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## The Hip and Athletic Performance

Zachary Long takes a closer look at hip anatomy and identifies common dysfunctions that can limit CrossFit athletes.

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Brian Malloy

The hips serve as the primary generator of force in the majority of movements performed in athletics, and this statement remains true for the exercises most commonly performed in CrossFit.

The pelvis, lumbar spine and core play a vital role in stabilizing the trunk to allow force to be transferred through the body.

Despite the importance of the lumbo-pelvic-hip complex, dysfunction of muscle activation and flexibility is very common. These dysfunctions can greatly decrease performance, and it is therefore important to identify common impairments seen in these areas and better understand the hips' relationship with the pelvis and lumbar spine.

### Anatomy Review

The hip is a ball-and-socket joint formed by the articulation between the head of the femur and the acetabulum. As seen in Figure 1 below, the acetabulum provides significant coverage of the femoral head, giving the joint a high level of stability. This allows the hip joint to support heavy loads and maintain the stability needed to generate high levels of power.

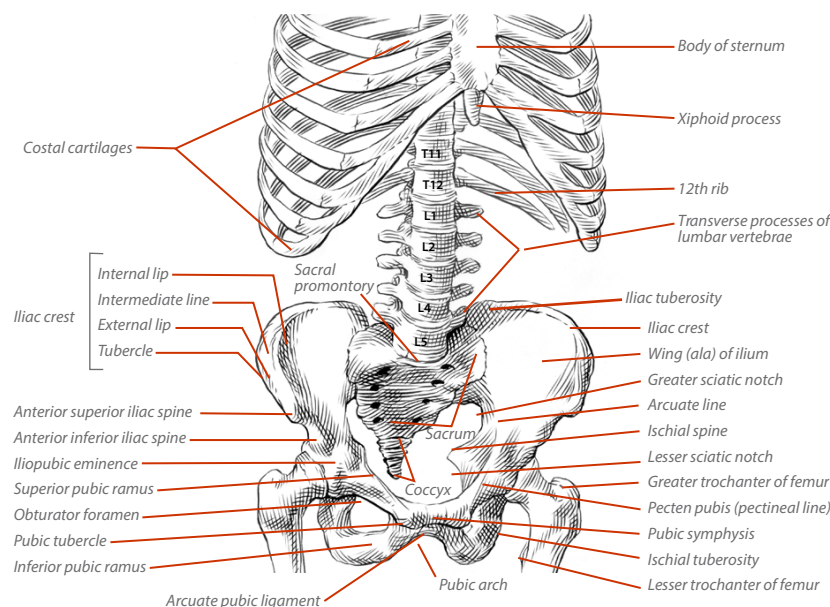
The acetabulum is formed by the fusion of the three bones: the ilium, ischium and pubis. Together, they are referred to as a hemipelvis. Each hemipelvis connects anteriorly with its contralateral counterpart at the pubic symphysis and posteriorly with the sacrum. The sacrum and coccyx form the lowest segments of the spine. Above the sacrum are the five vertebrae of the lumbar spine (1). Together, the proximal femur, pelvis and lumbar spine are referred to as the lumbo-pelvic-hip complex (LPHC) due to their intricate interconnections.

A variety of movements are available within the LPHC. The lumbar spine can flex, extend, rotate and side bend. At the pelvis, anterior and posterior tilting is possible. If one were to visualize the pelvis as a bowl filled with water, anterior tilt would spill water forward, and posterior tilt would do the opposite. The hip joint can flex, extend, adduct, abduct, internally rotate and externally rotate.

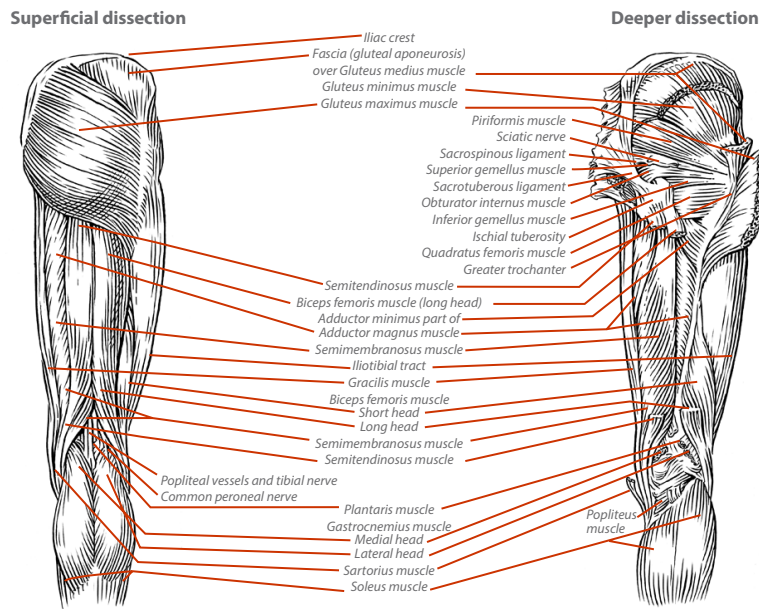
Movement in one joint of the LPHC affects the surrounding joints. For example, anterior tilting of the pelvis results in flexion of the hip and extension of the lumbar spine. Conversely, posterior tilting of the pelvis is seen with hip extension and lumbar flexion.

The gluteal muscles are the most commonly discussed hip muscles due to their extreme importance in athletic movements. The gluteus maximus is the largest of the three gluteals. The glute max originates in various attachments along the posterior pelvis, sacrum and coccyx and runs inferiolaterally to its insertion into the iliotibial tract (IT band), a dense band of connective tissue on the lateral thigh.

The glute max is a powerful hip extensor that externally rotates the femur and posteriorly rotates the pelvis. The glute max plays a critical role in power production for athletic movements.



**Figure 1: Bony anatomy of the lumbo-pelvic-hip complex.**



**Figure 2: Muscles of the posterior hip and thigh.**

The gluteus medius and minimus begin on the ilium and insert onto the greater trochanter on the lateral side of the proximal femur. These two muscles internally rotate the thigh, abduct the thigh and maintain a stable pelvis during single-leg positions, such as those seen in walking and running (1).

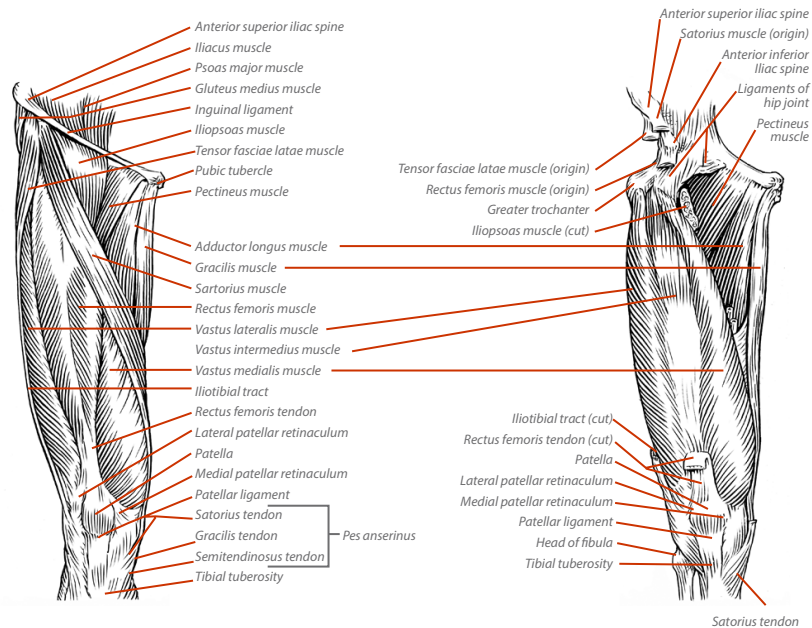
Together, all three gluteal muscles are important for controlling adduction of the thigh during activities such as squatting. Without their proper activation during a squat, the femur adducts, leading to the knees traveling toward each other during descent. This movement, also referred to as knee valgus, has been associated with multiple lower-extremity sports injuries in recent research studies and is often considered a movement fault. It is important to note that in examining the technique of many top weightlifters, a valgus knee movement is not uncommon, and these lifters seem to suffer no negative effects.

The hamstrings also play an important roll in hip extension. The semitendinosus, semimembranosus and biceps femoris all have an attachment to the ischial tuberosity on the inferior pelvis. The biceps femoris also has a proximal attachment on the posterior femur. All three hamstring muscles insert inferior to the knee joint,

giving them the ability to flex the knee in addition to their function as hip extensors (1).

On the anterior hip, several muscles function to flex the hip. The tensor fasciae latae (TFL) inserts onto the anterior iliac crest and inserts on the IT band. The TFL flexes and internally rotates the thigh, as well as abducts the thigh in combination with the gluteals. The rectus femoris is the only of the four quadriceps muscles to cross both the knee and the hip joint. This muscle both extends the knee and flexes the hip. The iliacus originates on the iliac and anterior sacrum and joins with the tendon of the psoas to insert on the lesser trochanter of the femur. The psoas originates on the five lumbar vertebrae and the 12th thoracic vertebrae, and, together with the iliacus, it flexes the hip joint. Together, the iliacus and psoas are often referred to as the iliopsoas. Finally, the sartorius attaches to the anterior superior iliac spine and inserts onto the medial tibia, allowing it to flex, abduct and laterally rotate the thigh and flex the knee (1).

The pectineus, adductor longus, adductor brevis, adductor magnus, gracilis and obturator externus make up the muscles of the medial thigh. These muscles all originate on the pubis or ischial tuberosity and have various



**Figure 3: Muscles of the anterior and medial thigh.**

attachments on the medial femur, and, in the case of the gracilis, the medial tibia. These muscles all work to adduct the thigh, and, depending on hip-joint positioning, the individual muscles may also flex, extend or rotate the hip (1).

The rectus abdominis is the most well known of the abdominal muscles. It runs from the xiphoid process to the pubic symphysis and forms the abdominal “six pack” in those with enough muscle definition. The rectus abdominis flexes the trunk and resists extension of the spine and anterior tilting of the pelvis. The internal and external obliques have various attachments on the lateral abdominal cavity. They provide lateral stability to the core and rotate the trunk. The transversus abdominis is the deepest of the abdominal muscles and runs laterally around the abdominal cavity. With the other three abdominal muscles, it helps to stabilize the trunk (1).

A variety of muscles, in several layers of the posterior spine, produce lumbar extension and resist lumbar flexion. These muscles include the erector spinae (iliocostalis, longissimus), quadratus lumborum, and the deep spinal muscles (multifidi, rotatores, interspinales and intertransversarii). These individual muscles may also produce lateral flexion of the trunk and rotation

of the spine (1,10). Their individual attachments and actions are beyond the scope of this anatomical review.

## Common Dysfunctions

Dr. Vladimir Janda has previously identified a common pattern of LPHC dysfunctions he referred to as lower crossed syndrome. The hip flexors (rectus femoris and iliopsoas), as well as the lumbar-spine erectors, were classified as muscles prone to tightness in this syndrome. Janda also identified the gluteals and abdominal muscles to be frequently underactive. This combination of dysfunctions often leads to an overextended lumbar spine and anteriorly tilted pelvis due to inflexibility and lack of proper motor control (7). This is a commonly observed pattern in athletic populations, resulting in decreased stability and power, potentially decreasing athletic performance.

While these dysfunctions can commonly be seen during static postures, it is important to note that they may also present during dynamic movement. In those who demonstrate these dysfunctions dynamically, they have neutral posture at rest but fail to maintain neutral positioning during athletic movements.

A great example of this can be seen during the squat. Rather than maintaining a neutral spine and pelvis during the descent, an athlete with a dysfunction initiates the squat by moving into a position of hyperextension of the lumbar spine and an anteriorly tilted pelvis. As he or she descends further, the anterior tilt may result in pain in the anterior hip as the femur impinges on the acetabulum, pinching the tissues between these boney structures.

In order to reach full squat depth, the athlete must then flex the lower back and posteriorly tilt the pelvis, resulting in what is frequently described as “butt wink” (11). The movement of the lumbar spine from a position of extension to flexion while under load places unnecessary levels of stress on the structures of the spine (9,10). Positioning the spine in hyperextension during squatting has also been shown to be detrimental to spine structures (10); therefore, it is imperative to maintain a neutral spine during lifting both for spine health and for the optimal transfer of power throughout the body.

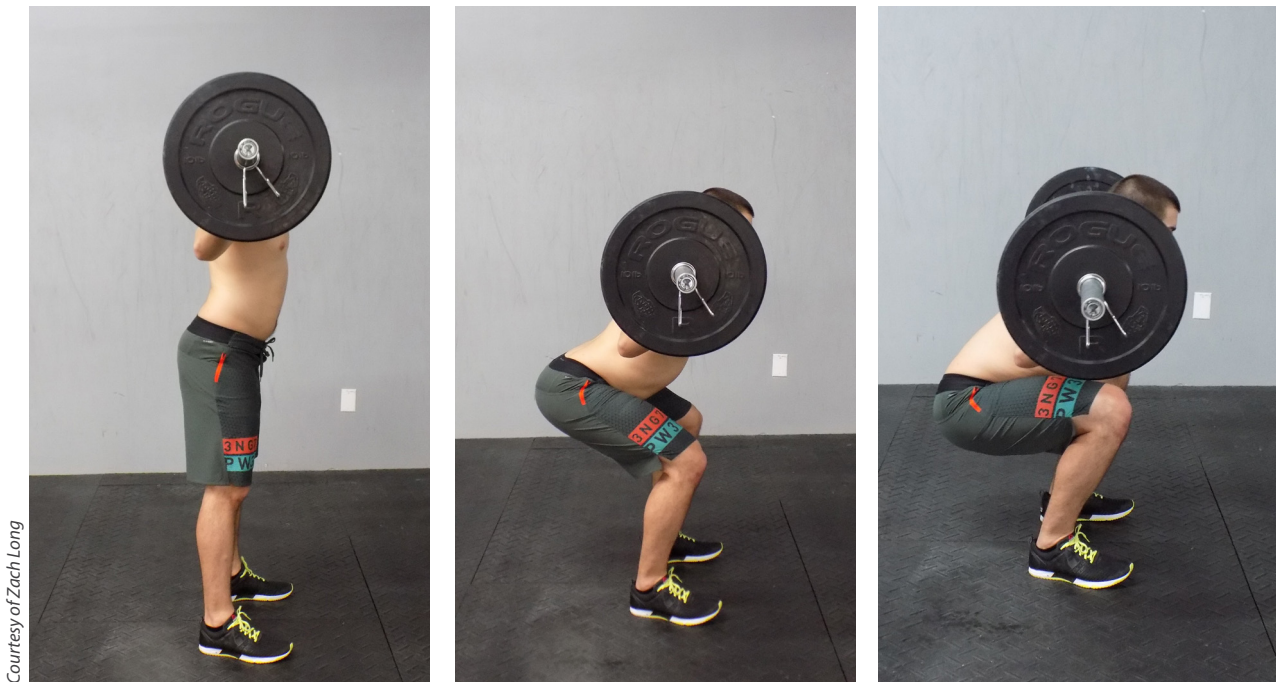
CrossFit Founder and CEO Greg Glassman has previously discussed what he referred to as muted hip function in the CrossFit Journal. Glassman stated some degree of muted

hip function is present in almost all athletes as they use knee extension rather than hip extension to produce power. Less-than-optimal recruitment of the glutes and hamstrings leads to poor spine positions, improper pelvic movement and excessive forces on the knee joint, with the ultimate effect being a “marked decrease in stability, balance and power” (3).

### LPHC Athlete Analysis

Analysis of the LPHC of a CrossFit athlete should begin with standing posture because it quickly and easily provides insight into likely dysfunctions. While looking at an athlete from the side, examine the lumbar-spine position and pelvic tilt. Many athletes will exhibit the overextended posture of lower crossed syndrome due to some combination of inhibited glutes and abdominal muscles as well as possible tightness of the hip flexors and lumbar extensors.

One easy way to identify these dysfunctions is to look at the waistline of the athlete. If the posterior waistline is higher than the anterior, he or she is likely demonstrating this syndrome. This posture can be seen in the initial position of the athlete in the squat sequence below.



***An overextended lumbar spine at the start of the squat may lead to hip impingement, and then lumbar flexion becomes necessary to reach full depth. This faulty pattern is referred to as a “butt wink.”***

### Testing Hip Flexibility

The Thomas test is a quick evaluation for tightness of the iliopsoas, rectus femoris and TFL. To perform the test, have the athlete lie on the back with buttocks on the edge of a table or box. Both knees should be pulled to the chest. Next, the coach should take one leg and slowly lower it while the athlete continues to hold the opposite leg to maintain a neutral spine.

With the test leg relaxed and lowered as much as possible, the coach should examine three things. First, does the tested hip reach full extension (0 degrees)? Failure to reach full extension indicates iliopsoas tightness. Next, examine the angle of the knee. In the absence of tightness of the rectus femoris, the knee should be at a 90-degree angle. If extended more than 90 degrees, rectus femoris tightness is present. Finally, the femur should not deviate laterally in the bottom position, as this would suggest tightness of the TFL.

An alternative test can be performed with the athlete lying on the stomach. The knee should be able to bend far enough for the heel to contact the buttocks. Inability to fully flex the knee without the hips rising off the ground or the lumbar spine extending would indicate tightness of the rectus femoris.

Hamstring flexibility can be easily tested with the athlete lying on the back. One leg is kept flat on the ground while the other is raised up with the knee straight. Hip-flexion angle should be examined at the point in which the athlete feels tension in the hamstrings or when the knee begins to bend. About 80-90 degrees of hip flexion is typically considered full hamstring flexibility. It is important that the non-tested leg remains flat on the ground and that the lumbar spine is positioned in neutral. Failure to maintain a neutral spine may anteriorly rotate the pelvis, which limits hip flexion and makes it appear that hamstring tightness is present when it may not be.

### Assessing LPHC Stability and Motor Control

The hip hinge provides great insight into an athlete's ability to load the hips while maintaining a neutral spine. The hinge is important for CrossFit athletes to master, as it is the foundational pattern of movements such as the deadlift, the Olympic lifts and the kettlebell swing.



Courtesy of Zach Long

***The Thomas test initial position (top); the athlete employing knee extension, indicating rectus femoris tightness (middle); the athlete showing good range of motion of the hip flexors (bottom). If the athlete cannot reach full hip extension, iliopsoas tightness is likely the cause.***



Courtesy of Zach Long

**Hip hinge performed with overextended and flexed spines.  
In some cases, lumbar flexion is much more dramatic.**

A dowel is placed along the athlete's spine so that it contacts the sacrum, thoracic spine and head (while the neck remains neutral). One hand holds the dowel in the arch of the low back, the other at the neck. With a slight knee bend, the athlete bends forward at the hips while striving to maintain a neutral spine by keeping the three points of contact between dowel and body. The athlete will flex at the hips until a stretch is felt in the hamstrings. In general, the athlete should be able to hinge low enough so that if the dowel was released and the arms lowered, his or her hands would be at approximately knee height.

During the hip hinge, failure to maintain contact with the sacrum indicates the athlete moves into lumbar flexion and cannot dissociate hip flexion from lumbar movement. This faulty movement may also be due to hamstring tightness. Inability to maintain thoracic-spine contact results from an athlete's tendency to move into lumbar hyperextension due to under recruitment of the abdominal muscles or glutes.

The trunk-stability push-up test provides excellent insight into an athlete's ability to resist lumbar extension and maintain a neutral spine. The athlete begins lying prone with the chest, stomach and hips on the ground. The knees should be extended so that they are not on the ground. The male athlete begins with his thumbs in line with his forehead and the female with thumbs in line with her chin; both have their hands at shoulder width and forearms raised off the floor. The athlete is instructed to ensure knees and elbows are off the ground before performing a push-up while keeping the torso rigid.

The coach watches to make sure the athlete doesn't reposition the hands lower before pushing and to ensure the entire body is lifted as a single unit. If the athlete is able to perform this movement, he or she has good core stabilization. If the athlete is unable to perform the movement, have the male reposition the thumbs in line with the chin and the female in line with the clavicle, then repeat (2). If the athlete is now able to complete the movement with proper technique, he or she has fair but non-optimal stabilization. If the movement is still unavailable, core stabilization can be considered poor. This test may also be limited by upper-body weakness in some individuals.

McGill, Childs and Liebenson have previously studied endurance times of side bridges and trunk extensions to identify normative ratios for trunk stability. Side bridges were performed by having the participant positioned on one side with the top foot in front of the bottom and legs extended. The participant assumed a straight line along the entire length of the body while supported on the elbow and feet, with the top arm resting on the chest. Time was stopped when the participant lowered the hips to the floor.

A modified version of the hip-extension test can easily be performed using a glute-ham developer (GHD). Position the GHD so the feet are firmly against the footplate and the athlete's body is parallel to the floor during the test. The athlete's anterior superior iliac spine should be resting on the GHD pad. The anterior superior iliac spine is the most anterior point that can be felt on the superior hip bone, usually approximately at the height of the waistline (see Figure 1 for its location).

A box is placed in front of the GHD about 25 cm under the top of the front pad and serves as the rest point before and after the test is performed. The athlete raises his or her body off the box with arms across the chest to begin the test, and time ends when the horizontal position cannot be maintained. The study found ratios of 0.65:1.0 in side-bridge-to-extensor endurance for men and 0.39:1.0 for women.

Large variations from these ratios may indicate holes in an athlete's core endurance. It is important to note that study participants were healthy and an average of 23 years old, so these ratios cannot be generalized to be applicable to all populations (5).

An altered version of the glute-bridge exercise that is commonly used in injury rehabilitation can provide good insight into an athlete's ability to recruit the gluteals. The athlete should lie on the back on a box or table. His or her feet should be positioned about 12 inches lower than the height of the box, with the knees bent to about 90 degrees. Have the athlete then perform 20 bridges by lifting the hips off the table. These bridges can be performed one leg at a time or both legs simultaneously.

After completion, ask the athlete what muscle group felt most worked—the hamstrings or the glutes? While both groups are active during this exercise, the position of the leg during this test should make the glutes the more



**Trunk-stability push-up performed with the entire body lifted while torso remains rigid.**



**An athlete demonstrates inability to stabilize the torso, resulting in a lag in the lower back.**

Courtesy of Zach Long



***Side-bridge (top) and extensor endurance tests.***



***Single-leg glute bridge to assess glute activation.***

active of the two. If the athlete indicates the hamstrings are more fatigued, he or she likely has some level of gluteal inhibition that should be addressed (8).

In his explanation of muted hip function, Glassman outlined the push press as the best way to identify an athlete exhibiting this dysfunction. Athletes with muted hip function will lose neutral spine and pelvic positioning during the last several reps of a 20-rep-max push press. This disadvantageous position will result in the hamstrings and glutes being improperly loaded for explosive hip extension and power being predominantly generated by the quadriceps. Glassman stated that this will often occur even in those with perfect squats, and it results in decreased stability and power (3).

Another easy analysis of glute activation can be observed during the lockout of the deadlift. Frequently, lifters will substitute hip extension performed by glute contraction for lumbar hyperextension on the last portion of the lift. This compensation may happen on initial reps or as the athlete becomes increasingly fatigued. Hyperextension at lockout places the lumbar spine under unnecessary stress.

The squat provides ample options for identifying dysfunctions in the LPHC as well as the rest of the body. For athletes with difficulty squatting to full depth, performing a goblet squat by holding a kettlebell in front of the chest or performing an assisted squat by holding a coach's hands during descent can provide insight into whether squatting is more limited by flexibility or stability deficits. If the squat pattern is normalized with these tests, stability is the primary factor, as the test alters the athlete's center of mass, allowing many to more easily find anterior-posterior stability during the squat (2).

The body-weight overhead squat test is another test variation commonly used in fitness assessments. The test is performed with the athlete standing barefoot in a hip-to-shoulder-width stance. The toes face forward, and the arms are raised overhead. The athlete is observed performing five squats from the anterior, lateral and posterior viewpoints. The coach observes for foot and ankle movement, lateral movements of the knee, trunk lean, lumbar-spine positioning, ability to maintain arms overhead, neck position, and weight shifting. Compensations can then be used to identify potential overactive and underactive muscles that limit functional movement patterns (4,6).



A more detailed explanation of the NASM's version of the overhead-squat test can be found [here](#) (4) and [here](#) (6).

### Correcting Dysfunctions

Addressing any dysfunctions found with tests such as those described above is important for optimal performance and injury prevention, but correcting dysfunctions often requires a long-term commitment for athletes.

A wide variety of treatment methods and philosophies can be used. Most commonly, decreased flexibility is improved using a combination of stretches, soft-tissue work and joint-mobilization techniques. Problems with stability and muscle activation are often addressed with progressive exercises designed to strengthen weak muscles and a variety of cueing methods to produce more desirable movement patterns.

No single treatment method is perfect, so the skilled coach will be open to differing philosophies and demonstrate the ability to individualize corrective strategies to each athlete.



Courtesy of Zach Long

*A push press performed by loading the glutes and hamstrings (top) vs. quad-dominant execution (bottom).*



*The assisted squat or goblet squat decreases stability requirements without reducing the flexibility requirements of the movement.*

### Conclusion

These tests constitute a good baseline assessment of the lumbo-pelvic-hip complex of the CrossFit athlete. Testing and addressing dysfunctions in flexibility, stability and movement patterns of athletes can and should be performed by CrossFit coaches, as well as by athletes themselves.

Implementation of corrective strategies by the modern fitness professional is wise. In the presence of pain and injury, referrals should be made to appropriately trained medical professionals.



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