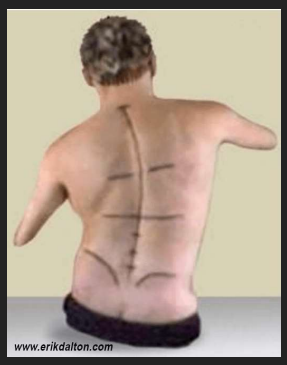

A different look at force production in sprinting.

Spinal Engine, what is it, can it be trained, & will it make athletes faster?

Angus Ross

SPRINZ 2022

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Contents

- Ground force and Speed
- Mass spring model
- Another piece of the puzzle - What is the spinal engine?
- Is there any evidence of SE having a positive performance effect in sprint running?
- Acceleration and Max V differences and SE implications
- Summary

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The key to running speed = ground force

- **Weyand et al 2000** – At Max velocity greater vertical ground forces dictate speed not faster recovery
- **Morin et al 2015 & Nagahara et al 2018** – Push more brake less – direction of force application not just total force critical to sprint performance in acceleration particularly

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What are the assumptions we making with regard to ground force?

A couple of obvious ones include;

1. **Mass spring model** – describes steady state running with relative accuracy

And perhaps a consequence of assumption #1

2. **The trunk, (and head) acts as an inert mass that sits on the leg springs** & the legs alone provide all the propulsive power & elasticity for sprinting
3. **2-dimensional modelling** remains a relatively valid way to describe the 3D movement that is human gait

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Mass spring model – Valid?

- MSM essentially characterizes the Upper body as an inert mass that sits on top of a weightless spring (leg).
- It is a simple but **relatively** accurate method for describing the relationships between many variables in gait at constant speed e.g. GCT, FT, vertical stiffness etc
- BUT….

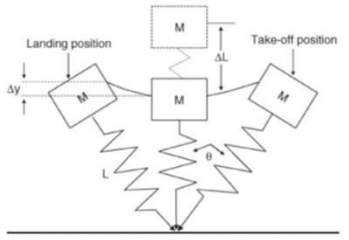
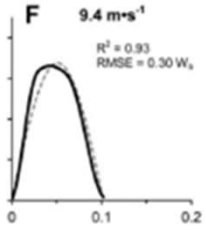


Fig. 4. Centre of mass (CM) displacement and change in leg length during the stance phase in running. Schematic representation of the spring-mass model as the leg spring travels through its arc during the stance phase. **L** = leg spring length; **M** = mass; **y** = vertical displacement of the CM.



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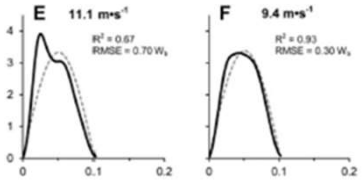
In Elite sprinting the MSM is not quite so good…

- Clark and Weyand data 2014 –differences between elites and sub elites runners in terms of vertical force.

"We conclude that a passive, simple- spring model has limited application to sprint running performance because the swiftest runners use an asymmetrical pattern of force application to maximize ground reaction forces and attain faster speeds"



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Perhaps we need to revisit these major assumptions…

- Is the trunk (including head) just an inert mass that sits on top of propulsive springs?
  - Perhaps not
- And does the 3D movement (including the trunk) seen in gait need to be examined more closely to see how it impacts ground force?
  - Perhaps it adds constructively to magnitude and direction of ground force?

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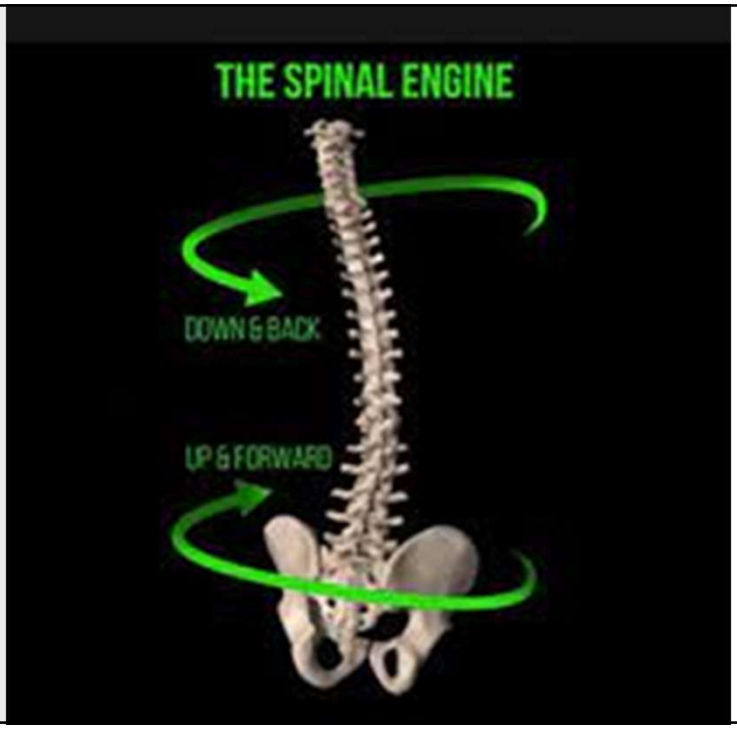
Introducing the Spinal Engine – a potential answer to the short falls of current theory?



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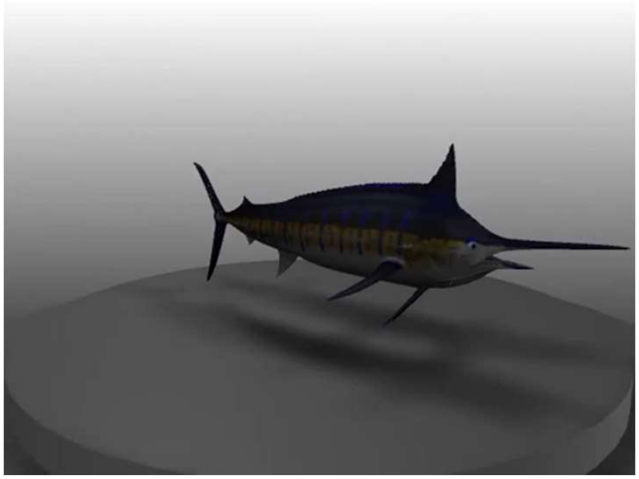
What is the spinal engine?

- Lovett (1903) discovered that a lordotic spine, when bent to either side, induced an axial torque at the pelvis
- Gracovetsky (1988) suggested that the evolutionary pressures for efficient locomotion on land forced the spine of our fish ancestors to evolve into our curved spine. The lordotic spine converts the primitive piscine lateral bend into an axial torque driving the pelvis…



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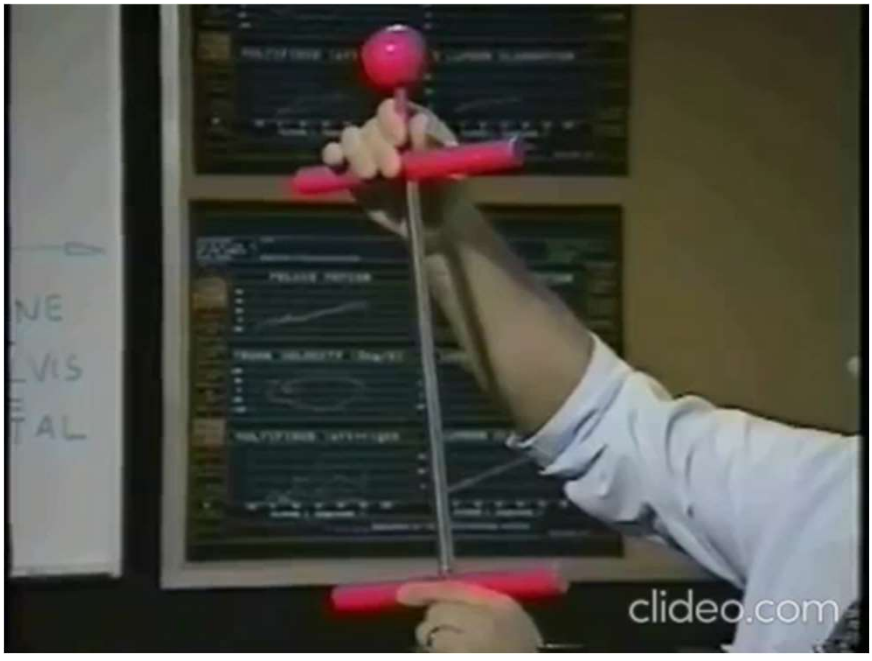

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The spinal engine allows gait to occur without legs…

Arguably then, the trunk & pelvis are running the show with legs serving to act as a spring-loaded mechanism to increase the movement amplitude of the gait initiated by the trunk

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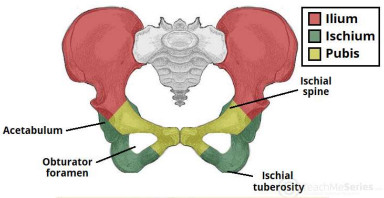
Spinal Engine basic summary

- Rather than the legs driving the axial rotation of the pelvis it is proposed that lateral trunk flexion and hip hitching of the free leg –induces the axial rotation of the pelvis.
- Legs then function to increase movement amplitude and transmit energy to and from the SE & ground via skeletal muscle, bone & fascia/ligamentous structures
- The SE in turn distributes energy across each joint to counter rotate pelvis and shoulders.
- Unknown whether the trunk acts directly as an elastic hammer for increasing vertical force production?



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Spinal Engine and elite sprinting

Noting all of these guys are elite – but lane 4 is the only sub 10 runner and arguably is the best SE exponent of group…

Current worlds fastest man (2022 WC in 100m Fred Kerley) in training showing what his trunk contributes to his gait…

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So, is there any data suggesting performance contributions from SE in high-speed running or SL jumping?

SL Jumping Sado et al., 2018 (elite HJ'ers)

Sprinters in acceleration Nagahara et al., 2018; Sado et al., 2020

Sprinters at Max Velocity Sado et al., 2019; Nagahara et al., 2018

- Lateral flexion in max sprinting seems to decrease in magnitude from 0-50m whereas axial rotation is maintained

- "The results implied that the hip abductors and lumbar lateral flexors have substantial potentials not only as stabilizers but also as energy generators and that they act as substantial energy generators during running single-leg jumps"

- "During the single-stance phase, the sum of the net mechanical work by lumbosacral lateral flexors and front hip abductors was 0.35 ± 0.14 J/kg, which comprised 9 ± 3% of the sum of the net joint work.

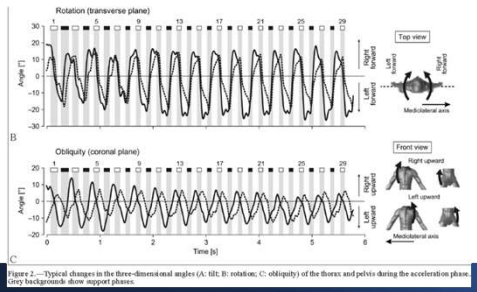

Figure 2.—Typical changes in the three-dimensional angles (A: tilt; B: rotation; C: obliquity) of the thorax and pelvis during the acceleration phase. Grey backgrounds show support phases.

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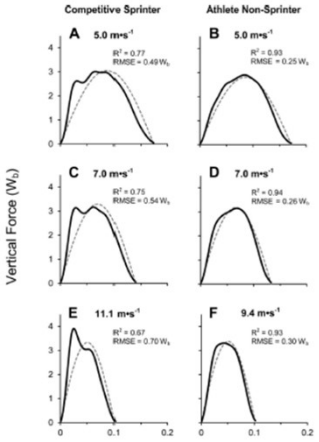
Does lateral flexion contribute to shape of the force curve with faster runners and explain some of divergence away form MSM?

- Clark and Weyand data 2014 – clear differences between elites and sub elites runners in terms of vertical force production.
- Unclear whether lateral flexion into ground contact & bouncing out of it contributes to this
- But Usain Bolt may provide some clues



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Lessons from the fastest man of all time…

- Significant Scoliosis to the RHS (and large lordosis)
- Appears able to laterally flex more into RHS ground contact
- Data from SMU lab suggests 1080lbs of peak force on RHS with a ground contact time of 0.085s vs 955lbs on LHS with a GCT of 0.097s

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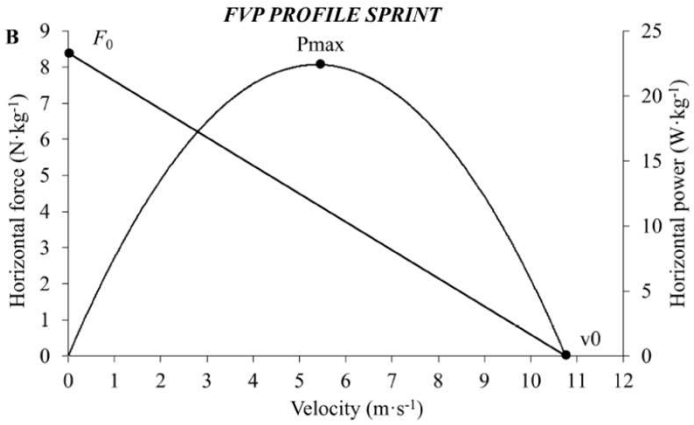
Acceleration and Max Velocity generic differences & SE training implications

- **Acceleration**: **muscle power relative to weight is a dominant factor in acceleration**
- **Max Velocity**: Horizontal power drops dramatically at Max V and expression of muscle power (shortening velocity and RFD) is perhaps not fast enough to express full potential (GCT<100ms) –**Fascial & Elastic (muscle amplifiers) elements more critical for top speed**.



THM: These facts and knowledge of specific athlete needs should dictate training emphasis for both SE and 'normal' training

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So to summarise the SE related sprinting data to date;

- Spinal engine (lat trunk flexion and hip adduction) – induces axial pelvic rotation & definitely contributes significant power output to SL jumps and first step in sprinting
- Upright sprinting appears to show similar pattern but data less definitive.
- Mechanism for force and power production in acceleration and top speed differ and SE training for these phases should reflect that.
  - Top speed in SE terms perhaps rotation dominant?
  - Acceleration in SE terms perhaps lateral flexion dominant?
- More data is required for certainty!

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Whilst we don't have definitive answers at this point some potential implications include;

- Training lateral trunk flexion, rotation and hip adduction (hip hitching) may very well positively impact ground force (and thus speed in sprinting)
- **The legs and feet are still critical as amplifiers of the spinal engine and propulsive energy generators in their own right – Thus they still need to be trained!**
- Trunk range of motion impacts speed and stride length – train to at least have enough
- The SE implications for training acceleration and Max V might be different

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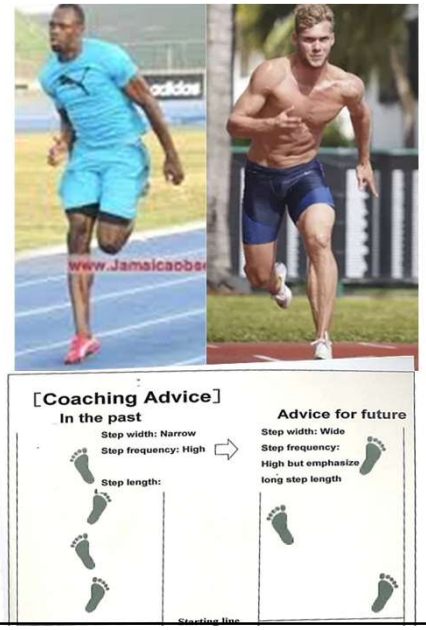
A final word on the impact of SE on running biomechanics

- Do we really know what good technique is?
- Are these positions wrong?
  - Potentially there is a lateral flexion bandwidth of viability, but its likely this bandwidth is very individual
- Keep and open mind - for example the speed skater like stride width seen in acceleration in some athletes isn't slower and is likely a faster option for SE monsters!
- Don't just look at, or film, your athletes from side on!



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Training the SE – many unknowns but may pay to consider the following;

- **ROM** – generically and with respect to lateral flexion and axial rotation (& internal and external rotation at the hip)
- **Muscle strength/power** – in trunk lateral flexion and rotation (includes lats, QL, Obliques, Psoas etc)
- **Fascial Slings and connections** - potentially including oscillation type work and/or hi rep ballistic loading

Basically train in 3D, & do it consistently but don't neglect the legs they remain the delivery mechanism!

A happy side effect of this stuff is that you can train for performance enhancement in terms of speed whilst carrying a lower limb injury = mental game changer.

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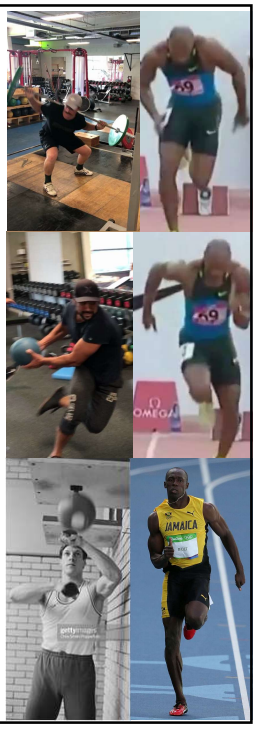
My current thinking. Train what you need & addressing the FV curve from a SE perspective

- **Initial acceleration** includes long ground contact times (250-150ms) and greater ROM in lateral flexion– this can be well addressed with appropriate rotational/flexion based strength training
- **Mid acceleration** – RFD more of priority and less time for application – shift towards speed focus address via sledge-hammer, med balls, plyos with rotational focus
- **Max Velocity** – SSC/elasticity dominated with very short periods of force application – diminished oscillation ROM for lateral flexion & yet increased rotation – address via speed ball, high speed banded oscillation work



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Final Thoughts

- SE training is not a magic bullet and doesn't cure cancer (or covid) but anecdotal & experimental evidence suggests it may be a useful addition to a sprinters (or jumpers or throwers) training
- You still need to do the basics!
  - Run/Jump/throw
  - Strength train generically
- All that said addressing the SE stuff may well take care of a rate limiting step either physically or biomechanically which could cause a significant performance improvement

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