

# GLOSSARY

## Motion Capture Dashboard

Pitching & Hitting



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# Pitcher Sequencing

## Pelvic Twist Velocity

Pelvis rotation angular velocity refers to the velocity at which the pelvis opens toward home plate. Sam displays an optimal pelvis rotational velocity. It is important that the rate at which the pelvis opens to home plate is less important than the pelvis sufficiently decelerating to allow for the trunk to begin acceleration and energy transfer to occur. There are several kinematics that make up pelvic deceleration, but lead hip internal rotation and lead knee extension are two primary decelerators that are crucial in allowing for the pelvis to decelerate effectively. Lead hip internal rotation can be seen when the lead foot hits the ground and the pelvis rotates over the top of the fixed stable leg. Visually, this is when the belt buckle moves toward the lead leg, allowing for greater lead leg ground reaction force impulse. Impulse refers to the amount of time force is being applied. Additionally lead leg knee extension velocity, can be seen when the lead leg rapidly opposes the ground through contraction of the quadriceps muscles of the lead leg, further aiding in the deceleration process of both the center of mass and pelvis. If a pitchers lead knee flexes after landing, they are minimizing rate at which the pelvis can decelerate which creates a kinematic and kinetic inefficiency.



## Shoulder Twist Velocity

Torso rotation velocity is a crucial component of athletes' ability to throw with velocity. The component of the delivery needs to happen after the pelvis rotational velocity has already peaked. This can be seen when an athlete's shoulder line moves from a parallel to perpendicular position through the delivery at its highest velocity. Torso rotation velocity is driven by the lower half initiating the linear drive phase creating linear momentum or speed toward the target. Once the lead leg hits the ground, ground reaction forces cause rotational velocity to occur at the pelvis while the trunk remains closed. Elastic energy at the core musculature is then created during this phase as separation occurs, which then triggers the initiation of trunk rotation and increased trunk rotation velocity.



## Elbow Extension Velocity

Elbow extension velocity is also a key performance indicator as it provides information as to what occurred earlier in the kinematic sequence. Elbow extension velocity can showcase a player's ability to transfer force through the upper extremity utilizing centrifugal force from trunk rotation out to the elbow and eventually through the fingertips. Elbow extension velocity is caused by the triceps concentrically contracting and the biceps eccentrically contracting to control extension.



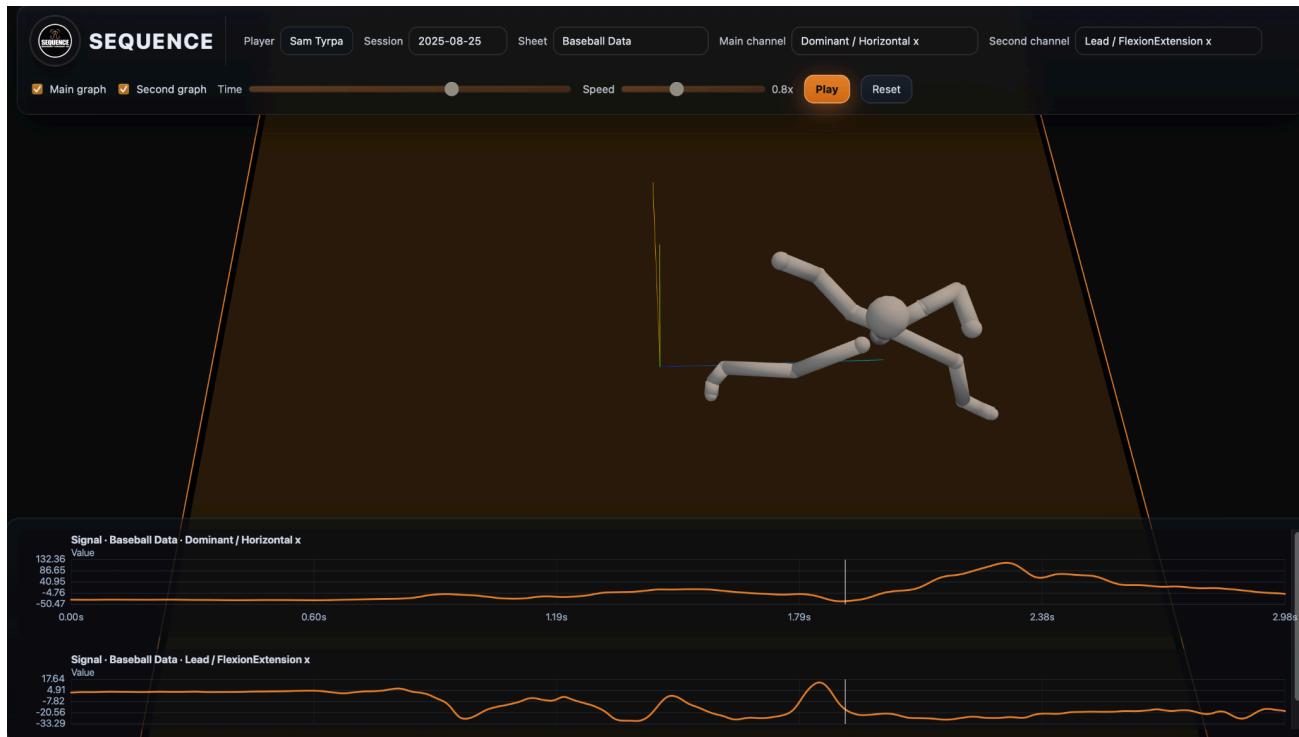
## Shoulder Rotation Velocity

Shoulder internal rotation velocity is crucial key performance indicator and arguably the most telling. Pitchers display an extremely high degree of rotation velocity in the shoulder. This has been described as the fastest move in sports. The shoulder displays increased demands on the muscles responsible for internal rotation. This is due to the fact that they are eccentrically oriented while being in maximal external rotation and then maximally contract and assume concentric orientation to propel the baseball. This has been noted by elite throwers as “getting on top of the ball” or “pulling down on the baseball”.



## Shoulder Horizontal

Shoulder Horizontal Abduction is a key component in a pitcher's arm action. This represents the angle between the throwing arm and the upper trunk. Allowing the arm to get behind the trunk line allows the pitcher to accelerate through a greater arc of motion, which has been commonly referred to as scapular retraction. Scapular retraction can be viewed as an arm action kinematic that plays a pivotal role in the loading and unloading of the shoulder joint in the transverse plane creating greater total range of motion for the upper extremity to accelerate through.



## Shoulder Elevation

Shoulder Abduction represents rotation of the shoulder joint away from the body. This should be roughly around 90 degrees give or take. Some believe that shoulder abduction creates arm slots, but we have found in motion capture analysis that elite throwers keep their upper arm in line with their acromion line or shoulder girdle. Failure to do so, can alter a pitcher's kinematics and lead compensations. This is a crucial component that can positively or negatively impact shoulder external, what is commonly referred to as layback.



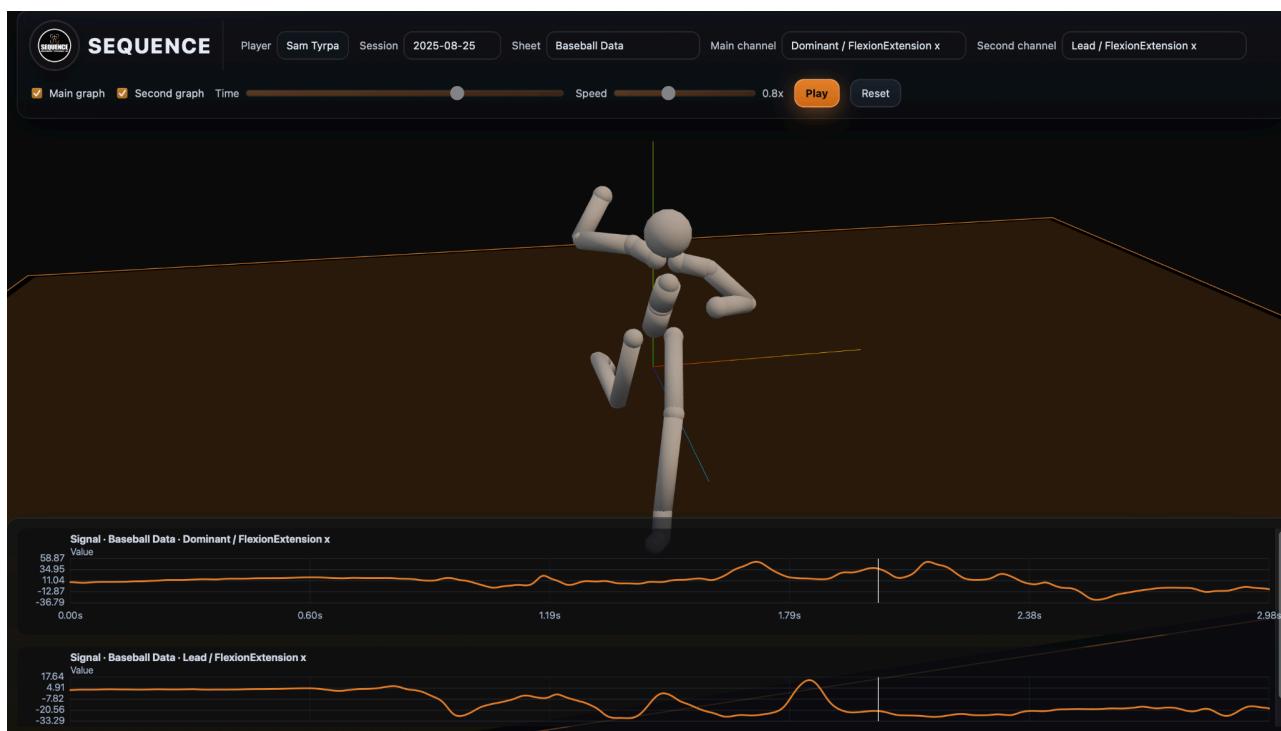
## Shoulder Rotation

Shoulder External Rotation is a key metric in more than one phase of the delivery and is technically defined as rotation of the humerus outward in the glenoid fossa. At foot plant we see elite pitchers attain around 45 degrees to 75 degrees so shoulder external rotation. Proper positioning and timing of the shoulder moving through external rotation is crucial in reducing the risk of injury through excess shoulder torque. During maximum external rotation, we typically see elite pitchers obtain between 160 degrees to 180 degrees of external rotation range of motion. The inability to achieve sufficient range of motion will limit the total range of motion to accelerate through internal rotation, a significant key performance indicator. In contrast, athletes that move through an excessive external rotation range of motion place themselves at greater risk of arm injuries as more torque is placed at the shoulder and elbow.



## Elbow Flexion/Extension dominant

Elbow flexion angle can be described as the angle between the humerus or upper arm and the forearm. Elbow flexion angle is significant and most often considered during the acceleration phase. It is crucial that a pitcher maintains his elbow flexion angle during maximum external rotation or layback to ensure that they do not accentuate stress to the throwing arm.



## Trunk Tilt Left/Right

Trunk tilt is frontal plane measurement and can be described as how much lateral trunk bend occurs to either the gloveside or throwing arm side. We look to optimally position the trunk in a neutral position at foot plant to optimize the position of the core musculature. Pitchers that demonstrate premature trunk tilt can limit their rotational capacity due to the limited amount of leverage their core musculature has in such a compromised position. Athletes should aim to remain stacked at foot plant.



## Shoulder Twist

Shoulder twist refers to torso rotation, which is a key performance indicator for all players. Being too open into foot strike could lead to arm side misses, injury, and decreased ball velocity. However, being too close to landing can alter a pitcher's sequence. The shoulder twist angle can be seen when an athlete's shoulder line moves from a parallel to perpendicular position at foot plant, but is specifically measured using the orientation of the acromion line around the vertical axis.



## Pelvis Twist

The Pelvis twist angle can be defined as the orientation of the hips around the vertical axis or transverse plane. This can be seen by where the athlete's belt buckle is facing relative to the pitching rubber. The pelvic rotational angle is significant in that proper positioning at landing represents the first rotational kinematic that directly transfers ground reaction force into the delivery. Failure to achieve proper positioning at landing can lead to improper timing throughout the delivery and minimize the degree of shoulder hip separation range of motion at foot plant.



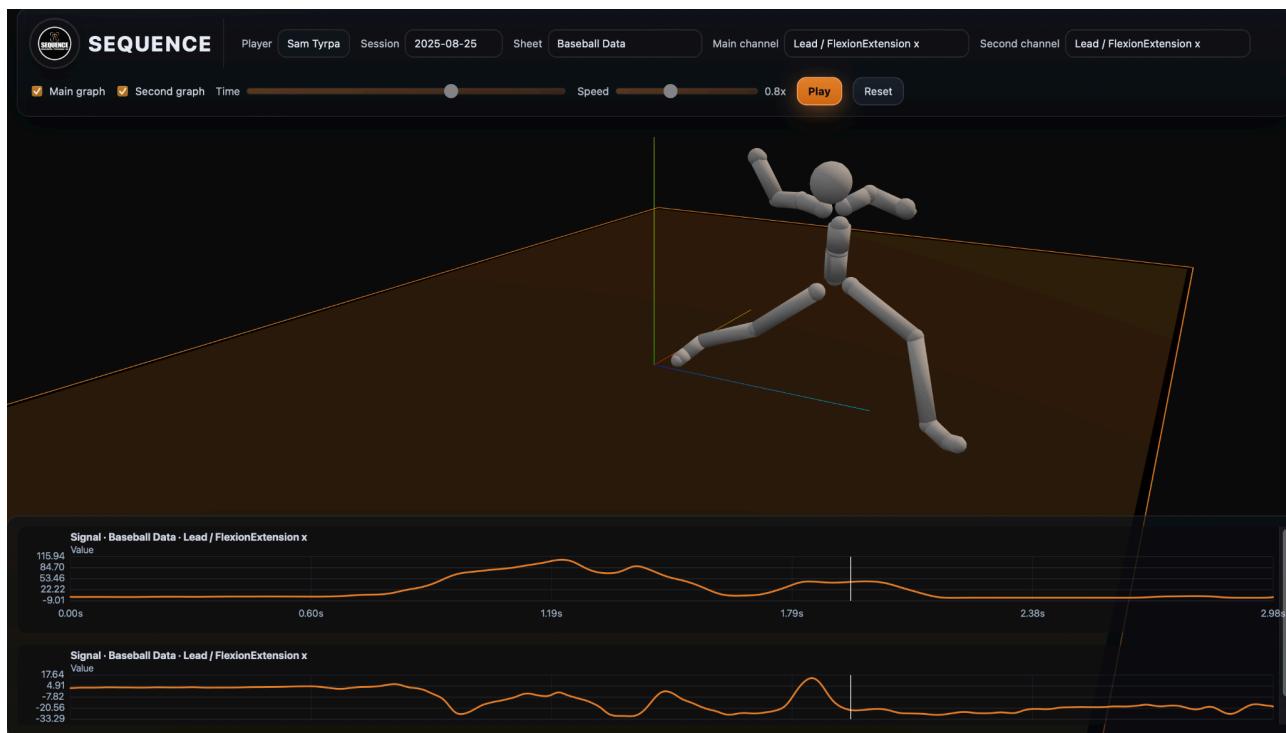
## Trunk Separation

Trunk separation can be defined as the angular difference between the difference between the pelvis and shoulder line, where the trunk lags behind the pelvis as energy is stored and released through segmental movement to achieve high degrees of ball velocity. Trunk separation plays a pivotal role in proper timing and positioning throughout the delivery and is key in demonstrating the proper throwing mechanics.



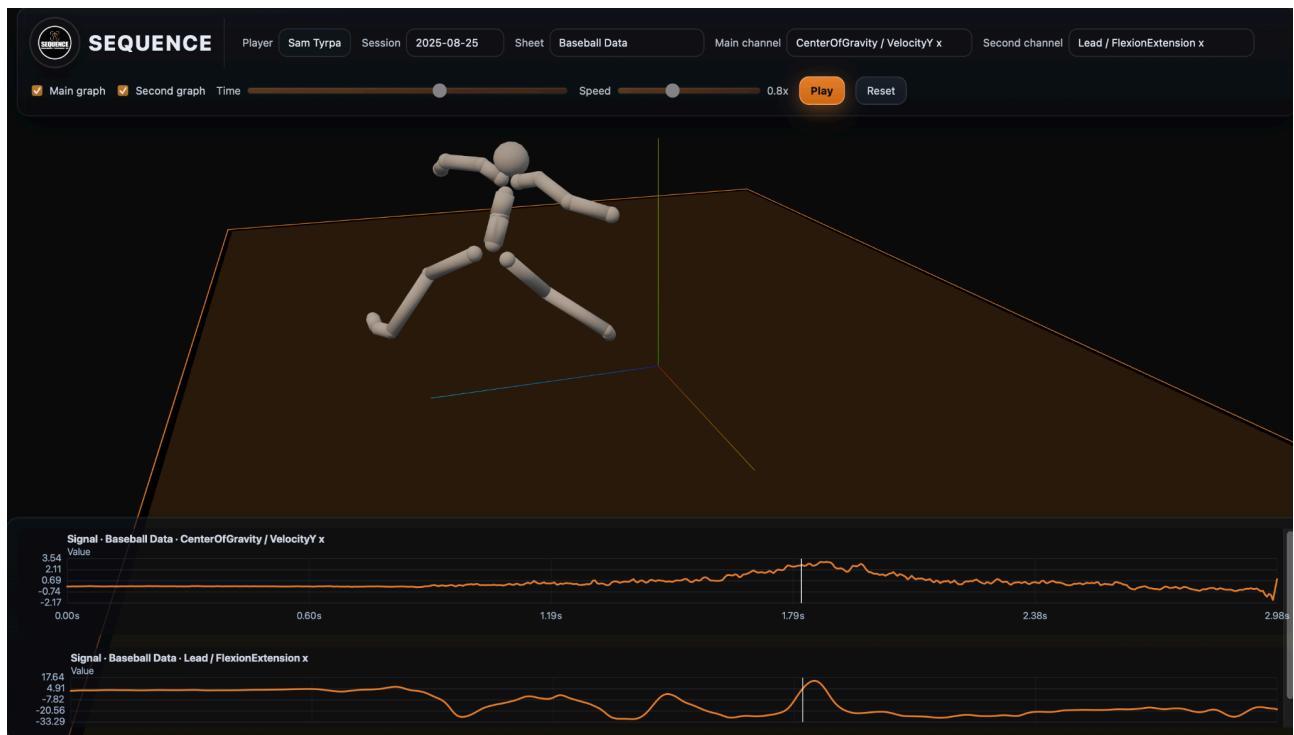
## Knee Flexion/Extension Lead

Lead knee flexion can be described as the angle between the thigh and the shin or the degree of bend to the lead knee. Having a greater degree of knee flexion at foot plant has been linked to increased velocity. In biomechanics, having a greater degree of knee flexion allows for more surface area to apply force, but if achieved after foot plant ground reaction forces may be diminished. Elite players can have up to 35 degrees of knee flexion at foot plant.



## Center of Gravity Velocity Y

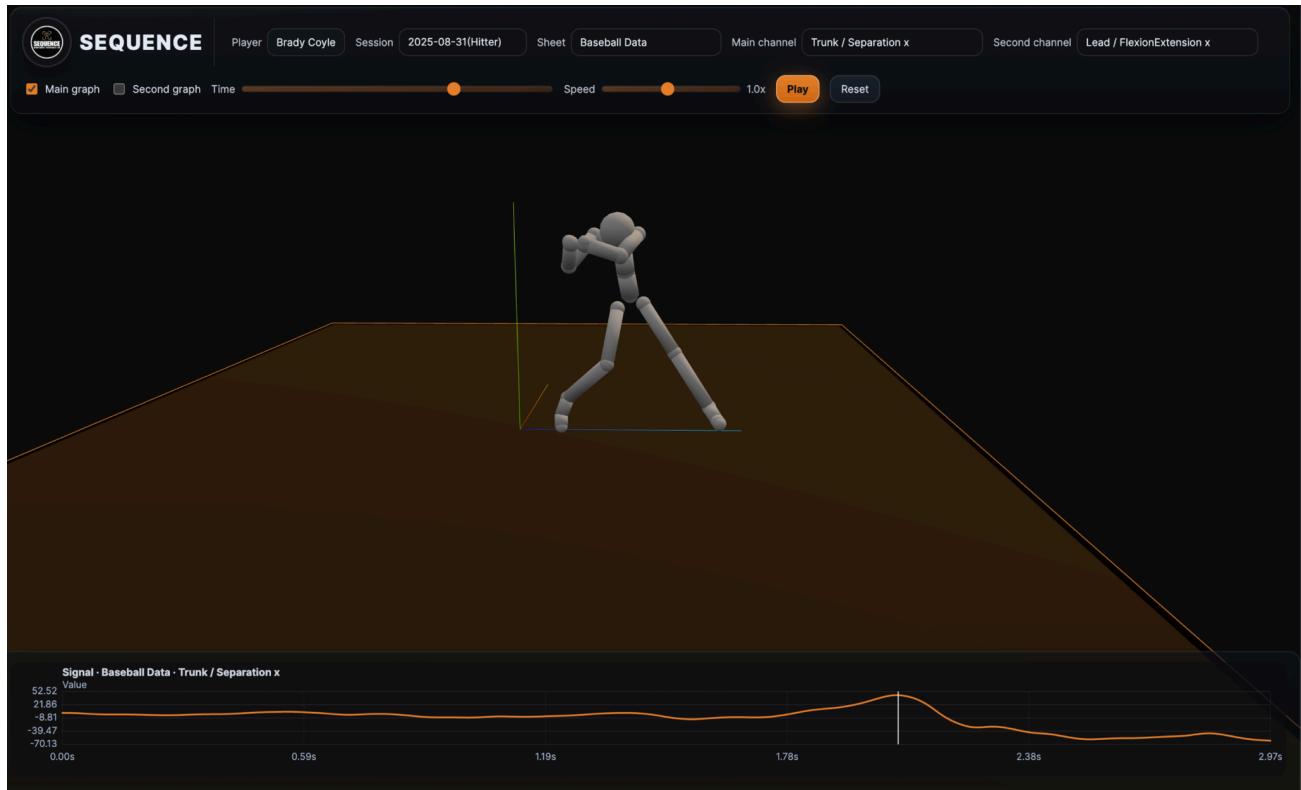
An athlete's center of gravity in the direction of the intended refers to the rate at which they move in that direction. An athlete who moves above at a higher rate indicates increased momentum into ball release. If an athlete is not able to sequence their delivery with an increased center of gravity velocity, they will be less efficient and achieve slower ball velocities. This highlights how individual each pitcher can be depending on their throwing style, body type, anthropometrics, and skill level.



# Hitter Sequencing

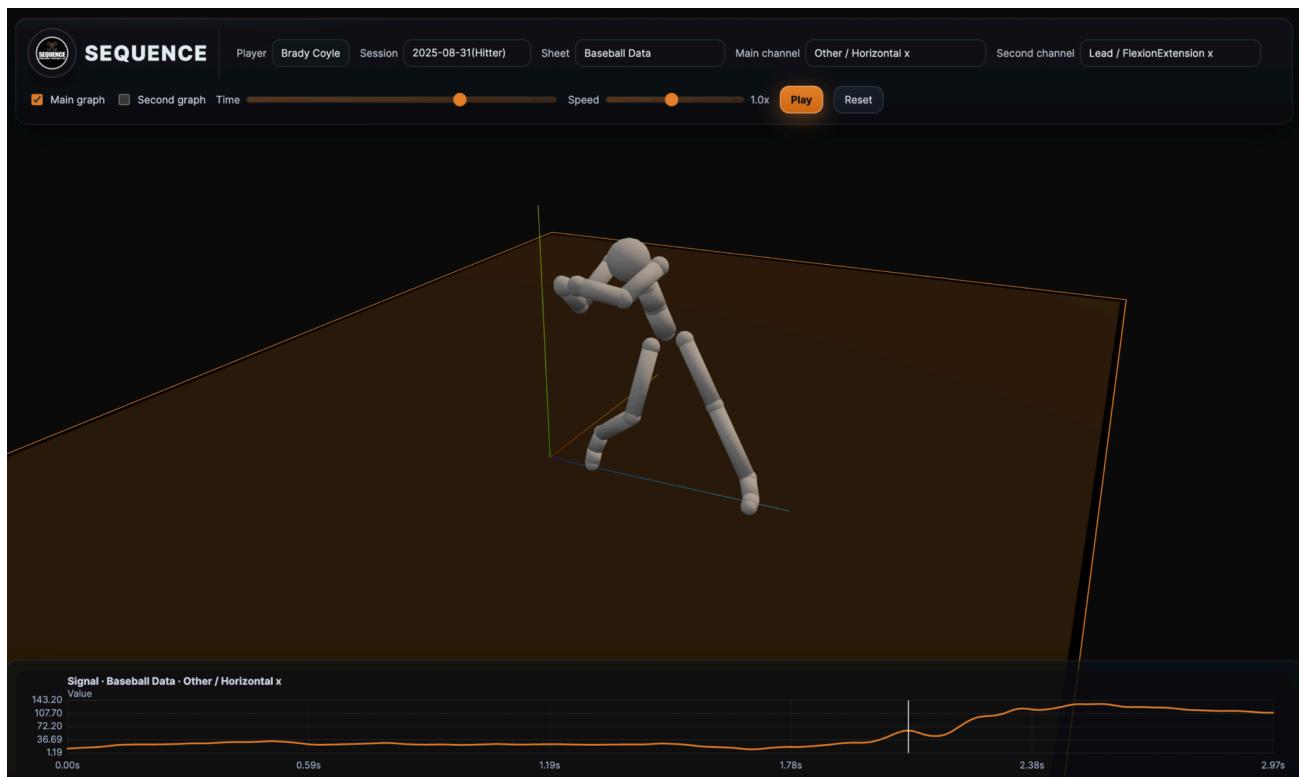
## Shoulder Hip Separation

Shoulder hip separation is of key performance due to the stretch shortening cycle. Having shoulder hip separation in many cases means the hitter properly sequenced up to that point in time.



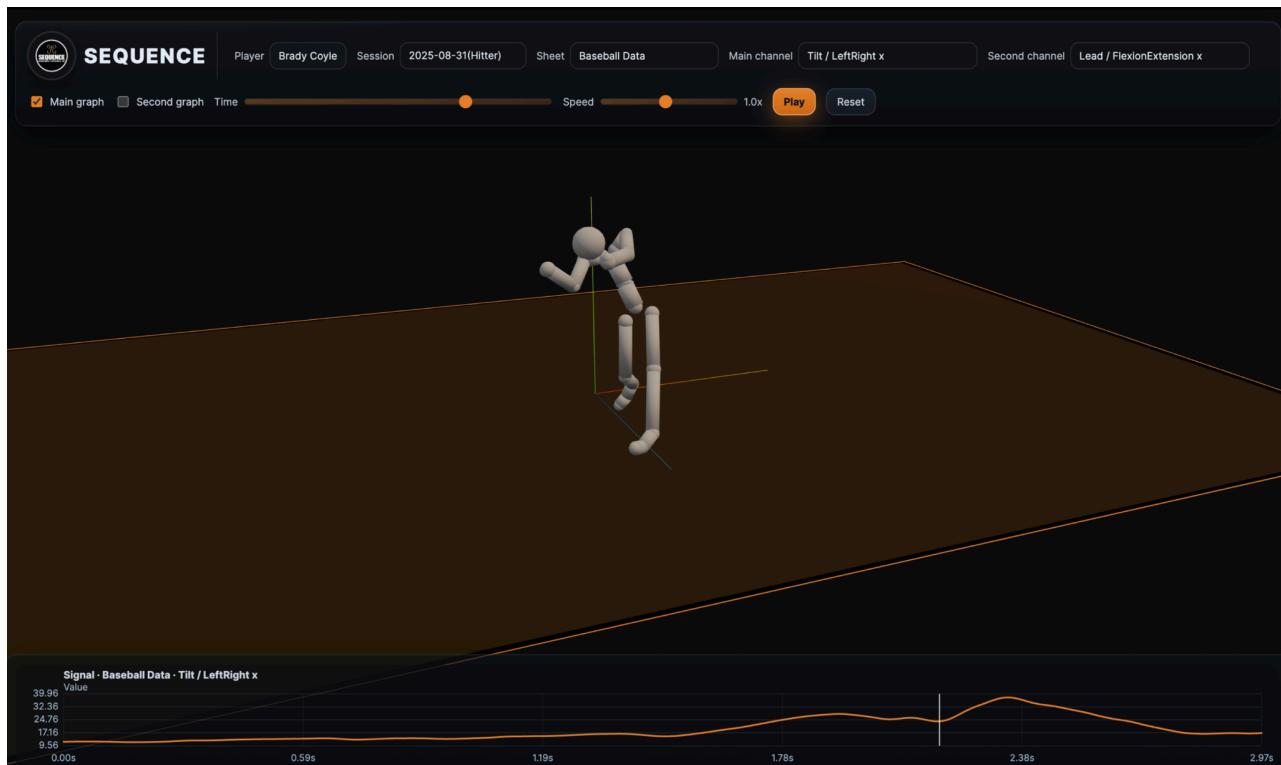
## Shoulder Horizontal Adduction

Horizontal adduction of the lead shoulder is crucial for the hitter's ability to maintain shoulder hip separation and is positively correlated with swing speed. Lead arm horizontal adduction can be described as the lead arm moving across the body in the transverse plane. This move often happens simultaneously with the pelvis initiating rotation and can play a role in effective sequencing.



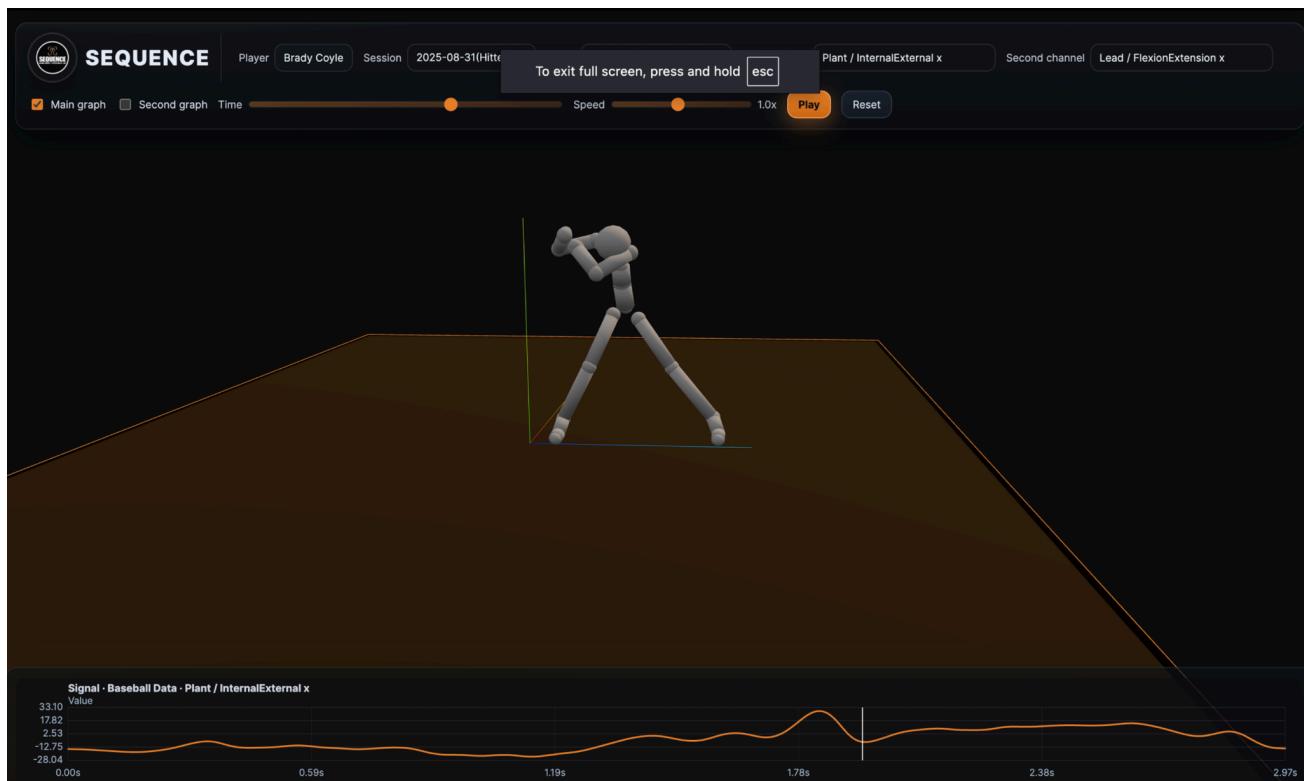
## Torso Lateral Flexion

Torso lateral flexion to the right is a key performance indicator because it highlights the hitter's ability to get on plane. This is where hitters are able to keep the barrel in the zone for longer periods of time due to lateral flexion or side bending the torso toward the home plate side. We also see hitters use this key performance trait when utilizing the old school cue taking the knob of the bat to the ball. The combination of the two allow for the appearance of the barrel tracking deeper when in reality the torso laterally tilted. This is also a position where hitters utilize the core musculature with the lats to enhance shoulder hip separation.



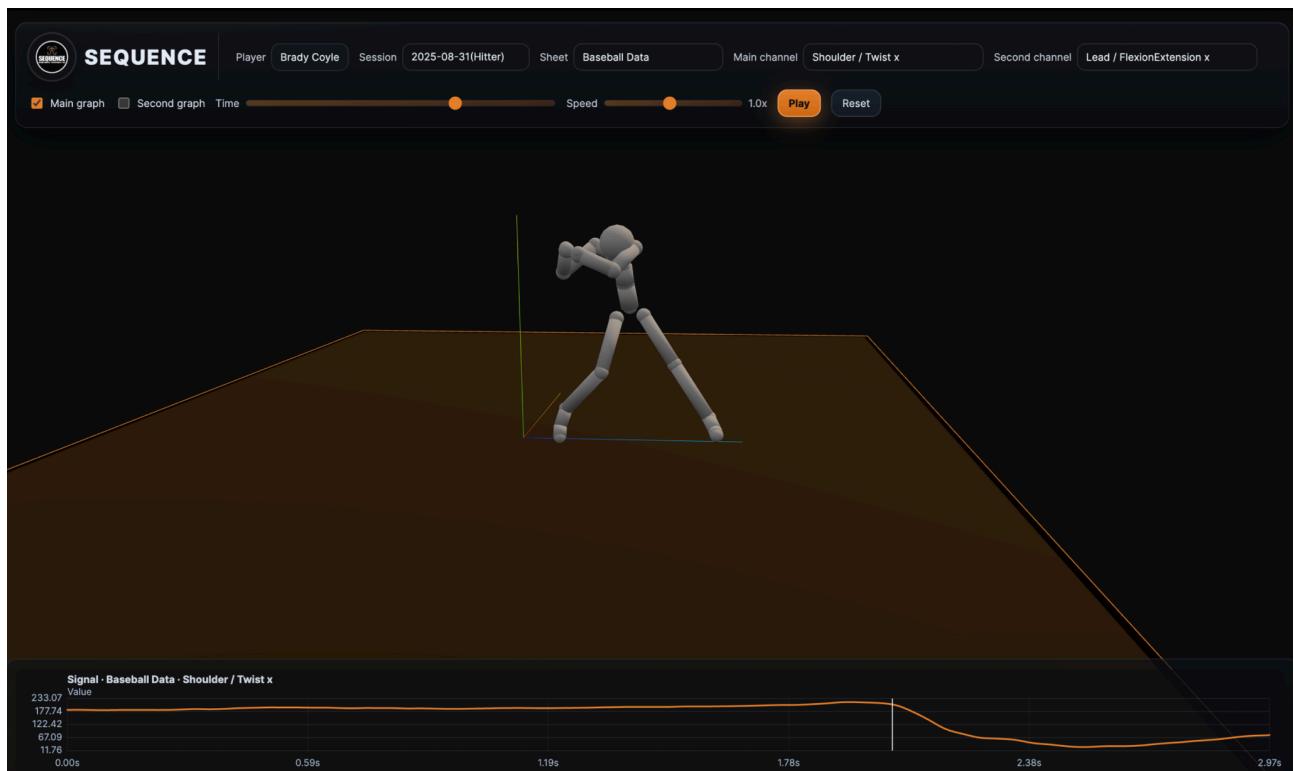
## Rear Hip Internal Rotation

Rear hip internal rotation can be described as the femur of the rear leg rotating inward toward the midline on the acetabulum. This can also occur when the acetabulum rotates over the top of the femur to load the rear hip. Both are effective strategies to either generate hip rotation or a foundational hip loading strategy.



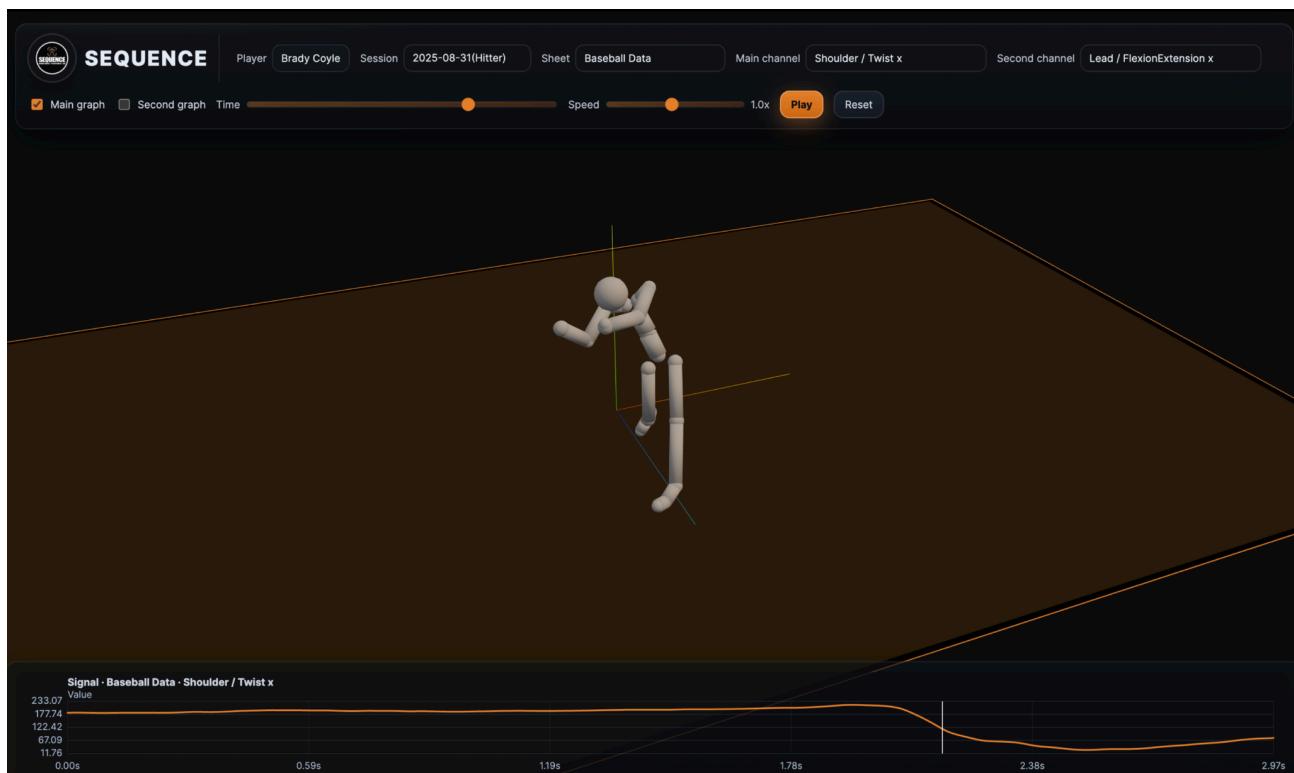
## Torso Counter Rotation

Torso counter rotation is a key element in creating the proper delay necessary to achieve dissociation between the pelvis and the torso. Torso counter rotation also plays a role in weight shift. At the start of the load, both the pelvis and torso shift/translate backward on the y-axis. There is a sweet spot in which the batter achieves adequate weight shift and is able to initiate rotation with the pelvis while being able to keep the head on the pitcher. If excessive counter rotation occurs, the batter will lose sight of the ball and use their peripheral vision to track pitches and may be unable to achieve an optimal torso rotational angle at ball contact. This may limit a hitter's ability to hit to all fields, which could describe a hitter that has to cheat to pull the baseball or a hitter that primarily hits the ball to the opposite field.



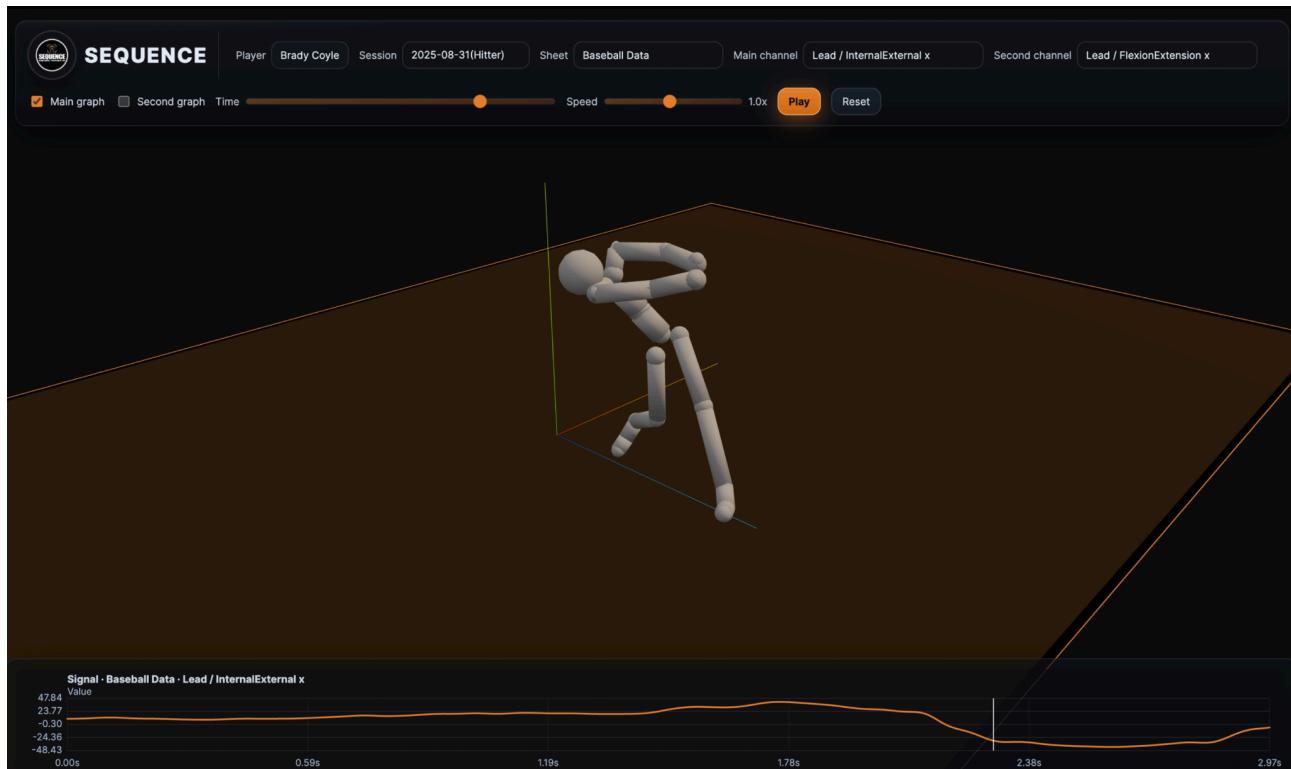
## Torso Rotation

Torso rotation to the plate occurs after the pelvis when the batter squares up the pitcher. Many elite players talk about keeping the torso closed as long as possible. This in part is due to the limited amount of time that torso rotation occurs inside.



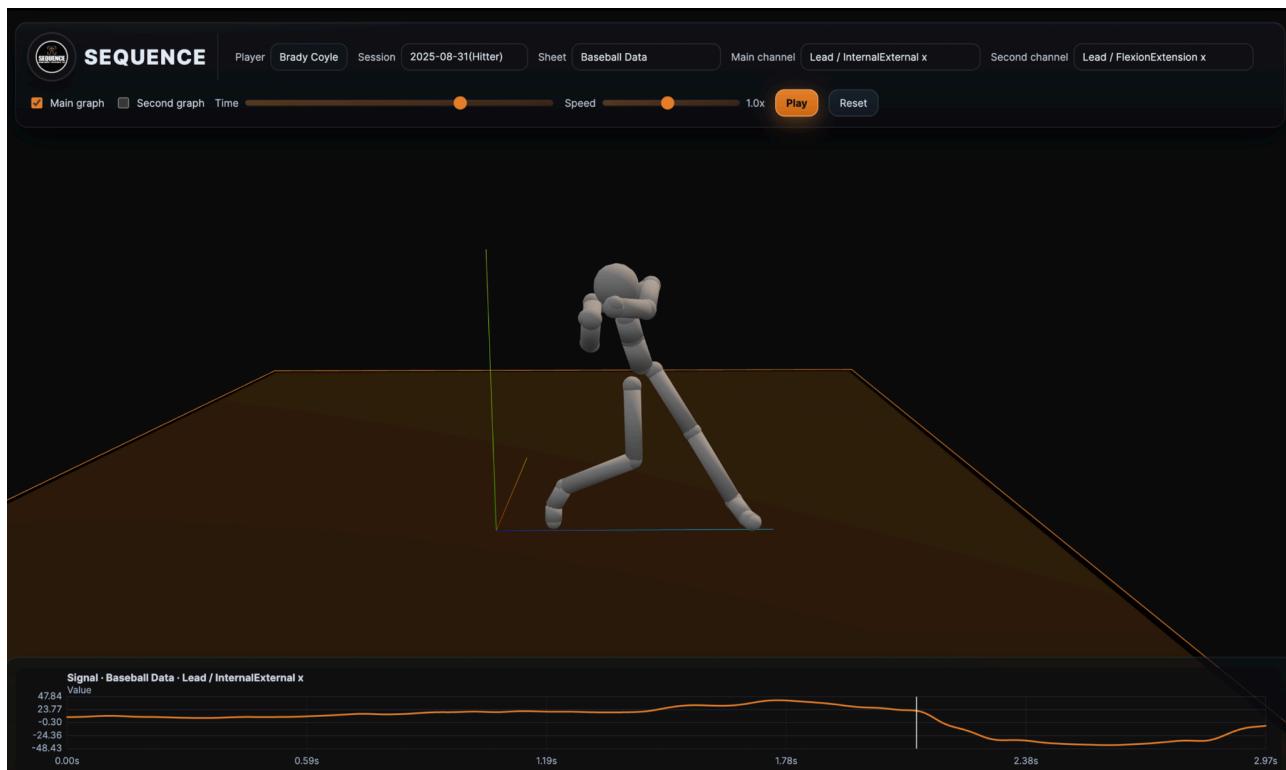
## Lead Hip Internal Rotation

Lead hip internal rotation makes for a successful lead leg block. This is crucial for energy to be delivered back up the chain. This could be described in the swing as turning your belt buckle toward your lead hip.



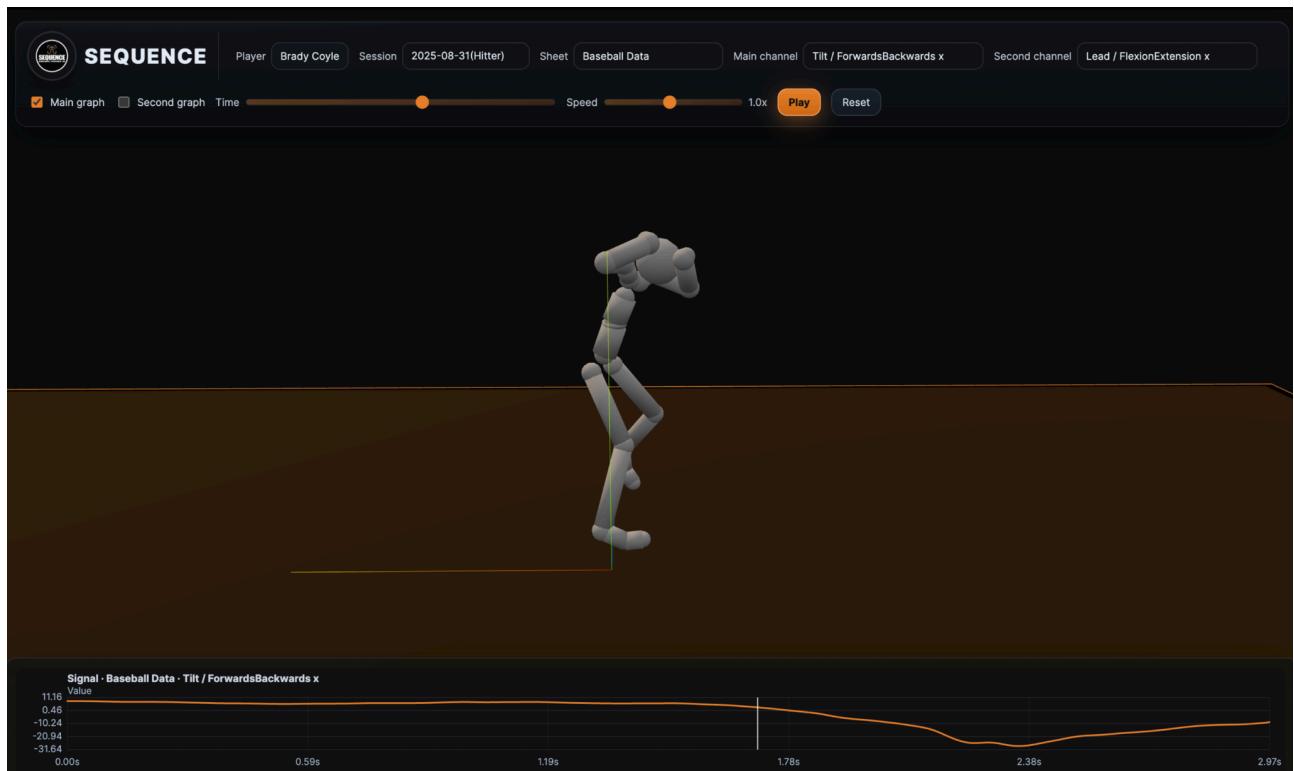
## Lead Hip External Rotation

Left hip external rotation is a key component of shoulder hip separation. The lead leg will make contact with the ground in external rotation as the back hip internally rotates, the pelvis will be initiating rotation, and the torso will still be in relative counter rotation. This will be the last instance prior to the lead hip transitioning into internal rotation and lead leg block.



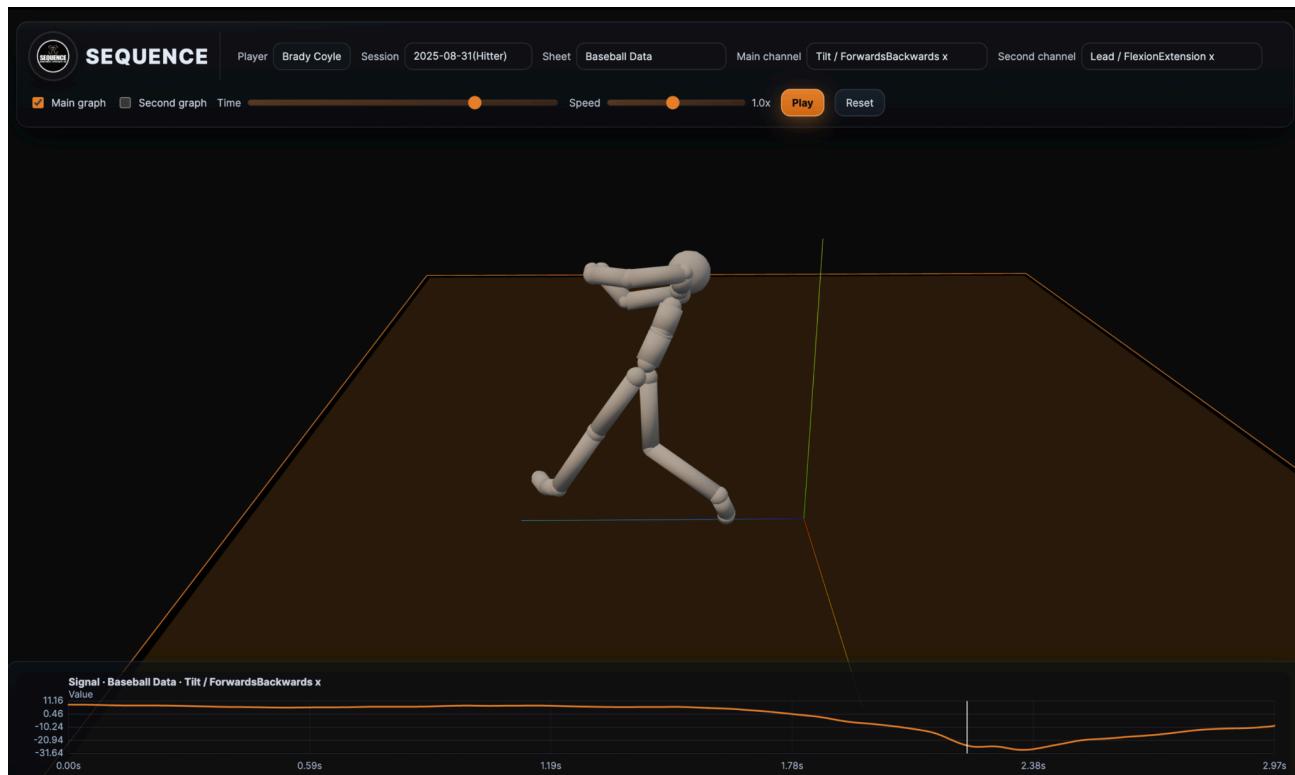
## Torso Tilt During Load Phase

Torso flexion during the load phase is a key performance indicator because of its ability to tell how neutral a batters spinal orientation is. Normally, elite hitters display neutral spines that are not excessively flexed or extended which gives them the most movement options moving forward.



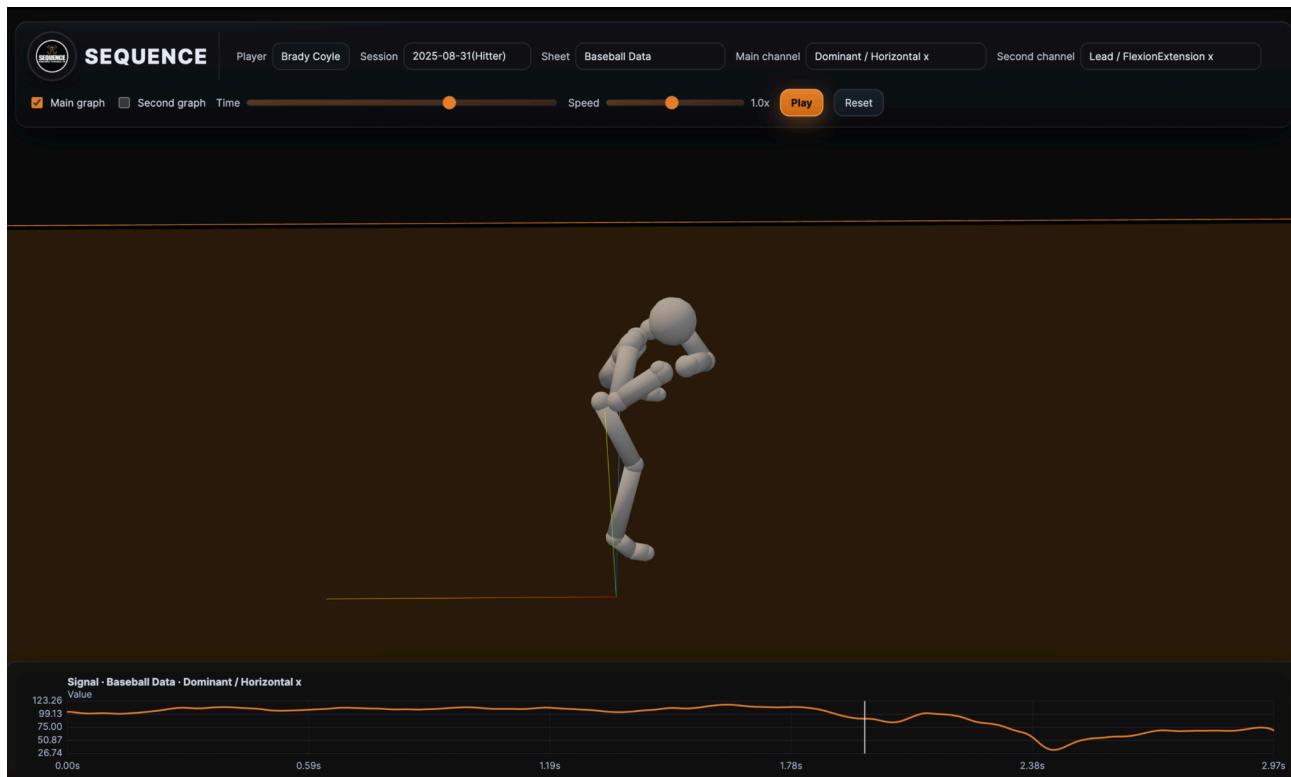
## Torso Extension During Rotation and Blocking Phase

Torso extension during rotation and the blocking phase is important to maintain swing plane, leverage hip extension, and enhance the lead hip pullback just prior to ball contact. These are all important characteristics of what we see the elite hitters demonstrate.



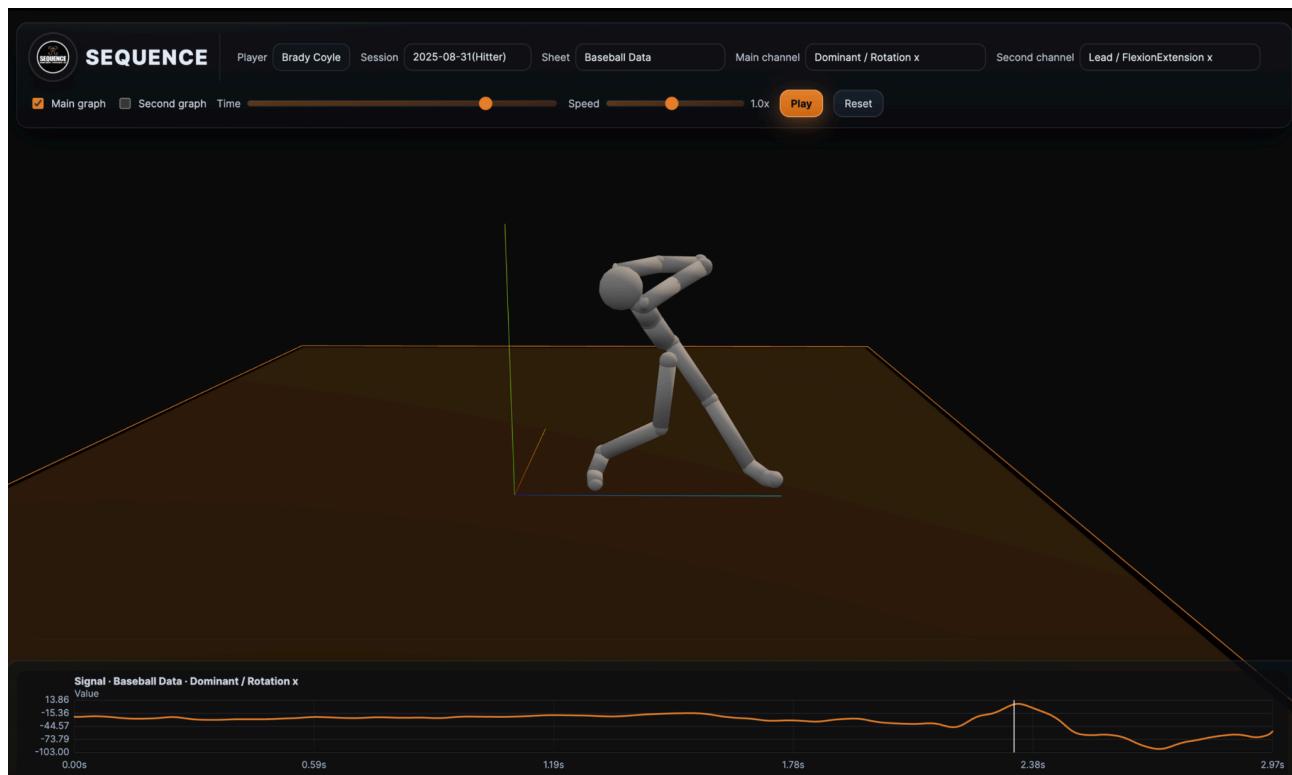
## Right Shoulder Horizontal Abduction During Loading Phase

The right shoulder horizontal abduction phase is a key component in the loading process. This allows for the scapula to move into external rotation on the rib cage. This connects the top hand to the rib cage during the loading phase via the scapula. This is the starting point to the old school hitting coach's phrase as a player having a compact swing. The inability to keep the scap on the rib cage promotes casting of the barrel. This would be the hitter's ability to create apical expansion in the right anterior chest wall to promote internal rotation on the ipsilateral side.



## Right Shoulder Rotation Unloading Phase

The unloading phase occurs when the back shoulder begins its transition downward into external rotation which can create better VBA numbers from Blast Motion. External rotation of the shoulder in the swing looks like the elbow is moving down and toward the pitcher. This creates the swing plane that looks similar to a nike swoosh.



## Rightward Lateral Pelvic Tilt

The rightward lateral pelvic tilt is also a component of the acceleration phase. Inability to laterally tilt the pelvis would limit the amount of internal rotation available at the hip. The lateral tilt of the pelvis happens just after the initiation of femoral internal rotation of the back leg. This can also help promote relative shoulder external rotation.



## Center of Gravity Z

As rotation begins elite hitters lower their center of gravity. This is one of our biggest indicators of a hitter being able to rotate successfully. This will inhibit a player's ability to adjust to off-speed. Brady demonstrates this effectively.

