip placement. This is the starting position.

From the starting position, the athlete commences the lift by raising the head (looking up at about 45°), and pulling the bar from the floor by extending the knees, hips and eventually the vertebral column so that the bar is pulled above the knees and to the thighs, where at about mid-thigh, it is slid up the thighs to the point of lift completion. The point of completion is attained when the knees and hips are extended, and the upper and lower vertebral column are also extended (not hyper-extended). Throughout the lift, the arms stay straight, and are that way at completion.

Ceremonial completion in powerlifting is attained when the frontal points of the shoulders pass behind the frontal points of the hips, while the knees and hips are straight. This is a good guideline for anyone doing deadlifts, although in powerlifting this position can often be reached with severely exaggerated kyphosis. Non-powerlifting athletes should be taught to complete the deadlift with upper and lower vertebrae extended to natural standing position, without extreme lordosis or kyphosis.

Stroke

The stroke is defined as the definable range of motion the bar travels during one repetition of the deadlift. During the

Figure 1: Liftoff

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stroke, the bar should be proximal to the athlete's anatomy in the following manner: the lift should start with the inside of the bar lined up with the front of the quadriceps. This is important because if you're too close to the bar, you could pull the bar too deep in the quadriceps; if you're too far from the bar, you are then doubling the pressure on the spinal erectors.

As the bar is lifted from the floor, it should close the gap to the tibias, but not touch them. The bar should rise almost exactly vertically up past the patellas. The bar should not touch the legs until it reaches the frontal-inferior protrusion of the quadriceps, by passing the patellas and lower thighs. Once this position is attained, the bar should not be buried into the quadriceps, but should be lightly slid along them until completion position is reached. This is the reason for individualized approaches.

The correct path of the stroke is designed by proper biomechanics. Generally, the proper biomechanics is achieved by collusion of knee extension, hip extension and vertebral extension. Knee extension is usually initiated first, quickly followed by hip extension and then back extension.

The stroke can be broken into three phases; analysis of each phase determines the importance of each kinesiological movement.

Three phases of the stroke

Any deadlift performed with heavy weight (approximately five repetition maximum and heavier) has a three phase stroke: the liftoff, the pull through the knees, and the lockout.

Liftoff

Liftoff is initiated by knee extension, quickly followed by hip extension. When an athlete “breaks the floor” with a heavy deadlift, strength should be the key element demonstrated, not power. An athlete who tries to rip the bar from the floor with heavy weight will often quickly dissipate power when the bar does not move with the yank, and then will dissipate strength as well, resulting in little or no bar movement. If such an athlete tries to power the bar from the platform, he will raise his hips due to knee extension without immediate hip extension. This, aided by exaggerated kyphosis, results in delayed bar movement, resulting in an unintended straight leg deadlift; the exaggerated kyphotic position stretches the erectors, leaving the lower back in a vulnerable position.

The starting position for the deadlift differs from the starting position for the power clean or the position of a medium-depth squat, which ideally exhibit a straight back. Unlike the starting position

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of the clean, which accentuates straight or slightly lordotic lumbar vertebrae, and straight thoracic vertebrae, the starting position at the very moment of liftoff with heavy weight for a deadlift exhibits slightly convex lumbar vertebrae and slightly kyphotic thoracic vertebrae. These spinal arcs should in no way be exaggerated, mind you, but the deadlift is most efficiently done, with the most weight handled, when the vertebral extensor muscles are extended through a range of motion, which is not seen during the power clean or squat.

Knee extension (with isometric hip stability), quickly followed by hip extension, is what initiates the liftoff. Although at this point the vertebral extensors are intended to be isometrically stabilized, lumbar convexity and kyphosis are often exaggerated as the knees and hips extend, buffering the force on the bar. It is important that these buffering actions are limited.

Pull through the knees

As the bar moves up toward the knees, knee extension decelerates (as the knees reach 180°) and hip extension causes the prime movement. Vertebral extension, especially lumbar extension, is necessary at this point in order to limit unwanted stress on the lower back. At this point there is great hip extending forces applied by the hamstrings and gluteals, and if the lumbar erectors do not respond with great isometric (or isotonic) strength, the lumbar erectors and lumbar-fascia are left in an extremely vulnerable position. During the pull through the knees, the head should be tilted upward in order to stimulate the trapezius and thoracic erectors to synergistically work with the lumbar erectors initiating vertebral extension.

The bar does not touch the shins or patellas, although it may come very close to the protruding kneecaps, and touches the thighs up one-quarter to one-third of their length, depending on the thickness of the thighs. Well-developed, thick quadriiceps will hinder the bar’s progress far earlier than will lean quadriceps.

Lockout

The lockout is accomplished by knee extension, hip extension, and vertebral extension, all coordinated to finish simultaneously. The knees have only a small range of motion left, and care must be taken that they aren’t slammed straight, well before hip and back extension are achieved. It is important that these joint actions are coordinated so as to guide the bar through the most efficient path. If the knees are locked, with little hip or vertebral extension occurring, the bar is left dangling out 6–8" from the thighs, causing increased and unnecessary stress on the erectors. If the knees are not locked out and hip extension is the only action, the bar is dragged into the ever-thickening quadriceps, making “hitching” (bouncing and jerking the bar up the thighs) a recourse, which is not wasted. Rebounding of the knees, a proper biomechanical maneuver during the power clean, is not wanted during the deadlift, for it causes the bar to be rested or “tabled” on the thighs, decreasing the training stress on the erectors, gluteals, and hamstrings—the muscle groups the athlete is specifically attempting to train with the deadlift.

The proper form during the lockout is for the knees to lock out slowly and the hips and vertebrae to extend to lockout collusively so that all three joints lock out together as the bar slides up the thighs. If
the coordination between the three body part movements is proper, and the synergistic forces that could be erringly misapplied (such as the latissimus dorsi and the teres major pulling the bar into the thighs forcefully enough to hinder vertical movement) are properly held in check, the bar should slide lightly up the thighs with no hitch, jerk, or bump. No one muscle group is overly stressed as long as three major motions are coordinated.

Disruptions of the ideal stroke

Disruptions of the ideal stroke are caused by improper biomechanics. One disruption is the contacting of the bar to the shins (tibias), and the dragging of the bar up the shins to the patellae. This is often due to coaching in weightlifting; the athlete is taught to keep the bar close to the body at all times, which results in the bar being pulled or rolled into the shins upon liftoff.

The opposite problem is of the bar getting beyond the ideal stroke distance from the body. Often this is the result of the knee extending without a coordinated extension of the hips, leaving the athlete in a straight leg deadlift position with the bar 6-12" from his shins. In powerlifters (powerlifters sometimes learn to develop an efficient stroke with the head marginally lowered) this may happen if the head does not lead the lift. In most beginners, if the head is raised as the liftoff begins, the extension of the hips will follow the raising of the hips caused by the extension of the knees.

A severe disruption of the ideal stroke happens when the athlete rushes to make the lift, or if the weight is too heavy. Hitching, heaving, tableting or bouncing results. Rushing to make the repetition results in slight flexing and extending (repetitively) of the knees and hips in order to accumulate enough ballistic forces to move the bar beyond the sticking point. The bar will ride up and down the thighs, inching its way to completion. Coaches should teach their athletes to avoid this at all costs. If the bar stops along the stroke, the athlete should try to summon enough will from the Gods to slowly slide the bar to completion, or put the weight down. A sharp coach or spotter may learn how to spot such a lift, adding a helping force on the bar to help the lifter finish the lift, by putting fingers under the midpoint of the bar between the lifter’s hands and forcing the bar up the stroke.

Functional anatomy

A great many muscles, from feet to face, are involved in the deadlift. The following is a brief analysis of the joint actions involved in the deadlift, with all major and some minor muscles identified.

The major joint actions of the deadlift are hip extension, vertebral extension, knee extension, and isometric phalangeal flexion (grip). Hip extension is performed largely by the gluteus maximus and the hamstrings. During liftoff, the gluteus maximus is the muscle most responsible for hip extension. The hamstrings (biceps femoris—longhead, semitendinosus, and semimembranosus) have their hip extension effect somewhat dampened by the bent knee at the liftoff point of the deadlift. As the lift progresses from the floor, and the knee straightens, the hamstrings have a much stronger hip extension leverage. As the hip joint, the gluteus maximus begins to run out of leverage and becomes a great outward rotator of the leg. Indeed, on a slippery floor it is common to see a lifter’s feet rotate outwardly as he or she nears the finish of the lift.

While the gluteus maximus runs out of leverage, due to hip extension, the hamstrings become the prime hip extensors. Meanwhile, the quadriceps (vastus lateralis, vastus intermedius, vastus medialis, and rectus femoris) have extended the knee, which raised the hips upward, putting the back and hip into working position. It is interesting to note that the rectus femoris crosses both the knee and the hip, with its action at the hip being hip flexion, antagonistic to the hip action during the deadlift. But the rectus femoris’ force at the hip is small compared to the force at the knee, so that during the deadlift (and squats) the rectus femoris force at the hip is easily countered by the force of the hip extensors, allowing it to contribute its force at the knee.

It is also interesting to note that although the quadriceps and hamstrings are usually antagonists to each other (in knee action), because the foot is planted and immovable during the deadlift, the quadriceps can pull the femur upward around the knee. At the same time, hamstrings, unable to rotate the fibula of the tibia around the knee in flexion, can pull from a fibula-tibia origin, and strongly rotate the hip in extension. This demonstrates the unique option afforded to muscles crossing two joints.

The erector spinae is the most distinguished muscle group in deadlifting, despite the fact that it is not involved in hip extension, the largest joint movement in deadlifting. “Wait ’til you see him put his ‘rectors to work,” or similar statements are often stated in reference to a great deadlifter. This extensive muscle of the back consists of three branches on either side of the vertebrae: the spinalis—the medial branch, the longissimus—the middle branch, and the iliocostalis—the lateral branch. The branches sit side by side, making the appearance of two muscular pipelines, one on each side of the vertebrae, running from the base of the spine all the way up under the scapulas and even to the cervical vertebrae and the skull’s temporal bone. Their lower attachments are the thoracolumbar fascia at the base of the spine, and the posterior portions of the lumbar, thoracic, and lower cervical vertebrae along with the angles of the ribs. The erectors are made of short fibers with intermediate origins and insertions throughout the span of the erectors. The upper attachments are angles of ribs, posterior portions of cervical and thoracic vertebrae, and even the mastoid process of the temporal bone.

Beneath the erector spinae are the deep posterior muscles of the spine, numerous in name and number, all aiding the erectors in vertebral extension and hyperextension.

The muscles mentioned up to this point cause hip extension, knee extension, and vertebral extension, which pretty much describes the deadlift. But for the deadlift to be possible, the scapulae, arms, and hands must play a mostly isometric, but vital, role during the lifting.

The scapula or shoulder girdle, the upper corner of the humerus, attaching the arm to the thorax, is attached and positioned over the posterior thorax by the rhomboids, the levator scapula, and, of course, the trapezius. The upper half of the trapezius, the rhomboids, and the levator scapula are very important in securing the scapula by isometric contraction and supporting the large amounts of weight at the end of the arms the deadlift can present. The posterior portion of the trapezius is especially important in supporting the distal end of the clavicle and the acromion process of the scapula when a heavy weight is held by the hand while the arm is down by the side.

Other muscles of the upper back become involved in a supportive role during the deadlift. For example, the latissimus dorsi, teres major, and posterior deltoid, all with controlling influence in the lifting (mostly extension) can help guide the path of the stroke of the bar during the deadlift by their force on the humerus. Strong extending force on the humerus by these muscles can cause the bar to move toward the body during the stroke.

Last but not least, as far as muscles go, is the grip. Along the forearm, the flexor digitorum superficialis and profundus are greatly involved in the clenching and holding of the hand around the bar. In the hand, the lumbricales manus and interossei palmares are imperative for the grip by the fingers. The opponents pollicis and adductor pollicis hold the thumb solidly over the bar and forefinger to stabilize the grip.

Although many minute anatomical details have not been discussed here, one is of momentary interest. The elbow is held together by strong ligaments with support from the biceps brachii, brachialis and the brachioradialis. Over the past few years there have been numerous cases of severely
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torn biceps while deadlifting. In the most notable cases, the athletes were extremely muscular, and may have had limitations of flexibility. Their cases seem to show that the biceps is used quite extensively in radialhumeral support during heavy deadlifting, and that deadlifting warrants attention to biceps flexibility.

As far as anatomical development from the deadlift is concerned, a top-rate deadlifter is often identifiable by well-developed “traps”, thick and well-defined erectors, well-developed hamstrings, and less visibly, thickly-callaused hands.

Just as short arms and a large chest define a biomechanical advantage for benchpressing, a lifter with long arms, short trunk, and medium length legs is defined as a deadlift natural. Lifters who move the bar the shortest distance with the best leverage during their stroke are the best deadlifters. Many of the great deadlift world recordholders fit the above description. Conversely, athletes with an anatomical structure similar to the dwarf—short arms, long trunk, and short legs—have the worst leverage for deadlifting, even though they seemingly have short strokes due to short legs. Hip extension is easier with shorter resistance levers involved, and a short trunk is a short resistance lever.

Sumo stance deadlift

In powerlifting, an alternative form to the regular stance deadlift is commonly used. Lifters who are strong squatters, with squat-advantageous builds—long trunks, short, thick legs with femurs naturally outwardly rotated—often find greater success using the sumo-style deadlift stance than using the regular stance.

An athlete preparing to deadlift using the sumo stance addresses the bar with feet wider than shoulder width and externally rotated, with the hands gripping the bar between the legs, usually a narrow 14–18° apart on the bar. The lifter’s hips are lower and the back is straighter during liftoff than during the regular stance deadlift. Stance width may vary greatly—from shoulderwidth, hands tucked just inside of the calves while grasping the bar, to a plate-to-plate stance virtually resembling a not-quite-there-split, and anything inbetween, usually dictated by natural hip external rotation. Usually a lifter’s form using the sumo stance attempts to mimic his or her fruitful squat form. As in the squat, the width of the feet is based on the anatomical structure. When trying to keep muscles in balance, the athlete should strive to keep the knees directly over the ankles.

For non-powerlifting training purposes, the sumo stance is virtually never used. The squat is more appropriate, producing greater training range of motion at the hip and knee.

Training hints

Deadlifting should only be done once a week. In fact, if heavy squats and cleans are part of the program, the deadlift can be done once every nine or ten days, such as once on Monday, Wednesday of the next week, Friday of the following week, and then ten days to the next Monday, and start the routine again. The erectors need plenty of rest between heavy workouts.

Some equipment and preparation is proper for deadlifting. Deadlifting should be done in flat-soled shoes with little give to the inner sole. Tennis or raquetball shoes work well. In an effort to handle heavier weights using the same lifting strength, the athlete should shave the hair from the thighs, and apply baby powder to the shaved areas before each heavy set. (Baby powder can be used regardless of how hairy the legs are.) This reduces the friction by allowing the bar to slide up easily. Without such aids, many a lifter has an easy time pulling the bar to the

Figure 4: Sumo stance deadlift — Liftoff.

Figure 5: Sumo stance deadlift — To the knees.
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Figure 6: Sumo stance deadlift—Lockout.

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thighs, only to have the bar stick to the hair as the sticking point of the lift is approached, causing the lifter to want to hitch and bounce the bar up the thighs.

An athlete should always use chalk on any heavy deadlift. Straps could be used as a training tool.

A belt is a must, although dependency on a belt should be avoided. This can be done by using a belt only for heavy sets, or doing all warm up and warm down sets without a belt.

Variations of the deadlift can be most fruitful. Doing deadlifts while standing on top of 2-6" blocks increases the stroke distance, creating greater joint range of motion. The ultimate block deadlift is the straight leg deadlift standing on a bench. Reaching down and touching the bar to the bench and extending back up may be the ultimate hamstring exercise. When performing stiff-legged, or straight leg deadlifts, the knees should have a slight bend. If you keep your legs straight, you will put enormous strain on the hamstrings.

More research is needed in this area, because it's possible the hamstrings should be strengthened in this way, but I have also seen strained hamstrings due to this method. Only light weight should be used, due to the stress on the erectors and lumbar vertebral ligaments. But using light weight for high repetitions is both a great flexibility exercise and a good rehabilitative exercise after knee operations.

Injury prevention

The deadlift definitely has its drawbacks. One is that because the range of motion stressed of the hips and knees is nowhere near full range, and that because heavy weights are used, the hips and hamstrings are prone to extreme tightness unless precautions are taken.

Another drawback is that because of the biomechanical nature of the lift, great stress is placed at the lower back. If the form goes awry, and too heavy a weight is used, damage of the lumbar vertebral ligaments, of the thoracolumbar fascia, of the erectors and the dorsal rami underneath may result.

It is imperative that athletes doing deadlifts keep the antagonistic muscle groups (to the prime movers for the deadlift) in top condition in order to maintain muscle balance, which will prevent postural changes and injury. Mainly, this means keeping the rectus abdominus in strong condition. Secondly, flexibility must be maintained. Hamstrings, quadriceps and erectors should be thoroughly stretched before and after each deadlift workout.