Sprint Mechanics and Fundamentals

Sprinting mechanics are essential for all field/arena sports and can be applied to various starting positions. While the initial acceleration pattern may differ, the fundamental concepts remain the same. In this document, we will explore four categories of sprinting mechanics:

1. General Concepts of Sprinting
2. Optimizing Acceleration Mechanics
3. Optimizing Transition Mechanics
4. Optimizing Maximum Velocity Mechanics

1. General Concepts of Sprinting

- Front side and Back side Mechanics:
- Backside Mechanics: Refers to everything that occurs behind the midline of the body, regardless of the body's position to the ground (upright or inclined).
- Front Side Mechanics: Involves the motion of the swing leg and arm that occurs in front of the body.
- Characteristics:
- Top athletes run fewer strides than their peers, typically around 40-45 steps for a 9.80 100m race.
- Ground Reaction Force: Athletes experience a load of approximately 5 times their bodyweight.
- Internal Forces: Athletes experience a load of approximately 7 times their bodyweight.

- Sprinting 101:
1) Small Mass: Focus on muscle mass that contributes to performance.
2) Big Force: Aim to apply as much force as possible.
3) Right Direction: Force should be positively propulsive, directed upwards and forwards.
4) Minimal Time: Apply force in the right direction within shorter periods of time.

- Newton's 4th Law:
- Excess body weight hinders optimized sprinting. Leaner athletes tend to be more effective sprinters, avoiding excess hypertrophy.
- Force Development and Sprinting:
- Force plays a significant role in running speed. Athletes must increase force applied to the ground in the right direction within minimal time.

- Minimize Horizontal Breaking Forces: Keep the contact point relatively close under the hips to avoid excessive braking forces.
- Maintain Feet Behind: Athletes should keep their feet behind them for 2-3 steps behind the center of mass to enhance stability and stride efficiency.
- Top End Speed Considerations: At top speed, some horizontal braking force is necessary for stability, but athletes should aim to touch down underneath the hips to minimize breaking forces.

2. Increase Propulsive Forces:
- Horizontal vs. Vertical Propulsive Groups:
- Vertical Force Application: Vertical force application is crucial for running faster. It is more important than the time spent in the air during the swing phase.
- Importance of Vertical Force: The loss of velocity in a bouncing ball is primarily due to the decrease in height with each bounce. Similarly, vertical propulsion is vital for maintaining speed.
- Spring Mass Model: Athletes should aim to create a stiff spring-like effect, similar to a pogo stick, to maximize propulsive forces.

▪ Horizontal Force is Important too.
-As you run faster the percentage increase of horizontal force contribution goes up.
-We treat the leg as a Swinging Spring or Swinging Pogo Stick; instead of treating the leg as pogo stick we treat it as a swing spring. As the leg swings through, that spring will be compressed, not vertically at first, but at some angle and then as the hip passes over the leg the compression start to uncoil Because leg is hinged at the hip, there will never be one clean force vector. There will always be some components of Vertical contribution and some components of Horizontal contribution; as and athletes passes over their ground contact, what was vertical will become horizontal force.
compresses at an angle. As the hip passes over the leg, the compression starts to uncoil. Due to the hip joint, there will always be a combination of vertical and horizontal force components. As the athlete passes over the ground contact, the vertical force becomes horizontal force.

▪ Horizontal Force is Vertical Force Turned on its Side:
- The application of force can be observed with respect to the ground or the body.
- Body positions remain relatively consistent throughout the sprint run. Exercise selection and muscle activation are important considerations when training.
- Differences in body positions are primarily due to the orientation of the body with respect to the ground.
▪ Increase Leg Stiffness:
- Leg stiffness refers to the leg's ability to act as a spring, similar to a rebounding super bouncy ball.
- Increasing leg stiffness is desirable.
- Momentum is developed early on in acceleration or running.

- Momentum is the quantity of motion an object or body possesses.
- Changes in momentum are primarily due to changes in velocity.
- Bodies will move at the same rate unless external forces (gravity in the downward direction and air resistance in the horizontal direction) act upon them.
- Vertical impulse refers to the amount of force applied vertically into the ground.
- Leg stiffness increases vertical impulse, resulting in shorter ground contact times and greater elastic return.

▪ Vertical Force Production:

- Vertical force production has several benefits. Firstly, it allows for greater displacement through the air, similar to the example of a super bouncy ball.
- Elite level sprinting is characterized by faster ground contact times and better maintenance of vertical displacement.
- The path of the center of mass follows a sinusoidal curve, reaching an apex in flight and a low point in support.
- It's important to note that the low point should not be significantly lower than the touchdown point.
- Vertical force production increases both stride length and stride frequency.
- While better sprinters may appear to bounce, research indicates that flight times are similar and ground contact times are actually shorter. Elite athletes seem to float over the ground.
- The key differentiator for elite athletes is the amount of vertical displacement they have after ground contact. They apply significant vertical force with minimal amortization at the ankle, knee, and hip, resulting in a stiff spring-like effect.

▪ Stride Frequency:

- Stride frequency consists of two components: the time spent on the ground and the time spent in the air. It determines how fast you turnover.
- Since the best sprinters spend less time on the ground, increased force applied to the ground leads to higher stride frequency.

▪ Stride Length and Frequency: Benefit of Greater Force Application:

- Greater force application offers two benefits. Firstly, it creates a bigger and stiffer spring, allowing for faster ground contact times and maintaining velocity through the air, resulting in increased stride length.
- Secondly, it enables a higher stride frequency as the stiff spring allows for quick ground contact and takeoff.
- Neurologically, turnover can be increased through training. However, to run faster, it's crucial to apply more mass-specific force to the ground in the appropriate direction within shorter periods of time.
- Being relatively light in body weight is advantageous for generating mass-specific force.

▪ Sprinting is an Extremely Complex Motor Task:

- Some coaches oversimplify sprinting by attributing it solely to innate factors such as fast twitch and slow twitch muscle fiber composition. However, research shows that sprinting is far more complex than that.
- Many elite-level athletes did not excel in youth or high school track, indicating that speed can be developed.

- Sprinting involves the rapid activation and deactivation of practically every muscle in the human body. Efficient sprinting requires not only fast muscle contractions but also quick muscle deactivation in the most efficient manner.
- Lower extremity activation patterns in sprinting are highly complex, with muscles turning on and off at various phases of the sprint step cycle. Proper activation and deactivation enhance sprinting efficiency.

▪ Sprinting Fast is an Unnatural Activity:

- While some athletes may naturally possess the physical capacity and body proportions for efficient sprinting mechanics, most athletes will not optimize their mechanics without coaching.
- Sprinting is a skill that can be learned, and the principles of motor learning can be applied to improve sprinting mechanics. By learning how to produce more efficient movement, athletes can run faster.

▪ Optimizing Mechanics:

- Optimizing mechanics requires considering the different kinematics associated with acceleration versus top-end speed.
- In some sports, acceleration is the primary focus, while in others, there may be a combination of both acceleration and top-end speed.
- It's important to recognize that the mechanics and physical capacities required for acceleration are different from those needed for top-end speed.

General Sprinting Mechanics

- Better sprinters exhibit front-side dominance, spending most of their swing phase in front of their body with very little time spent behind them. This is due to the stiff spring-like effect created by their mechanics.
- Ground contact time during sprinting is very short, typically ranging from 0.08 to 0.1 seconds. Since ground contact time is so brief, we must focus on setting up what occurs on the ground during the swing phase.
- Full extension, especially hyperextension of the hip, is neither necessary nor beneficial. Minimizing backside mechanics is important. Hyperextending the hip and leaving the feet behind the body does not contribute significantly to speed.
- The ideal touchdown at top speed is characterized by the swing leg's knee being even with the support knee. There should be no daylight between the thighs, and in efficient sprinters, the swing leg's thigh may even be slightly in front of the support leg.

▪ Posture:

- Posture plays a crucial role in achieving optimal sprinting positions. It refers to the positioning of the head, neck, spine, and pelvis.
- Posture is often compared to the mast and rudder for the limbs. If the core of the body is not positioned correctly, it becomes challenging for the limbs to perform as desired.

- Maintaining appropriate posture is essential for achieving high knee position and front-side mechanics. Extreme anterior pelvic tilt, where the pelvis is rotated downward, hinders the ability to achieve the desired mechanics. Similar relationships exist with the head and spine.
- Coaching the arms and legs alone will be ineffective if posture is not correct.
▪ Posture Specifics:
- In terms of posture, we aim for neutral postural alignment. The trunk should be erect, and the head should be level with the hips. Depending on the phase of the run, such as during acceleration, the trunk may be inclined to the ground, but neutral postural alignment should still be maintained.
- Throughout the run, the head should not be thrown back, the chin should not be tucked to the chest, and the upper back should not be rounded. The head should be in line with the spine, and the pelvis should be directly under the spine with a neutral or slightly posterior pelvic tilt.
- The movements of the limbs originate from the core of the body, so proper alignment and stabilization of the core are crucial for optimal limb movement. There should be an appropriate amount of shoulder and hip axis orientation, as well as pelvic undulation or oscillation. The hips should rise on one side while lowering on the other side during running.
▪ Pelvic Tilt:
- We generally aim for neutral to posterior pelvic tilt. Posterior pelvic tilt can decrease hamstring tension and increase quadricep muscle tension, allowing athletes to achieve better front-side mechanics during the swing phase. This, in turn, enables more efficient ground contact.
- Some athletes, especially those who spend a lot of time sitting in chairs, may have a significant anterior pelvic tilt. It's important to train them to improve their pelvic orientation through mobility and strength exercises. Cueing them to feel a slight posterior pelvic tilt or aiming for a neutral pelvic tilt can be helpful.
- Cues such as "feel the pelvis rotate up towards the face a little" or "tuck the tummy" can assist athletes in achieving the desired pelvic tilt

2. Optimizing Acceleration Mechanics

When observing athletes during acceleration, here's what we should look for:

- What to See:

- We should see a significant split of the arms and legs, regardless of the sport or starting position. This split will be relative to what we observe at top-end speed. In the early stages, such as the first step, the split of the arms and legs should be more pronounced.
- Athletes should exhibit a forward lean from the ankles, not by bending at the hips. The force applied to the ground should align with the body's long axis, creating a "Power Line" from the ankle through the hip and up to the head.

- Near complete pushes and triple extension should be evident. This means extending the ankle, knee, and hip without hyperextension. The legs should actively extend using muscles like the glutes, hamstrings, and gastrocnemius. Avoiding hyperextension reduces ground contact time and improves force application.
- Early in acceleration, it is beneficial to have a lower heel recovery. This means the swing leg foot should travel close to the ground, creating a positive shin angle with respect to the ground.
- We should see a significant split between the arms and legs during acceleration, regardless of the sport or starting position. This split will be relative to what we see at top-end speed. In the early stages of acceleration, such as the first step, the split should be more pronounced.
- Athletes should exhibit a forward lean from the ankles, not by bending at the hips. The force applied to the ground should align with the body's long axis, creating a "Power Line" from the ankle through the top of the hip and head.
- Near complete pushes and triple extension should be observed. Triple extension involves extending the ankle, knee, and hip without hyperextending any joint. This extension is actively generated by engaging the glutes, hamstrings, and gastrocnemius muscles.
- A lower heel recovery is beneficial during acceleration, even for athletes in arena/field sports. This means the swing leg foot should travel low to the ground, creating a positive shin angle. This allows for a quick piston-like action to apply horizontal force during acceleration.
- There should be a gradual progression of body angles throughout each step of acceleration. The initial step should have a significant incline to the ground, with the feet feeling behind the body. With each subsequent step, the body gradually progresses towards an upright sprinting position. This progression should be seamless and gradual, avoiding any sudden popping off the ground.

- What to Say:

- "During acceleration, we want to see a big split between your arms and legs, regardless of the sport or starting position. This split should be more pronounced in the early stages of acceleration."
- "Maintain a forward lean from the ankles, ensuring that the force you apply to the ground aligns with your body's long axis. Imagine a 'Power Line' running from your ankle through the top of your hip and head."
- "Focus on near complete pushes and triple extension, extending your ankle, knee, and hip without hyperextending any joint. Engage your glutes, hamstrings, and gastrocnemius muscles to actively extend your legs."
- "Keep a lower heel recovery, meaning your swing leg foot should travel low to the ground. This creates a positive shin angle and allows for a quick piston-like action to generate horizontal force during acceleration."
- "Gradually progress your body angles with each step, starting with a significant incline to the ground and gradually moving towards an upright sprinting position. Avoid any sudden popping off the ground and aim for a seamless and gradual progression."

3. Optimizing Transition Mechanics

- What to See:

- "Imagine the motion of 'butt kicking' to prepare for the piston-like action of driving the leg back down to the ground. This will help generate a significant amount of horizontal force, which is crucial for acceleration."
- "During the transition phase, we should observe a gradual progression of body angles. On the first step, we should be significantly inclined to the ground, with the feet feeling behind us. With each subsequent step, we push ourselves up gradually. Avoid any sudden popping off the ground and aim for a seamless and gradual progression."

▪ What to Say (Motor Learning Concepts):

- "Sprinting is a skill, and we can apply motor learning concepts to improve it. Use analogies whenever possible to help athletes understand and execute the desired movements."
- "Focus on external cues rather than internal cues. Instead of telling athletes to put their arm at a specific angle, use cues like 'knees to chest' to encourage bringing the knees up or 'shade the Sun' to promote a forceful arm swing that shifts the center of mass."
- "Provide feedback beyond verbal cues. Use temporal feedback by emphasizing the timing of acceleration and exaggerating the push-off phase. Treat the legs like pistons rather than a bicycle, cueing athletes to 'drag the toe' for a lower heel recovery."
- "Use external reference positions to guide athletes. Encourage them to 'step over to the opposite ankle' or 'push themselves up on every single step' to optimize transition mechanics."

▪ What to See:

- We should see a continued progression of body angles throughout the transition phase. It's important to maintain proper posture throughout the entire run, avoiding throwing the head back or causing the hips to go forward, which can compromise postural integrity.
- There should be gradual changes in limb movement magnitude. The initial big split of the arms and legs will tone down slightly. The swing arm will be more closed, and there will be a progressively higher heel recovery during the swing phase.

- What to Say:

- "To achieve the desired movement characteristics, cue the athlete to 'push themselves tall' and imagine hitting their head on the top of the sky. This external reference helps maintain an upright posture."
- "Encourage the athlete to 'tuck the hips' to achieve a posterior pelvic tilt during the arm swing. Use the cue 'cheek to cheek' to emphasize that the arm swing should not be static. The hand should come to the facial cheek as it swings forward and go back towards the butt cheek as it swings backward."

- "Guide the athlete to 'step over the ankle,' 'step over the calf,' and 'step over the knee' to facilitate the gradual transition from a more piston-like leg action to a more cyclical leg action."

4. Optimizing Maximum Velocity Mechanics

- What to See:

- We should aim for an effective ground contact position where the foot is almost directly underneath the hips, and the swing leg is in line with the support leg.
- To achieve this, several components are necessary:
1. Upright posture: There should be a vertical stack of the head on top of the spine, on top of the pelvis.
2. High knee recovery: The athlete should maintain front side mechanics throughout, with a high knee recovery.
3. Relaxation: The face, shoulders, and hands should be relaxed during the sprint.
4. Foot contact under the hips: The foot should make contact with the ground directly under the hips.
5. Vertical shin angle: The shin angle at ground contact should be approximately 90 degrees to ensure vertical force application.
6. Pre-activation: While we don't explicitly tell athletes to fire specific muscles, we want to set up movement patterns that naturally activate the glutes and hamstrings.

- What to Say:

- "To achieve an upright body position, imagine balancing a bowl on your head. This will help you maintain a vertical stack with your head on top of your spine and pelvis."
- "For an active top-end speed arm swing, imagine 'slamming the elbows down' or 'elbowing a small person.' This can increase vertical propulsive force to the ground."
- "Focus on stepping over the opposite knee to maintain front side mechanics. You can also imagine feeling everything in front of you to reinforce this position."
- "To promote an active foot snap in the front side position, imagine having a rubber band attached from your heel to your butt. This will help you actively bring your foot up and avoid significant leg trailing."
- "To relax the hands, face, and shoulders, imagine 'letting your eyelids jiggle.' While your eyelids won't actually jiggle, this cue helps convey the level of relaxation we want to achieve."
- "Remember, sprinting is all about efficiency rather than effort. Focus on displaying controlled violence in your lower extremities and arm swing, while keeping the rest of your body relaxed."
-We can tell athletes to run tall and bounce. A lot of athletes will feel that super bouncy ball sensation so we can tell them to “push up” or “push down. We're trying to get them to feel like a super bouncy ball using an analogy.