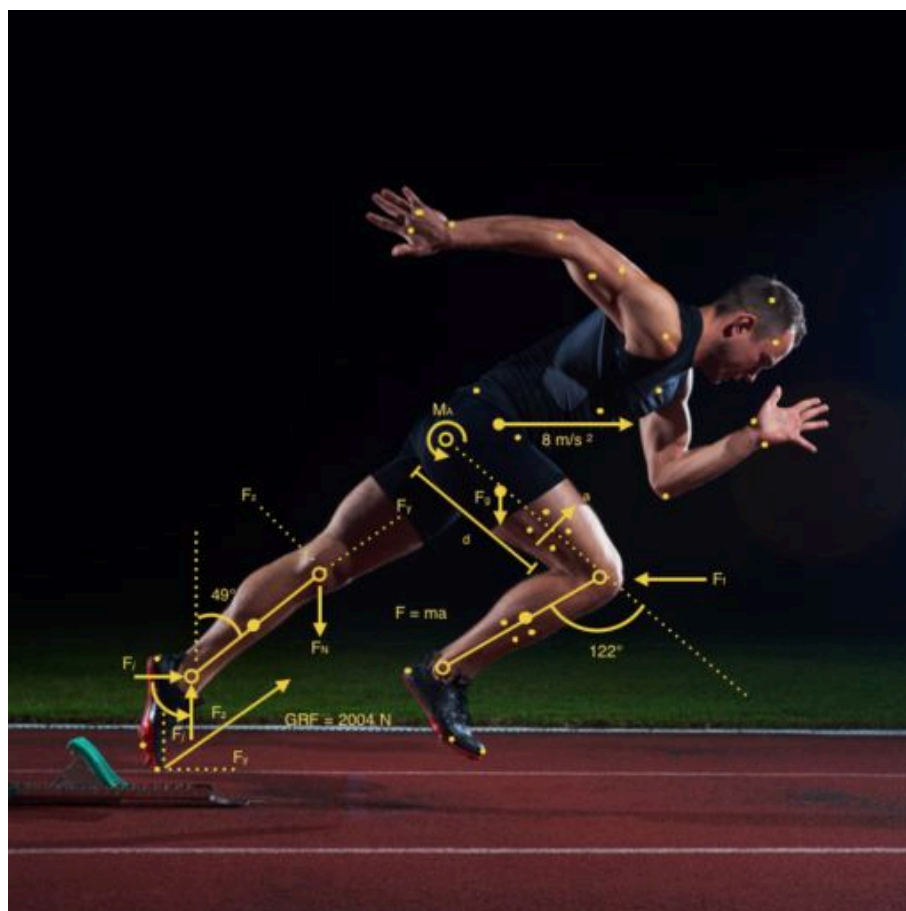


How to coach Sprinting Kinematics & Kinetics (Part 1)

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I wanted to follow up with some thoughts from my last article, [Sprint Technique, Maturation & Strength](#). Specifically about developing the appropriate force production for sprinters with reference to recent research and some much older advice given by a couple of the best sprint coaches in the world (at the time).

Programming for a Sprint Athlete

Traditionally there has been two key aspects to the programming for a sprint athlete – the first is the focus on specific conditioning developing both the neuromuscular and musculoskeletal systems required to run with speed.

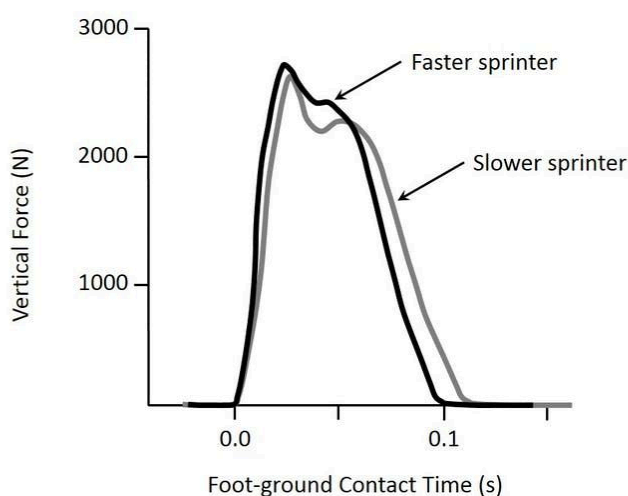
This has historically resulted in very fast athletes but due to the often misunderstood role sprint technique plays in high level performance, we have often seen athletes whom have struggled with injury their entire career or as is often the case, athletes start with 100m sprinting and over time

move up to the 400m sprints because the high velocity work required for the shorter sprints causes too many injuries.

What has become evident in recent years with some great research being published is the kinematic (motion of limbs) and kinetic factors (forces involved) that have been shown to be key in what separates good from great sprint athletes.

Upon a review of the most recent sports science literature you find that vertical force production at ground contact is the leading component of sprint kinetics that separates good from great sprinters.

Add to that attribute the appropriate kinematics at the hip joint (hip angular velocity) and we find two key attributes that if improved should result in your athlete maximising their sprint performance over the shorter sprint distances.



Before I delve into the specifics of the above research, I wanted to cover off why there is a focus on vertical forces and not horizontal forces (considering the athlete is wanting to cover the ground horizontally as quickly as they can).

Vertical Force Vs. Horizontal Force

When the athlete first leaves the blocks, the way to overcome inertia and accelerate is to apply force that has a high horizontal component – leaving the blocks at $\sim 45^\circ$ should result in the athlete being able to apply the most efficient horizontal force to the ground allowing them to quickly accelerate and reach their top speed.

It is the transition from acceleration to top speed where we see many technical challenges, going from a largely horizontal force production technique (acceleration phase) to vertical force production (maximum velocity).

If not done correctly can result in the athlete quickly getting themselves into the incorrect sprint position resulting in lower top speeds and increased loads placed on the likes of the hamstrings (and hip flexors).



Why the transition from horizontal to vertical? When the athlete first leaves the blocks they have the time to apply force to the ground to overcome their body weight (~250ms), also as we want to increase the athlete's horizontal velocity at this point it makes sense to have the athlete apply mainly horizontal forces.

As the athlete approaches top speed, two things happen:

1. they now have much less time on the ground to apply force (100ms or less) and
2. the vertical forces with each ground contact quickly rise to several times body weight (up to 5 times body weight for elite sprinters).



If the athlete tries to leave their foot on the ground longer to apply larger forces, they run the risk of letting their mechanics becoming "rear sided" which dramatically exposes the hamstrings to injury (see previous article).

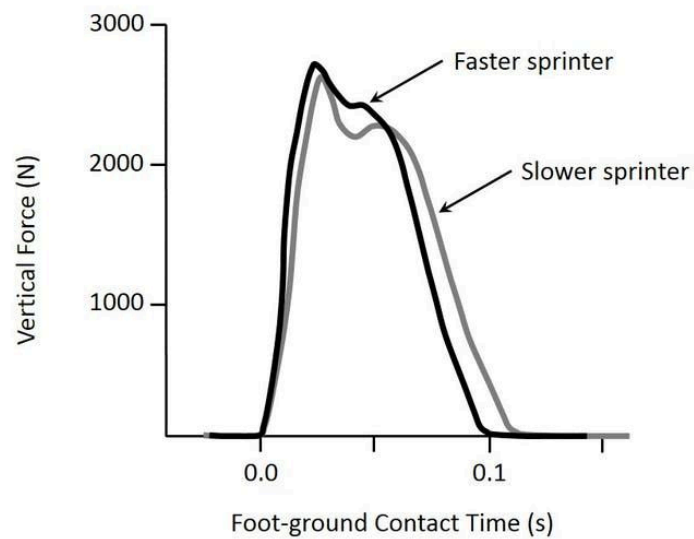


I use the example of standing over a high speed treadmill, if you place one foot on this treadmill slowly, what will happen is that the foot will be whisked behind you very quickly, this is what is happening when you are covering the ground at 9+m/s – every millisecond longer on the ground results in the foot ending up further behind your centre of gravity before you can pull it off the ground for the next stride cycle.

Also once the athlete has reached their maximal running velocity, the athlete has little reduction in speed when in the air (air resistance is negligible) and so it is only when the foot touches the ground that the athlete will potentially slow down.

So combine the fact that you want the athlete to spend as little time on the ground as possible at top speed and that the forces at each ground contact are vertically up to 5-times body weight leads to the quandary of how do you develop the appropriate “speed strength” to allow the athlete to apply these vertical forces in the time they have ($<100\text{ms}$).

Further complicating this challenging physical requirement is that a more detailed force analysis of elite versus sub-elite sprinters show that within the $<100\text{ms}$ available to apply force, the elite of the elite are able to apply higher forces in the first $\sim 30\%$ of the time on the ground ($\sim 30\text{ms}$).



TEACHING VERTICAL FORCE APPLICATION

Many years ago I was fortunate to spend several months with at the time, two of the best sprint coaches in the world:

Dan Pfaff – coach of Donovan Bailey (9.84WR, 1996 Olympic Champion), Bruny Surin (9.84), Obadele Thompson (9.87, 19.97).



John Smith – coach of Maurice Green (9.79WR, 2000 Olympic Champion) Ato Boldon (9.86, 19.77), Jon Drummond (9.92), Marie Jose Perec (48.25, 1996 Olympic Champion).



Interestingly they took quite different approaches to this vertical force application requirement. Smith would focus on knee drive (using Newton's 3rd law – for every action (knee drive) there is an equal and opposite reaction (opposing leg driving to the ground) whilst Pfaff would have his athletes actively drive their feet into the ground (with almost flat feet) in an effort to maximise ground reaction forces and use the elasticity of the ankle joint to rebound the athlete off the ground to the next stride.

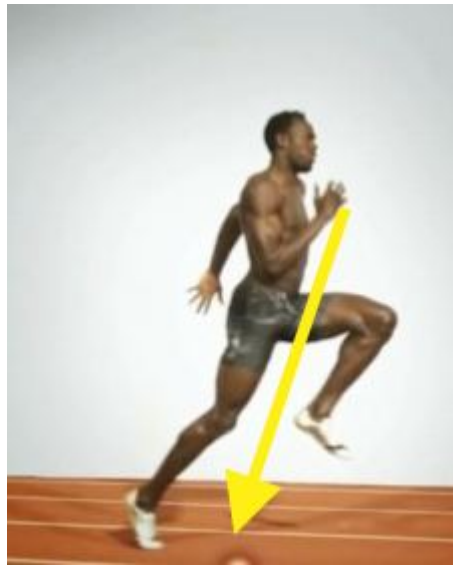
Pfaff was more scientific of the two coaches and talked at length about the ground reaction force requirements of elite sprinting (it wasn't until 15 years later that research fully backed up his early views on force application to the ground (vertically) and impact upon maximum running velocity).

Force application should be in the same direction relative to body position regardless of the section of the race. What do I mean by this?

When accelerating from the blocks – the athlete should focus on good thigh/foot recovery and then a forceful drive back to the ground whilst at top speed the athlete should be focusing on driving their foot into the ground directly under their COG.



Relative to the athlete's torso – both athletes are driving their thighs in largely the same direction.



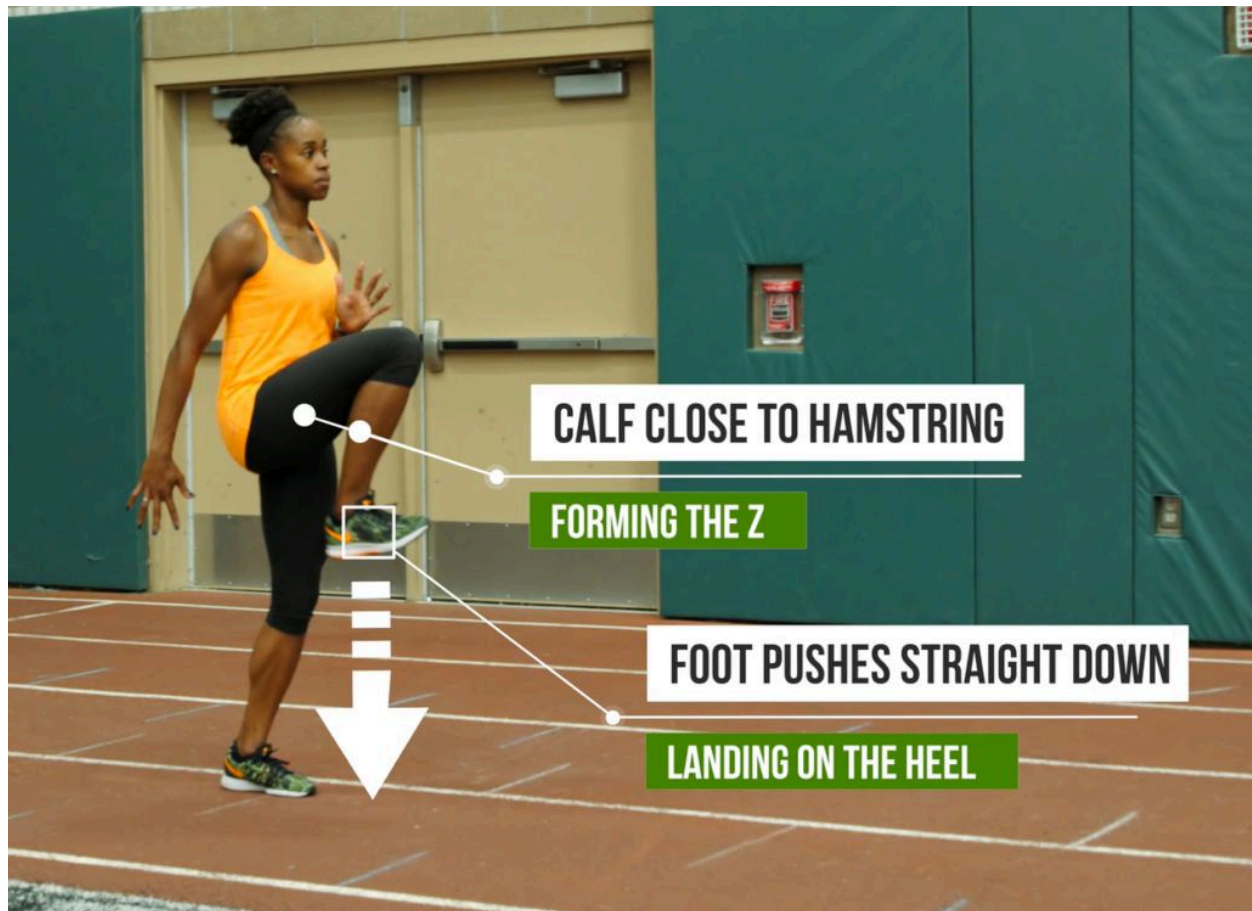
Drills are key

What I typically see in my day to day coaching is athletes of all ages going through the motions with their drills as part of their warmup.

What I emphasize with my athletes is that the warmup and associated drills are an important component of the total training session (not something to get out of the way as quickly as possible).

As such I have my athletes spend quite a bit of time during their warmup performing sprint drills (Skipping & Running A's, B's, rapid leg switches, single leg stiff ankle bounds, etc).

It is during this early phase of the general preparation phase that you can work on and reinforce the correct limb mechanics to maximise the athlete's capacity to dynamically drive their foot into the ground and generate the required ground reaction force in as short a time as possible.



Mechanics whilst running/sprinting

The second phase to developing the appropriate sprint mechanics is in the reinforcement of the correct limb positioning during all running sessions.

This start with athletes having to perform the correct limb positioning during tempo runs (these allow the athlete to clock up a lot of volume with medium intensity with a focus upon good knee lift and vertical force application).



You will be amazed how quickly a well conditioned athlete can become fatigued when you ask them to maintain the correct pelvic, hip, knee & ankle positions whilst trying to run a 200m or 300m tempo repetition!!

In my experience, as fatigue sets in (this can be neural fatigue over 100m – not just metabolic fatigue you might see over 400m), the athlete will subconsciously try to increase their impulse by increasing their time on the ground (Impulse = force x time).

If this happens two technical faults will creep into their movement pattern:

1. They will start to anterior pelvic tilt as their leg stays on the ground for longer resulting in a lower front knee height position, and
2. Their mechanics will start to become more “rear sided” rather than the preferred front side sprint mechanics.

Whilst this might allow the athlete to apply more force, it leads to very poor mechanics, increased ground contact times, increased exposure to hamstring injury and overall incorrect force production mechanics for effective and efficient sprinting.

In [Part 2](#) I will cover topics such as Vertical Load Generation & Tolerance & Tolerating the Ground Reaction Force at Maximum Velocity.

Check out [Part 2](#) and [Part 3](#)

