# STABILITY AND THE SQUAT: FRONT-LOADED VERSUS BACK-LOADED SQUATTING—PART 4

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Over the previous three articles of this four-part series, many different aspects of stabilization in strength training were discussed. The first article covered proper trunk (or spinal) stabilization (25). The second article introduced the concept of functional capacity (FC) and described a compensatory stabilizing strategy in the strength training population called the extension/compression stabilizing strategy (ECSS) (26). The third article introduced exercises designed to increase an athlete's FC for proper trunk stabilization to address the athlete resorting to the ECSS (27). The final installment of this series on stabilization will focus on a common exercise utilized in strength training: the squat. To many strength and conditioning coaches and athletes, the squat is a pillar of lower body training. For those involved in functional training and who utilize functional assessment, the squat is also of central importance.

As pervasive as this movement is in strength training and rehabilitation, it is often taught in a way that perpetuates the ECSS. This article will compare different squat variations as they pertain to stabilization and discuss technique that preserves and promotes proper stabilization strategies. The purpose is to shed light on these issues in hopes of helping to better apply the concepts covered in this series of articles more effectively in training (25,26,27).

## REVIEW OF TRUNK STABILIZATION

Through the work of researchers and therapists, it is known that proper stabilization of the spine results from two major mechanisms:

- Co-contraction of the torso musculature (8,10,13,14,15,21,23)
- Intra-abdominal pressure (IAP) (2,8,9,10,13,14,15,18,21,23)

Pavel Kolar, a physiotherapist from the Czech Republic and creator of Dynamic Neuromuscular Stabilization, has demonstrated that both mechanisms are driven by the thoracic diaphragm (13,14,15). Attaching to the lower four ribs and the spine at the thoraco-lumbar junction, the diaphragm is located between the thoracic and abdominal cavities (Figure 1) (24). It has a horizontally-oriented central tendon surrounded by vertically-oriented muscle fibers. The diaphragm works with the abdominal wall and pelvic floor to control and stabilize the trunk and spine (13). During a concentric contraction, the central tendon is pulled downwards, approximating it with the pelvis (24). This motion compresses the abdominal contents, pushing them into the torso musculature (abdominal wall, pelvic floor, and dorsal muscles, such as the erector spinae and quadratus lumborum), resulting in co-activation of these structures. At lower force outputs (e.g., getting up out of a chair, bending down to tie one's shoes, or raising a hand to wave to a friend), this co-activation, combined with the inherent passive stability provided by the skeletal and fascial systems, is where the vast majority of trunk stability results (13,23).

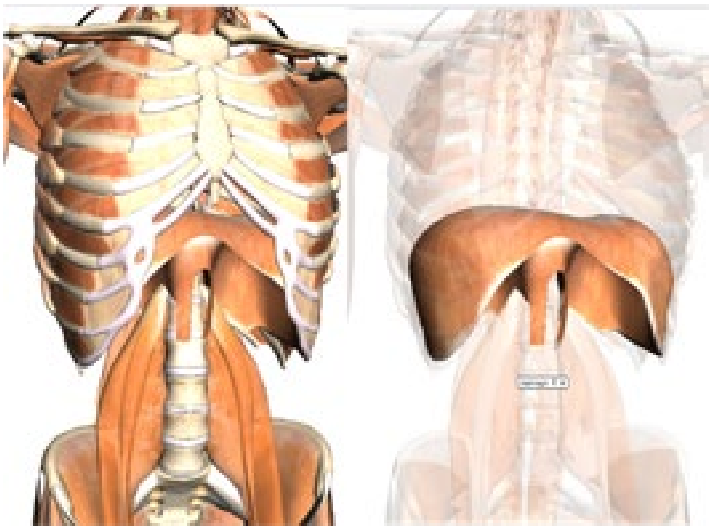

FIGURE 1. DIAPHRAGM

At higher thresholds, however, such as in the bottom of a heavy squat, an athlete will need more than just co-contraction of the torso musculature to meet the increased stabilization demands of the task—the athlete will also need IAP. Assuming the temperature and contents within a container remain constant, the only way to change the pressure within the container (such as the abdomen) is to alter the volume. This is known as the ideal gas law, the equation for which is: $PV = nRT$ (3). This law demonstrates that pressure and volume are inversely related. In regards to stabilization and IAP, this law is of central importance. By decreasing the volume of the abdominal cavity, athletes are able to increase the pressure within it. Therefore, to maximize trunk stability, which is often necessary in strength training and sports in general, the athlete needs to shrink the volume of the abdominal cavity to raise the pressure within it (8,10,13,15,18,23). This results from the diaphragm, abdominal wall, and pelvic floor working together to control the volume and, therefore, the pressure within the abdomen.

During a stabilizing event where maximal rigidity or stiffness of the trunk and spine is necessary (e.g., at impact of a kick by a mixed martial artist or during the pull of a one repetition maximum [1RM] attempt in the deadlift), the diaphragm must strongly contract to approximate its central tendon with the pelvic floor. Such an action creates a powerful outward-pushing force into the abdominal wall. In lower threshold activities, such as raising a cup of coffee to the mouth, the abdominal wall will eccentrically react to this outward-pushing force until the necessary abdominal volume (and therefore stability) has been achieved. In a maximal bracing event, however, the abdominal wall must increase its stiffness to minimize its lengthening (expansion). As the diaphragm continues to contract and approximate its central tendon with the pelvis, the abdominal wall must hold its position in a strong isometric contraction, reducing the abdominal volume to as small as possible. This reduction in volume not only generates a massive amount of IAP, but also creates a powerful co-contraction of the torso musculature, the combination of which results in the desired torso stiffness. In movements like the squat or deadlift, the athlete is attempting to make the torso as rigid as possible and the muscles are isometrically activated. Maintaining such rigidity of the torso requires utilization of both IAP and a strong co-contraction of the torso musculature.

Another principle put forth by Pavel Kolar that is very relevant to lifting technique is that if attempting to maximize these two mechanisms, an athlete needs to maintain a parallel alignment of the thoracic diaphragm and pelvic floor (Figure 2) (13). This is important for two main reasons:

1. In this position, because of the muscle fiber alignment, the thoracic diaphragm is able to maximally approximate its central tendon with the pelvis. This results in an optimal and efficient reduction of the intra-abdominal volume, enabling the athlete to generate more IAP when necessary.

2. This position is such that all of the muscles of the abdomen are able to eccentrically react to the outward-pushing force created by the descending diaphragm. This enables the athlete to co-activate all of the torso musculature instead of only a portion of them.

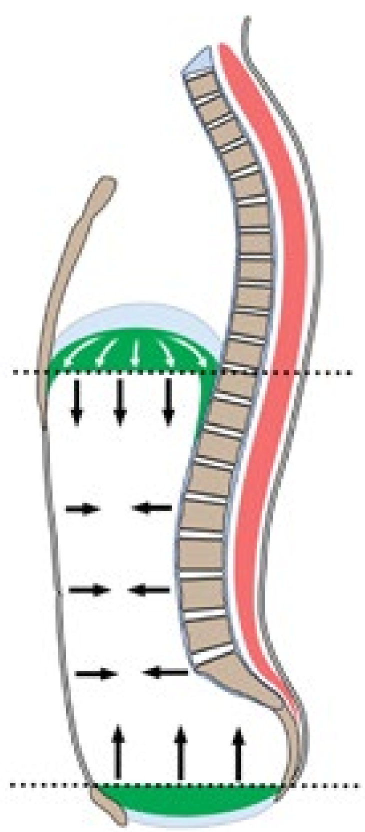

**FIGURE 2. PROPER STABILIZATION – SIDE VIEW**

Because of the significant stability requirements involved, proper lifting technique mandates that an athlete maintain alignment of the torso in such a position that they are able to utilize co-activation of the torso musculature and IAP. Therefore, concerted efforts must be applied to preserve a parallel relationship between the diaphragm and pelvic floor. If such a relationship is lost, then the athlete will be forced to compensate, which ultimately compromises function and performance. Unfortunately, for a variety of reasons, such a loss of positioning is common in strength training.

## REVIEW OF THE ECSS

In such situations where the athlete loses this optimal (parallel) orientation of the diaphragm and pelvic floor, they are often forced into a compensatory stabilizing strategy referred to as the ECSS. Because of the postural alignment (elevated chest, hyperextended lumbar spine, and anteriorly tilted pelvis) associated with this strategy, generating maximal IAP or achieving co-activation of the torso musculature can be difficult, if not impossible (13). Instead, the athlete must generate torso stiffness via hyper-activation of the spinal extensors and hip flexors. This hyperactivity extends the lumbar spine and pulls the pelvis farther into an anterior tilt. In this position, the abdominal wall and gluteal muscles are weak and inhibited, and the diaphragm and pelvic floor are oblique to each other in the sagittal plane (Figure 3) (11,13). Here, the only means by which the athlete is able to stabilize the trunk is through extension and compression of the lumbar spine.

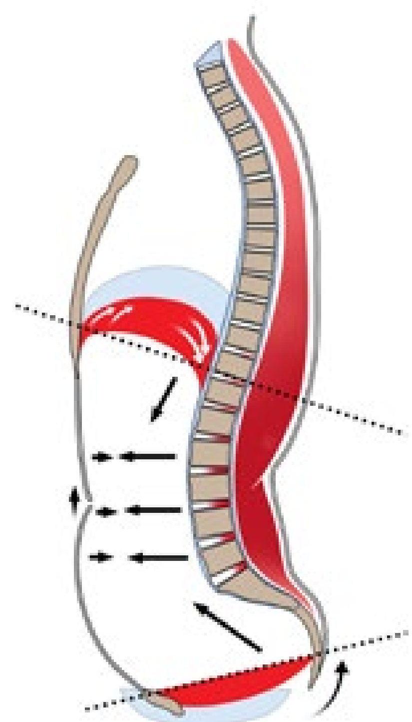

**FIGURE 3. POOR STABILIZATION STRATEGY – SIDE VIEW**

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What is unfortunate is that the ECSS is not only a byproduct of training, but is even internationally sought after by strength and conditioning coaches and athletes all over the world. This is perhaps most evident in the strength and conditioning industry's obsession with the posterior chain. For example, popular websites have articles specifically designed to train the "posterior chain," (Figure 4). There is no question that the posterior chain is important, even essential to function (particularly in weight training), but balanced co-activation between the posterior chain and other muscles involved in the movement is essential for optimal function (13). Over-emphasis on the posterior chain can potentially lead to injury, movement dysfunction, stubborn technical flaws, and even decreased performance.

The strength and conditioning industry's love of the posterior chain is prominently manifested in technical cuing and exercise selections. Common cues like "butt back, chest up," "find your hamstrings," and "sit back on your heels" all hyper-emphasize the posterior chain, thereby, perpetuating the ECSS. In programming, it is common to see a workout with power cleans, back squats, Romanian deadlifts (RDLs), and supermans superset with hyperextensions on the glute-ham developer for "core training." While each of these exercises has its place in strength training, this combination over-emphasizes the posterior chain and, therefore, fosters the ECSS. Athletes need to be cued properly and programs constructed in a way that trains proper stabilizing strategies instead of strengthening the athletes' compensation patterns.

FIGURE 4. POSTERIOR CHAIN

## REVIEW OF PERTINENT BIOMECHANICS

In regards to trunk stability in weight training, there are many factors that make proper stabilization difficult, often even preventing it all together. This article will focus on torque. Torque is defined as a force that has the ability to cause rotational force around an axis (7). In the body, axes are found in close proximity to the joints (due to the shape of the joint surfaces, axes are not always within the joints themselves) and the torque acting on these axes is generated by the muscles. Muscles create force around an axis (joint) to prevent, control, or create motion; in each case, torque is being generated regardless of whether movement occurs or not.

In regards to biomechanics and weight training, there are two major categories of torque affecting a movement: torque generated by muscles (henceforth referred to as the effort) and torque generated by the load (henceforth referred to as the resistance). In strength training, or any movement for that matter, the effort torque ($T_E$) works with or against the resistance torque ($T_R$) to execute the movement (Figure 5).

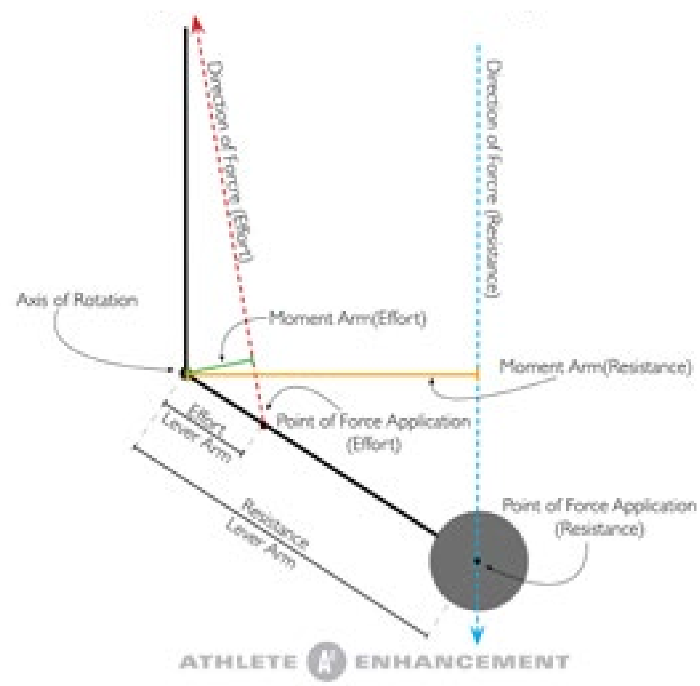


FIGURE 5. COMPONENTS OF A LEVER SYSTEM

While there are many forms of external force (e.g., friction or inertia) that may contribute to the force profile of the movement, this article will focus on one force, gravity. This is the main force discussed or quantified when lifting and is one of the main variables manipulated in training. If an athlete was asked "what is your deadlift max?," he or she would respond with a number which represents the weight on the bar, which is a quantification of the gravitational force involved in the movement.

The equation for torque is T = force x moment arm (17). The moment arm is not an actual physical structure, it is the shortest distance from the axis to the direction of force; as such, it is a straight line and is perpendicular to the direction of force (17). In the squat, unless using weight releasers, resistance bands, or chains, the load (force) does not change. However, as long as the athlete is in motion, the length of the moment arms involved are in constant flux. This means the torque output necessary to execute the movement is constantly changing. As the moment arms acting on all the joints participating in the movement (e.g., hip, knee, and ankle mortise) lengthen and shorten, the torque output necessary to overcome the load in a given position change (Figure 6). The proportionate length of the effort moment arm relative to the length of the resistance moment arm is one of the main variables dictating an athlete's biomechanical advantage (or disadvantage) over the load—a huge factor influencing proper technique. It is also one of the major factors affecting the effort or difficulty to maintain proper trunk stabilization strategies. The higher the necessary torque output, the more difficult it is to maintain proper positioning (the more effort is required), the more likely an athlete will exceed their FC for this force output, driving them to compensate with the ECSS. This is most evident at the bottom of the squat. Because of a significant increase in moment arm length, it feels much more difficult to hold proper positioning than in the top of the squat.

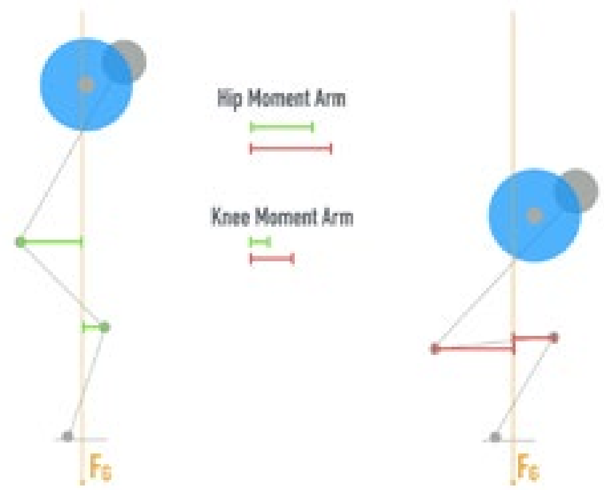


FIGURE 6. MOMENT ARM LENGTH CHANGE IN THE SQUAT

## COMPARISON OF SQUAT VARIATIONS

While there are a large variety of squat variations in strength training, putting athletes in slightly different positions, this article will focus on the three main variations: high bar back squat (HBBS), low bar back squat (LBBS), and front squat (FS). In each of these movements, the athlete seeks to stiffen their torso in an attempt to make it as rigid as possible, essentially converting their 24-segment spine into one solid unit. Assuming proper technique, the spine should not move in the squat, it should only change orientation. All of the motion should occur at the hips, knees, ankles, and feet. To accomplish this with the greatest success, the athlete needs to utilize both a strong co-contraction of the torso musculature and IAP. This is particularly important at maximal and near-maximal loads, where the torque output ($T_E$) is very high.

Because of morphology and change in bar placement, each of these squat variations has different degrees of difficulty to maintain a proper trunk stabilization strategy. Assuming a constant load, the main factor affecting torque output is the length of the moment arm acting on the spine. As stated above, in a squat, the athlete is attempting to stiffen their torso to block any and all motion within the spine. In reality, there is an axis at each of these joints and, therefore, a moment arm lengthening and shortening as the athlete executes the movement. For clarity, this article will assume that torso stiffness is maintained so that only one moment arm acting on the torso is considered (Figure 7).

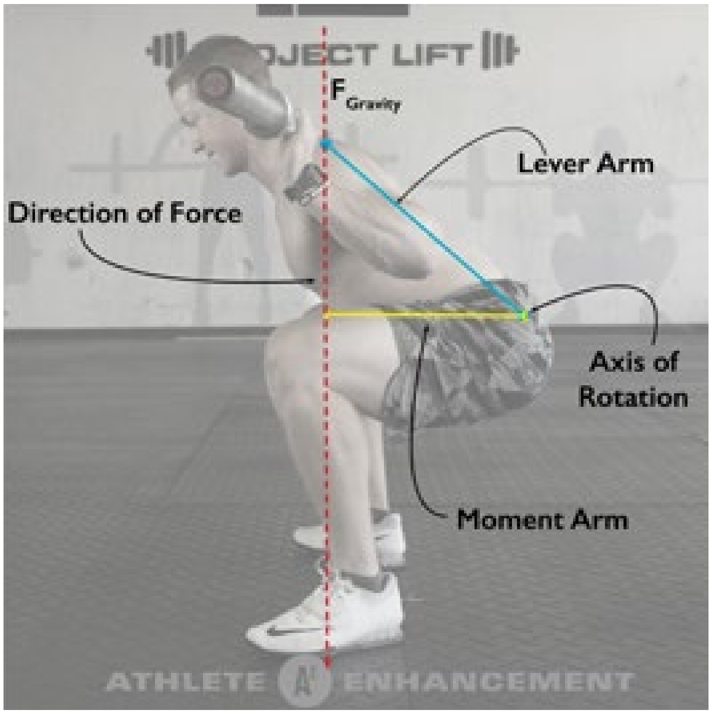


FIGURE 7. SQUAT BIOMECHANICS

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When torso stiffness is preserved, the trunk functions like a rigid lever arm, it remains stiff and does not change length. In a lever system, the lever arm is the distance from the axis to the point where the force is applied (i.e., the point of application) (17). Unlike a moment arm, the lever arm does not change length. A good example of this is the femur (thigh bone). During a squat, the hip will flex and extend. This motion changes the position of the femur (a lever arm), which alters the length of the moment arm acting on the hip, but the length of the femur itself does not change. In an ideal situation, when torso stiffness is preserved, the length of the spine does not change in the squat.

With the torso acting as a rigid lever arm in the upright position, the moment arm is very small. However, as the athlete descends in the squat, and the torso angle becomes more horizontal, the moment arm becomes longer and the effort torque necessary to overcome the resistance significantly increases. Torso orientation, therefore, has a strong impact on the necessary torque output of the spine during a squat. This was demonstrated recently when researchers found increased activity of the trunk muscles with the trunk at 30 degrees versus the trunk at 0 degrees (6). Essentially, due to the increased torque demand, the flatter the torso angle, the more difficult it is to both maintain this orientation and to preserve the desired stiffness of the torso. This increases the likelihood that the athlete will be forced to compensate and resort to the ECSS.

Because of the difference in bar placement between these squat variations (HBBS, LBBS, and FS), the torso angle necessary to achieve a full-depth squat is different. The squat with the most vertical torso angle is the FS. Because the bar is placed in front of the spine, the torso is more vertical; therefore, the effort necessary to maintain proper posture of the trunk is less than that of the back squat variations (Figure 8).

The squat with the next most vertical torso angle is the HBBS. Unlike its low bar counterpart, the HBBS utilizes ankle mortise dorsiflexion. Because the tibia, femur, and spine are all connected by joints, there is an inverse relationship between the angle of the shin and the angle of the torso—the more horizontal the shin, the more vertical the spine and vice versa (Figure 9). Because the HBBS utilizes ankle mortise dorsiflexion, the tibia moves from a vertical position to a more horizontal one (via dorsiflexion of the ankle mortise joint and pronation of the foot) as the athlete descends, which results in a more vertical spine angle at the bottom of the squat. As such, the effort ($T_E$) to maintain torso positioning is less.

The squat with the flattest torso angle is the LBBS. This is because in the LBBS, athletes seek to maintain a more vertical shin angle (sometimes completely vertical) during the squat. In the LBBS, athletes often attempt to mitigate any ankle mortise dorsiflexion to 1) limit the total range of motion of the squat, resulting in less work (force x distance) and 2) maximize utilization of the hips, perhaps the most powerful of the lower extremity joints. The cost of this is a more horizontal torso angle. If the athlete kept the same bar placement as a HBBS (Figure 10), the moment arm(s) acting on the spine would be extremely long, increasing the difficulty ($T_E$) of maintaining proper positioning. To account for this, athletes will lower the bar placement, which shortens the moment arm(s) acting on the spine, making it easier to maintain the given torso angle. Because of the more horizontal torso angle in the LBBS, maintaining appropriate posture and a proper stabilizing strategy is extremely challenging compared to the other squat variations. This means that it is more likely that athletes will be forced to compensate into an ECSS to maintain the necessary torso rigidity in the LBBS than in the HBBS or FS.

Another factor making proper stabilization more challenging in some squat variations is bar placement. Independent of the torso angle, it is much more difficult for athletes to stabilize properly in the squat when the bar is placed on the back as opposed to front-loaded squats, such as goblet squats or FS. Perhaps because of the tactile input on the back, in both the HBBS and


FIGURE 8. COMPARISON OF TORSO ANGLE IN THE SQUAT

the LBBS, athletes typically extend their spines to handle the load. This action activates the ECSS, resulting in an inability to stabilize properly.

This is most pronounced in the LBBS. Because of the more horizontal spine angle in the LBBS, the athlete needs to lower the bar placement to shorten the moment arm(s) acting on the spine. This does improve the athlete's mechanical leverage over the resistance (load); however, because of the lower bar placement, athletes frequently arch their lower backs excessively to support the load. Because of the propensity to force the athlete into hyper-extension of the lumbar spine, back-loaded squats will more likely perpetuate the ECSS; and with it, bring the consequences in movement, technique, and performance. This is not to say that these movements should be avoided in strength training, but rather, they should be used purposefully and perhaps programmed with other ECSS-breaking exercises, such as those covered in the previous article (27).

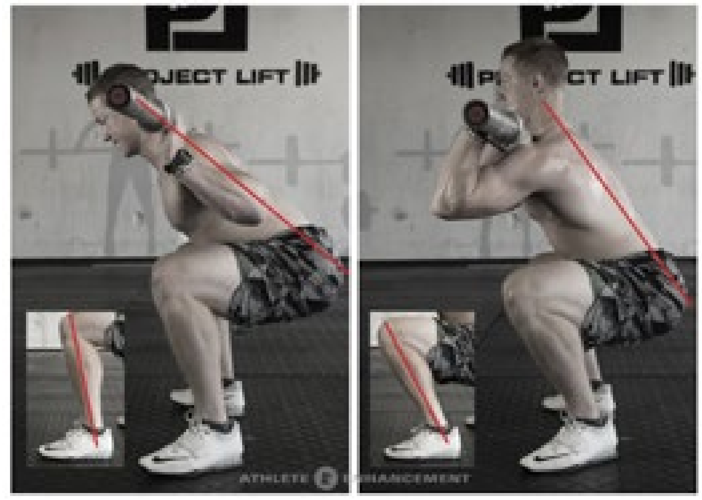

FIGURE 9. SHIN VERSUS SPINE ANGLE

## CONSEQUENCES OF SQUATTING WITH THE ECSS

One significant cost in movement that comes with using the ECSS in the squat is a reduction in available hip flexion range of motion. Regardless of the squat being performed, hip flexion range of motion is a key factor. As the athlete descends in the squat, the hips undergo flexion. Once the athlete's hip flexion range of motion has been exhausted, they have a choice: stop at that depth or continue to squat with a compensatory movement strategy. If the athlete continues the squat, they will often do so with flexion of the lumbar spine (i.e., "butt wink") to get down to the desired depth. As has been proven many times in research by several researchers, this loaded, flexed position at the bottom of the squat is undesirable because of its link to spinal disc injury (20,21).

Unless an athlete is performing an assisted safety squat with their hands holding onto the rig and maintaining a perfectly upright torso, squatting to or below parallel without any loss in spinal position requires a minimum of 100 degrees of hip flexion range of motion. It actually takes closer to 120 degrees, if parallel is defined as the hip crease level with the top of the knee. Most people have between 110 and 120 degrees of hip flexion available (19). This means that, in most cases, athletes need virtually all of their available hip flexion range of motion to achieve a full-depth squat. Any loss in hip flexion range of motion, therefore, may result in an undesired flexed position at the bottom of the squat.


FIGURE 10. BAR PLACEMENT

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One of the consequences with using an ECSS is that it affects pelvis position. People often associate an anterior pelvic tilt with lumbar extension. While this is most certainly the case, what is overlooked is the fact that when standing, as in a squat, the anterior position of the pelvis occurs as a result of closed-chain hip flexion (movement of the pelvis on the femur) (Figure 11). When an athlete stabilizes with an ECSS, the pelvis is anteriorly tilted. As discussed in previous articles, trunk stabilization precedes movement (9,10,23,25,26,27). This means that before an athlete even gets under the bar, if they are under the control of the ECSS, they have less hip flexion range of motion available to them for the squat due to the starting (postural) position of the pelvis. If an athlete happens to have typical hip flexion range of motion (e.g., 120 degrees total) and the pelvis is anteriorly tilted 30 degrees because of the ECSS, then the athlete only has 90 degrees left to use for the squat. As the athlete descends to just above parallel, they will likely lose their spinal position and compensate into spinal flexion. If, however, this athlete started with the pelvis in a neutral position, the athlete would have been able to squat below parallel without any loss in spinal position (assuming no other functional blocks, such as limited ankle mortise dorsiflexion, are present).

The requisite hip flexion range of motion necessary for proper execution of a squat is different for each variation. As discussed above, due to the changes in loading position of the bar, the HBBS, LBBS, and FS all have different torso angles. The more horizontal the torso angle in a given squat, the more hip flexion is required to execute this squat without compensatory loss in

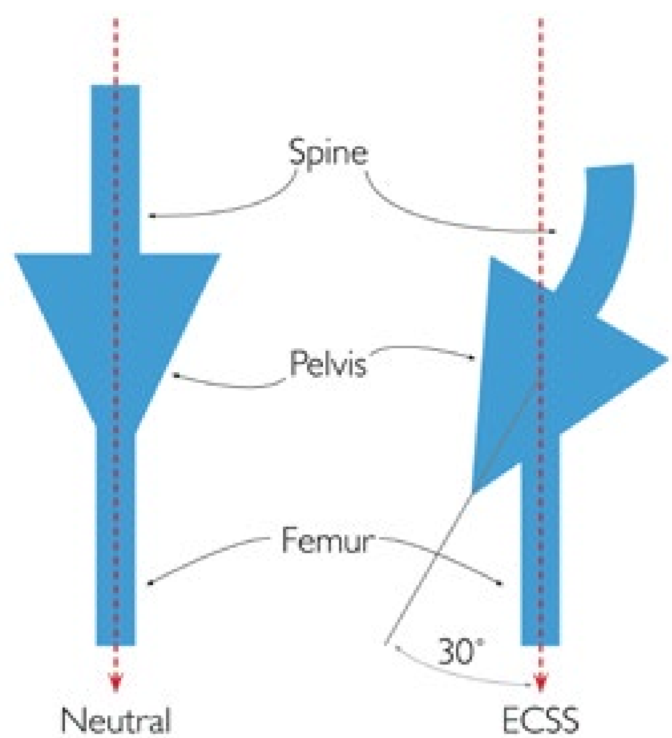


FIGURE 11. COMPARISON OF PELVIS POSITION

spinal position (Figure 12). Because the bar is loaded in front of the torso, the FS has the most upright torso angle and, therefore, requires the least amount of hip flexion range of motion to achieve full depth. Strength and conditioning coaches may have noticed that athletes typically are able to squat deeper in the FS than the back squat, or that the "butt wink" occurs later (deeper) in the squat motion; this is why. While the HBBS has a similar shin angle to the FS, because the bar is loaded on the back, the torso angle is flatter, which again, occurs through closed-chain hip flexion. Even though they have similar shin angles, squatting to full depth requires more hip flexion range of motion in the HBBS due to the more flattened spine angle.

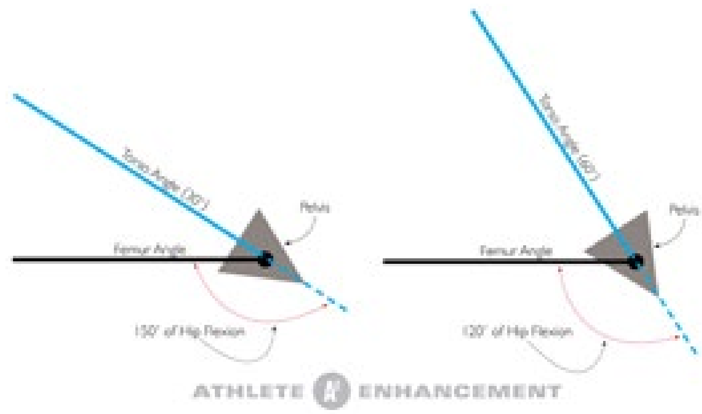


FIGURE 12. COMPARISON OF HIP FLEXION RANGE OF MOTION IN THE SQUAT (RELATIVE TO TORSO ANGLE)

The squat with the flattest spine angle and which requires the most hip flexion is the LBBS. Because the shin angle remains almost vertical, the spine angle in the LBBS is significantly more flat than the HBBS and the FS. Therefore, executing the LBBS without any loss of spinal position requires an abnormal amount of hip flexion range of motion. If the athlete lacks this prerequisite hip flexion range of motion, the athlete will be unable to achieve the desired depth without lumbar flexion.

## SQUATTING TECHNIQUE

One of the main objectives in the squat is to preserve proper positioning of the torso. This enables a strong co-contraction of the torso musculature and allows maximal IAP to be generated, resulting in improved torso stiffness for increased performance and safety (13). Proper torso positioning for the squat involves the following:

- Elongated spine
- Pulled down ribcage (without loss of spinal positioning)
- Neutral pelvis (iliac crest pointing upwards towards the ribcage)
- Activated abdominal wall (not sucked in, but pushed against, as described above)

Because of the increased loads common in the squat and athletes' natural desire to push themselves, maintaining this position can be rather difficult. Additionally, executing a squat with the above described torso position requires good functional competence. If an athlete, for example, lacks sufficient hip mobility, ankle dorsiflexion range of motion, or adequate stability of the lumbar spine, then then the athlete is more likely to compensate, which often results in activation of the ECSS.

To maintain proper torso position, the athlete will need to brace for a movement. To accomplish this, the athlete must think about keeping the spine long and then pressurizing the abdomen. Pressurizing the abdomen is driven by concentric contraction of the diaphragm and it feels like one is bearing down (13). There is no drawing in of the abdomen or concentric contraction of the back muscles (spinal extensors). The athlete should think about stabilizing from the inside out. As the athlete braces, it is important that the elongated spinal position is not lost. When done properly, the athlete's ribcage will be pulled downward secondary to activation of the internal and external obliques. Often, when an athlete attempts to pull their ribs down, they will flex their spine instead of downwardly rotating the ribs on the spine (more specifically, downward rotation of the ribs at the costovertebral joints); the resulting flexed position of the spine is undesirable in a squat. Stabilizing properly in the squat is often surprisingly difficult and may require specific exercises to teach the athlete how to execute this stabilizing strategy. For examples of such exercises, please refer to the previous article (27). Once the athlete is able to stabilize the trunk properly without load, then the athlete is ready to squat.

To improve an athlete's chances of maintaining proper torso alignment, within the limits of human morphology, an athlete is attempting to maintain as vertical of a torso orientation as possible; however, an athlete does not want to do so at the expense of the torso alignment, stabilizing strategy, or knee positioning.

In regards to the knees, they should be allowed to travel forwards as long as the athlete does not lose full-foot loading or they do not travel excessively beyond the toes (5). The knees typically travel 1 – 2 in. past the end of the toes as the athlete passes through parallel, and regress back over the toes in the bottom of the squat. Moving the knees forward does help upright the torso angle (because there is an inverse relationship between shin and torso angle), but there is a point of diminishing returns. The farther the knees travel past the toes, the longer the moment arm acting on the knees (Figure 13), which increases the torque demand on the knee extensors, potentially increasing the risk of injury to this joint.

Once the bar is set and the athlete has stepped away from the rig, the athlete needs to increase their torso stiffness in preparation for the squat. To do so, the athlete will take in a breath and then, without losing the elongated spinal position, pressurize the abdomen (through a concentric contraction of the diaphragm). A good coaching cue is to "push out into your sides." "Push into your

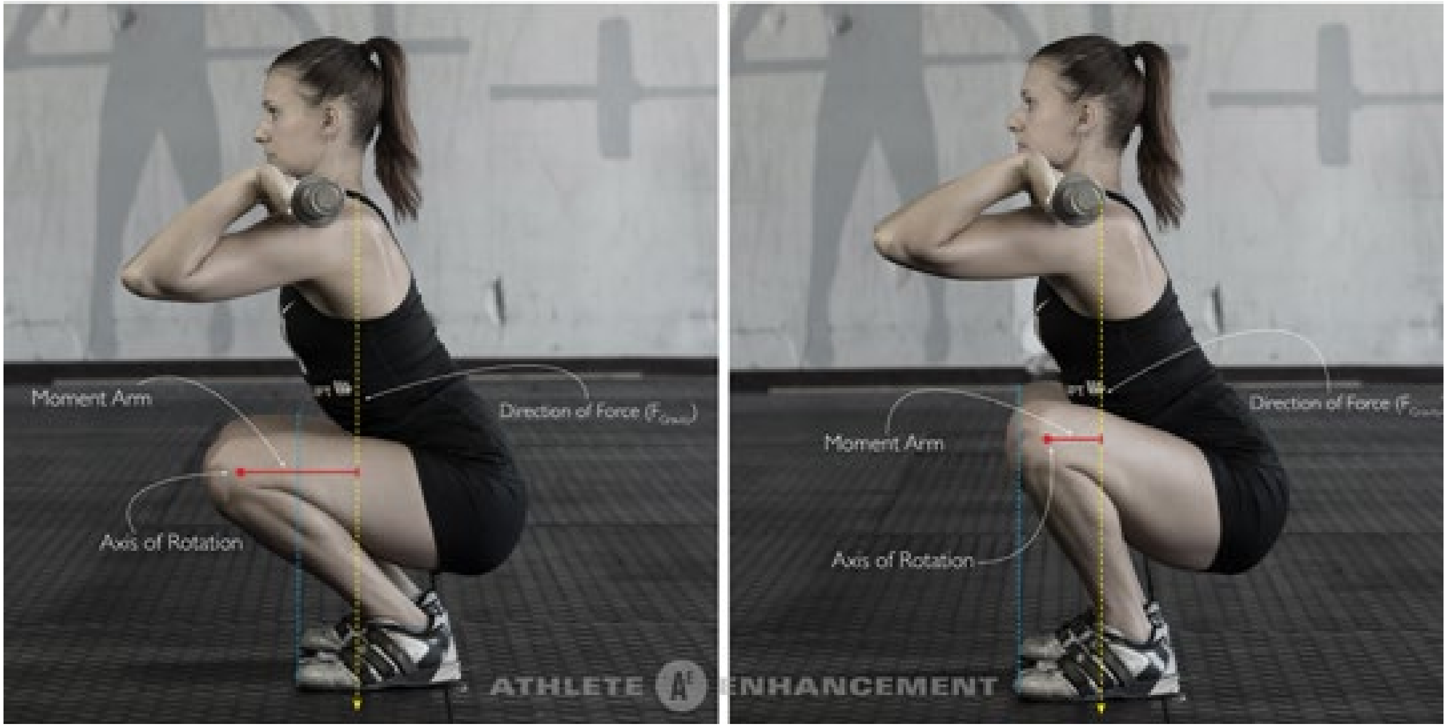


**FIGURE 13. COMPARISON OF KNEE POSITION IN THE SQUAT**

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belly" is a commonly used cue, but may not promote a proper stabilizing strategy; it usually results in the athlete arching the lumbar spine to increase the pressure pushing forwards. If the athlete braces properly, they should feel the entire abdominal wall activate, which pulls the ribcage downward due to the activation of the internal and external obliques. Again, the action of pulling the ribcage down should not compromise the elongated spine position. Now that the torso is positioned and ready, the athlete can begin the squat.

In the squat, the bar path should be (mostly) vertical. There is, however, a setting phase where the athlete goes from standing up straight to getting into position. During this initial phase, the athlete will unlock their knees, let the hips slide back, and, in order to maintain full-foot loading, allow the torso to tilt forwards slightly. In this set position, the full foot will be loaded, the knees will be slightly bent (patella over the midfoot), and the barbell will be just in front of the toes (Figure 14). From this position, the athlete will allow the knees to move forward and the pelvis to move backward simultaneously. Once the knees have translated


**FIGURE 14. SQUAT SET POSITION**

forward over the toes (or perhaps 1 – 2 in. past the toes), they will stop and the pelvis will continue to move down and back until the desired squat depth has been achieved.

The athlete does not need to think about moving their torso, just maintaining its rigidity. If the athlete keeps the entire foot loaded, the spine position in the squat results from what the knees and hips do. As the athlete descends towards parallel, the torso angle will become increasingly more horizontal because the pelvis will continue to move backwards. As this happens, the moment arms acting on the spine will lengthen until they reach full length at parallel. As the moment arms lengthen, the torque the body needs to generate increases ($T_{Effort}$). This increased torque demand means that this position is more difficult to maintain; therefore, the athlete will have to work harder to maintain proper torso stiffness. So, as the athlete approaches parallel, they will have to focus on increasing the magnitude of the brace. What often happens is that the athlete starts in a good position, but as the athlete descends into the squat, lacking the strength to maintain proper torso position, the athlete will compensate into the ECSS. For this reason, focused effort to keep the ribs down and the abdomen braced needs to be applied, while not allowing the spine to be pulled into a flexed position.

A common coaching cue that prevents athletes from maintaining proper alignment (and perpetuates the ECSS) is "chest up." This cue is not bad in all situations, but the mentality that the chest must remain upright at all costs often causes athletes to arch their lumbar spine and elevate their ribcage, breaking the parallel relationship between the diaphragm and pelvic floor (Figure 15). Strength and conditioning coaches express this "avoid flattening of the torso angle at all costs" mentality in drills like wall-facing squats (Figure 16), which teaches the athlete to maintain an upright torso and forces them into a hyperextended position in which they have no alternative but to use the ECSS. This mentality perpetuates an environment where athletes are often afraid of a more horizontal torso angle. This position, however, is natural in a quality squat where proper torso alignment is preserved. Strength and conditioning coaches should allow the athlete to achieve a more horizontal torso angle in the squat. This will allow the athlete to preserve torso rigidity during the movement with a proper stabilizing strategy. Once the load reaches a magnitude where the athlete is unable to stabilize properly, the load can either be decreased or the strength and conditioning coach could limit the athlete's range of motion.

## CONCLUSION

Squatting may be commonplace in the weight room, but proper execution of this great exercise is difficult. Strength and conditioning coaches will need to properly select exercises and cue their athletes in a way that not only allows for a proper stabilizing strategy to occur, but promotes it. Considering all the

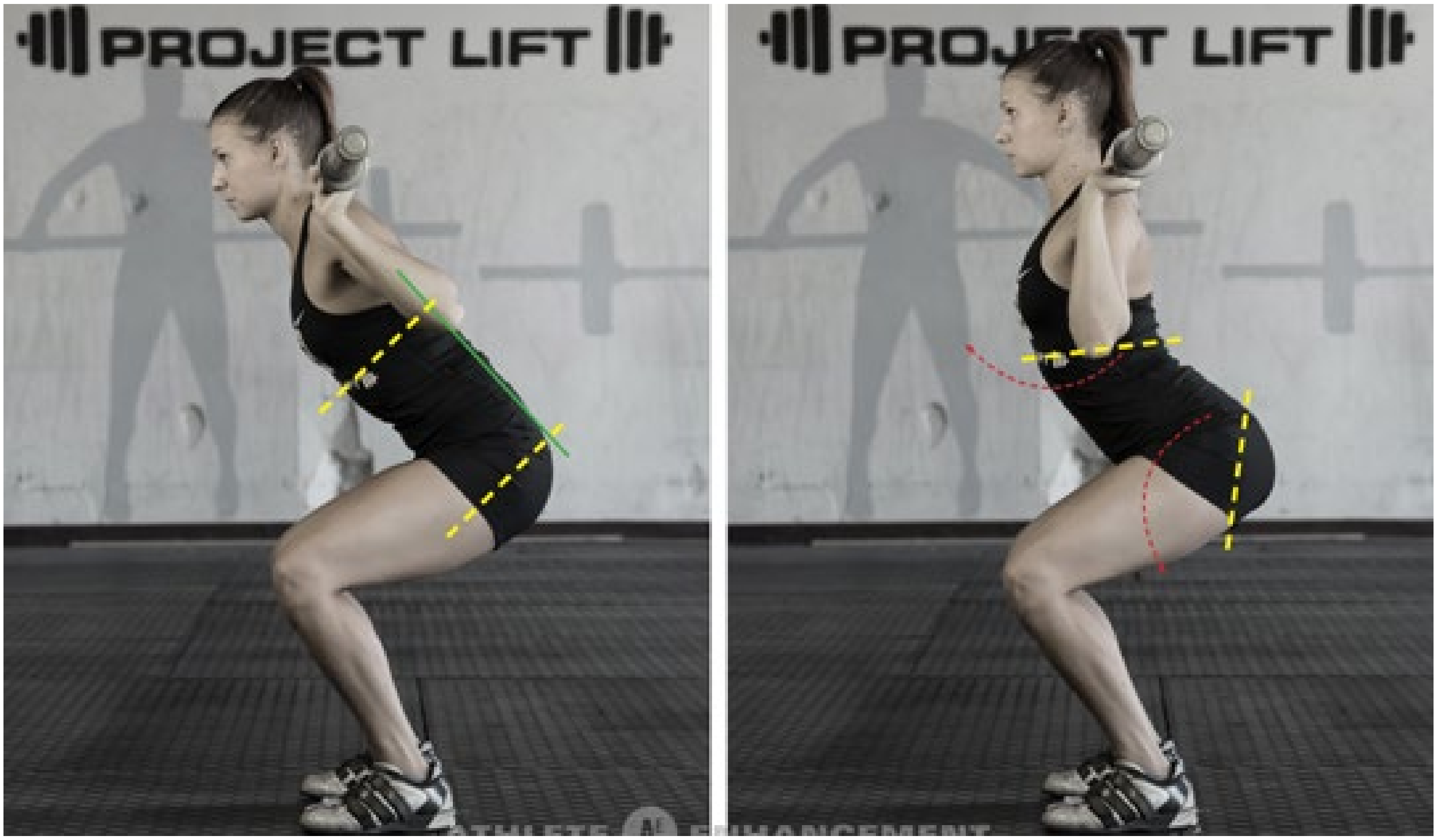


**FIGURE 15. COMPARISON OF SQUATS**

variables discussed above, it is the author's opinion that the squat variation that most favorably trains proper trunk stability, and which, therefore, should be favored in programming, is the FS. Both the LBBS and HBBS certainly have their place in strength training, but strength and conditioning coaches need to be aware of the high propensity of these movements to foster the ECSS and potential lower back injury due to the increased likelihood of loading the lumbar spine in flexion (20,21). Also, strength and conditioning coaches will likely need to program auxiliary exercises to improve their athlete's functional competence so that they are able to squat with the proper technique described in this article. When programming and coaching the squat, the strength and conditioning coach should be cognizant of the athlete's torso alignment and allow them to go into a more horizontal spine angle as long as they are able to maintain proper torso alignment. Remember, the ECSS is a compensation for trunk instability. As such, it comes with a cost: deceased functional competence, stubborn technical flaws, higher propensity for disc injuries, and even limiting performance. In making the transition from technique where the ECSS is utilized to the one that is described in this article, strength and conditioning coaches may find that it takes a few sessions to figure it out. However, strength and conditioning coaches and athletes will quickly discover that squatting with proper torso alignment can be extremely rewarding.

**FIGURE 16. WALL-FACING SQUAT**

RICHARD ULM, DC, CSCS

**TABLE 1. SQUAT TECHNIQUE COMPARISON**

| | TRADITIONAL | NEW STYLE |
|---|---|---|
| **Chest Position** | Elevated | Down |
| **Lumbar Spine Position** | Hyper-extended | Neutral |
| **Pelvis Position** | Anteriorly tilted | Neutral |
| **Trunk Muscles Involved** | Posterior chain | All torso musculature |
| **Stabilizing Strategy** | ECSS | Ideal |
| **IAP** | Minimal | Maximal |
| **Foot Landing** | Heel | Full foot |

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