
Sprint performance:
Strategies to maximise velocity
Dr. Aaron Uthoff
November 11th, 2022
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What is Speed?

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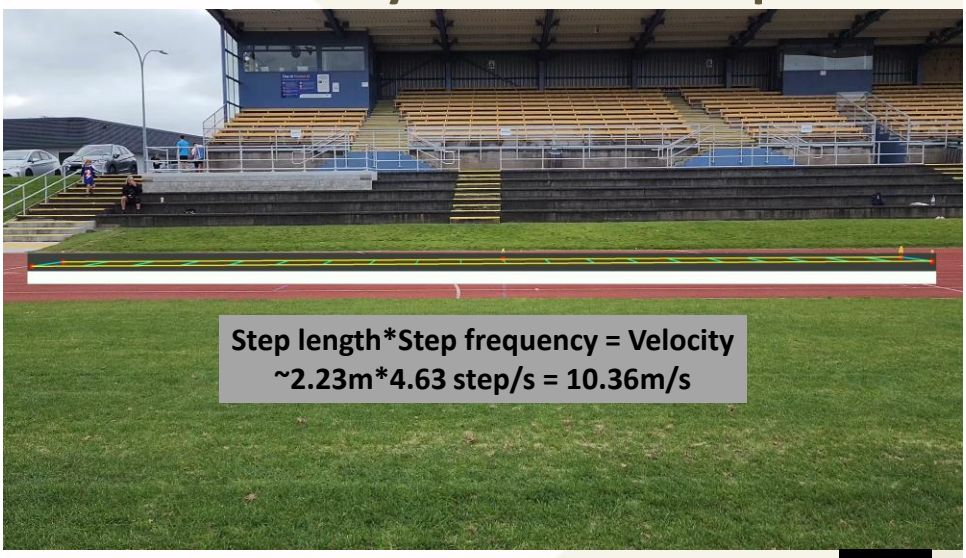
Another Way to Calculate Speed



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Step Length

Determinants:
Leg Length
Magnitude of Ground Reaction Forces

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Step Frequency

Flight Time + Contact Time

Flight Time:
Orientation of Force Application

Contact Time:
Rate of Force Application

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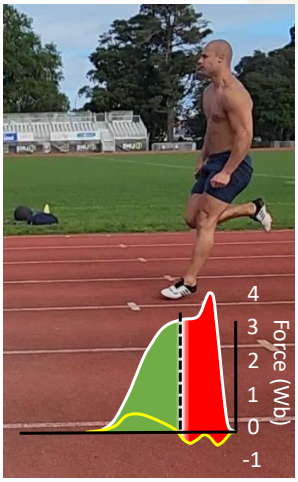
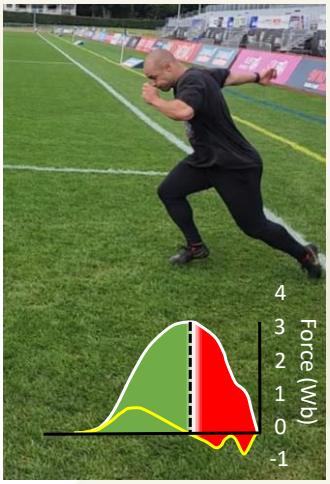
Force Application:
Acceleration vs Max Velocity





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Should athletes spend more time on the ground applying force or get off the ground quicker to prepare for the next step?

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Sprint mechanics in world-class athletes: a new insight into the limits of human locomotion

G. Rabita[1], S. Dorel[2], J. Slawinski[3], E. Sàez-de-Villarreal[4], A. Couturier[1], P. Samozino[5], J-B. Morin[6]

Sprint performance					
10 m time (s)	1.85 (0.10)	1.79 (0.02)	1.90 (0.12)	−6.1	1.10
15 m time (s)	2.50 (0.10)	2.40 (0.02)	2.58 (0.09)	−7.5	1.80
20 m time (s)	3.05 (0.13)	2.94 (0.02)	3.13 (0.13)	−6.5	1.46
30 m time (s)	4.08 (0.18)	3.93 (0.03)	4.20 (0.15)	−6.9	1.50
40 m time (s)	5.10 (0.25)	4.90 (0.07)	5.27 (0.21)	−7.6	1.48
40 m maximal velocity (m/s)	9.78 (0.52)	10.24 (0.19)	9.33 (0.31)	8.9	3.64
Spatiotemporal parameters					
Contact time					
$t_{c\,mean}$ (ms)	396 (33)	376 (13)	412 (36)	−9.6	1.09
Maximal contact time (ms)	193 (28)	191 (18)	193 (30)	−1.0	0.07
Minimal contact time (ms)	94 (4)	94 (5)	94 (4)	0.0	0.0
Aerial time					
$t_{f\,mean}$ (ms)	75 (20)	81 (13)	70 (25)	13.6	0.55
Maximal aerial time (ms)	124 (7)	120 (6)	128 (5)	−6.7	1.14
Minimal aerial time (ms)	50 (13)	42 (13)	56 (10)	−33.3	1.04
Step frequency					
Sf_{mean} (Hz)	2.14 (0.17)	2.20 (0.12)	2.09 (0.21)	5.0	0.64
Minimal frequency (Hz)	3.92 (0.34)	3.94 (0.44)	3.90 (0.44)	1.0	0.11
Maximal frequency (Hz)	4.87 (0.23)	4.95 (0.12)	4.80 (0.30)	3.0	0.65
Step length					
Sf_{mean} (m)	0.99 (0.11)	0.96 (0.16)	1.01 (0.06)	−5.2	0.45
Minimal step length (m)	1.11 (0.12)	1.18 (0.07)	1.06 (0.14)	10.2	1.00
Maximal step length (m)	2.19 (0.11)	2.22 (0.10)	2.17 (0.12)	2.3	0.45
Force- and power-velocity parameters					
Averaged F_z (N/kg)	17.3 (0.5)	17.2 (0.4)	17.5 (0.5)	−2.0	0.59
Averaged F_x (N/kg)	3.3 (0.3)	3.5 (0.6)	3.1 (0.2)	9.7	1.75
Averaged P_x (W/kg)	20.8 (2.2)	22.5 (1.1)	19.4 (1.9)	13.9	1.99
Averaged RF (% F_{res})	19.2 (1.3)	20.3 (0.7)	18.3 (1.0)	9.7	2.31
V0 (m/s)	11.38 (0.84)	11.90 (0.23)	10.99 (0.97)	7.6	0.12
F_0 (N)	776 (93)	855 (60)	744 (90)	13.0	1.19
Relative F_0 (N/kg)	9.77 (0.84)	9.95 (0.67)	9.62 (1.06)	3.3	0.39
Theoretical P_{hmax} (W)	2328 (295)	2550 (283)	2150 (158)	15.7	1.35
Measured P_{hmax} (W)	2421 (321)	2695 (244)	2201 (158)	18.3	1.53
Relative P_{hmax} (W/kg)	29.3 (2.3)	31.1 (0.8)	27.8 (2.2)	10.6	1.43
Relative P_{hpeak} (W/kg)	30.5 (2.9)	32.9 (1.2)	28.5 (2.1)	13.4	1.51
RF0 (%)	70.6 (5.4)	71.6 (2.6)	70.1 (7.3)	2.1	0.02
D_{RF}	−0.067 (0.007)	−0.064 (0.003)	−0.069 (0.009)	−7.8	0.71
Mean difference RF_{ecr} − RF_{hz} (% RF_{ecr})	0.25 (0.06)	0.29 (0.03)	0.21 (0.03)	27.6	1.33

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Maximal contact time (ms)	No Difference	0.07
Minimal contact time (ms)		0.0
Maximal aerial time (ms)	Much Lower	1.14
Minimal aerial time (ms)		1.04
Minimal frequency (Hz)	Somewhat Faster	0.11
Maximal frequency (Hz)		0.65
Minimal step length (m)	Somewhat to Much Further	1.00
Maximal step length (m)		0.45
Averaged F_z (N/kg)	Vertical = Much Greater Horizontal = Substantially Greater	0.59
Averaged F_y (N/kg)		1.75
Averaged P_y (W/kg)	Substantially greater	1.99
Averaged RF (% F_{tot})		2.31

Accounting for phases of the sprint?

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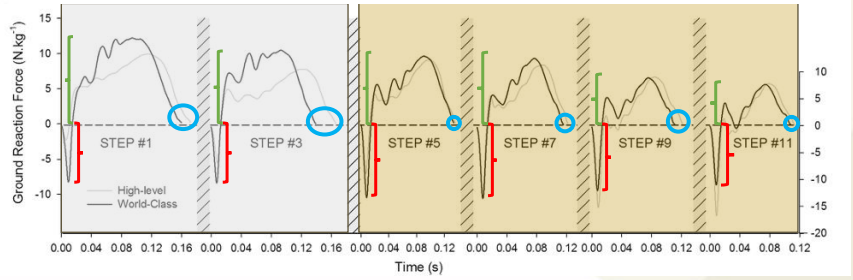
Acceleration capability in elite sprinters and ground impulse: Push more, brake less?

Jean-Benoît Morin[a,*], Jean Slawinski[b], Sylvain Dorel[c], Eduardo Saez de villareal[d], Antoine Couturier[e], Pierre Samozino[f], Matt Brughelli[g], Giuseppe Rabita[e]



Push harder, not longer during early acceleration

Brake less and push fast during mid to late acceleration

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J Appl Physiol 108: 950–961, 2010.
First published January 21, 2010; doi:10.1152/japplphysiol.00947.2009.

The biological limits to running speed are imposed from the ground up

Peter G. Weyand,[1,2] Rosalind F. Sandell,[1,2] Danille N. L. Prime,[2] and Matthew W. Bundle[3]

"stance phase limit to running speed is imposed not by the maximum forces that the limbs can apply to the ground but rather by the minimum time needed to apply the large, mass-specific forces necessary"

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Should athletes spend more time on the ground applying force or get off the ground quicker to prepare for the next step?

How should athletes maximise their time on the ground to prepare for the next step?

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Provide extremely high magnitudes of orientation-specific force as fast as possible!

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How

↑Horizontal Propulsive Force = Switching Thigh + Positive Shin Angle

↓Horizontal Braking Force = Pushing Down and Scissoring Thigh

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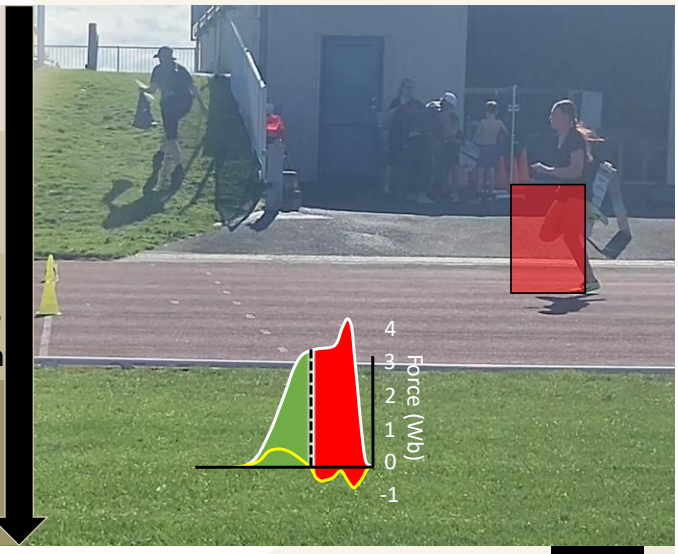
Excessive Backside Mechanics

Causes:
Poor Coordination
Weak Hip Flexors

Concerns:
High Braking Forces
Hamstring Strain

Goals:
Improve Switch Time
↑Hip Flexor Strength

Exercises:
Dribbles
Straight Leg Runs
Resisted Hip Flexion



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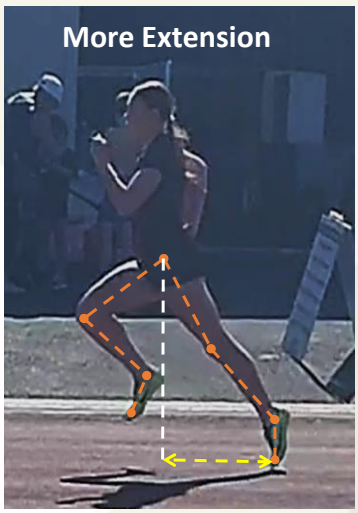
Excessive Backside Mechanics



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Excessive Backside Mechanics

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Overstriding

Causes:
Weak ECC Hamstring Strength in Flexion

Concerns:
High Braking Forces

Goals:
Decrease Leg Casting
↑ECC Knee Flexion strength

Exercises:
Razor Curls/Pulse
Bent Hammy Tantrum

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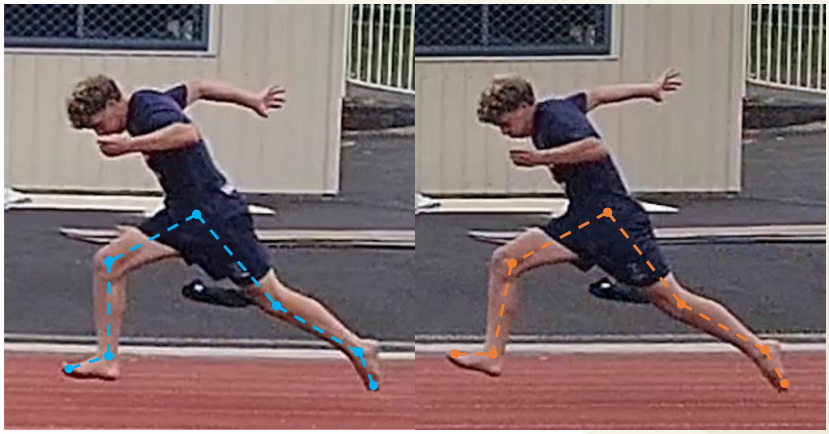
Overstriding



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Overstriding

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Thank You

https://academics.aut.ac.nz/aaron.uthoff

dr.aaronuthoff

drauthoff

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