Sprint performance: Strategies to maximise velocity

Dr. Aaron Uthoff November 11th, 2022



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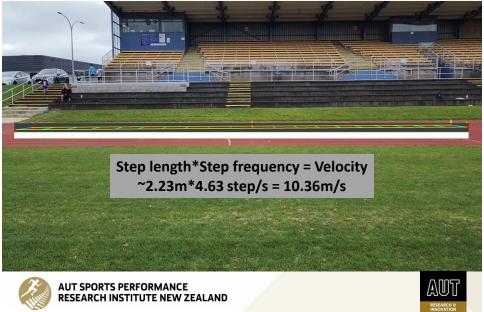




What is Speed?



Another Way to Calculate Speed



Step Length



Determinants: Leg Length Magnitude of Ground Reaction Forces





Step Frequency



Flight Time + Contact Time

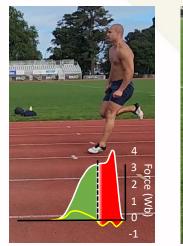
Flight Time: Orientation of Force Application

Contact Time: Rate of Force Application





Force Application: Acceleration vs Max Velocity











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

| Sprit graformance 1.85 (0.10) 1.79 (0.02) 1.90 (12) -6.1 1.10 15 m time (s) 2.50 (0.10) 2.40 (0.02) 2.58 (0.99) -7.5 1.86 20 m time (s) 3.05 (0.13) 2.40 (0.02) 2.58 (0.99) -7.5 1.86 30 m time (s) 4.08 (0.18) 3.93 (0.03) 4.20 (0.15) -6.5 1.50 40 m time (s) 5.10 (0.25) 4.90 (0.07) 5.27 (0.21) -7.6 1.84 40 m time (s) 5.10 (0.25) 1.24 (0.19) 9.33 (0.31) 8.9 3.64 Spatiotemporal parameters Contact time 3.96 (3.3) 276 (1.3) 412 (36) -9.6 1.09 Mean maximal contact time (ms) 3.94 (2.9) 1.91 (18) 1.93 (3.0) -0.07 Mean maximal contact time (ms) 3.94 (4) 0.0 0.07 |
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| 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) 3.13 (0.13) -6.5 1.80 20 m time (s) 3.05 (0.13) 2.94 (0.02) 3.13 (0.13) -6.5 1.60 30 m time (s) 4.06 (0.18) 3.93 (0.03) 4.20 (0.15) -6.9 1.50 40 m taximites 5.10 (0.25) 4.90 (0.07) 5.27 (0.21) -7.6 1.48 40 m maximal velocity (m/s) 5.710 (0.25) 4.90 (0.07) 5.27 (0.21) -7.8 1.48 40 m maximal velocity (m/s) 5.710 (0.25) 4.90 (0.07) 5.27 (0.21) -7.6 1.48 40 m maximal velocity (m/s) 5.710 (0.25) 4.90 (0.07) 5.27 (0.21) -7.6 1.48 40 m maximal velocity (m/s) 5.710 (0.22) 1.92 (0.31) 8.9 3.64 Exemptional 3.96 (3.3) 3.76 (1.3) 1.12 (3.0) -9.6 1.99 Maximal contact time (m/ms) 1.93 (2.8) 1.91 (1.8) 1.93 (30) -1.0 0.0 0.0 |
| 15 m time (s) 2.50 (0.10) 2.40 (0.02) 2.56 (0.99) -7.5 1.80 20 m time (s) 3.05 (0.13) 2.94 (0.02) 2.56 (0.99) -6.5 1.46 30 m time (s) 4.08 (0.18) 3.80 (0.33) 4.20 (0.15) -6.5 1.46 40 m maximal velocity (m/s) 5.78 (0.52) 10.24 (0.19) 9.33 (0.31) 8.9 3.64 5patiotemporal parameters 9.78 (0.52) 10.24 (0.19) 9.33 (0.31) 3.64 Contact time (ms) 153 (23) 11.18) 132 (20) -6.1 1.02 Minimiz domated time (ms) 153 (23) 11.18) 153 (20) -0.0 0.0 |
| 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) 4.90 (0.07) 5.27 (0.21) -7.6 1.48 Stationemoral parameters 0.78 (0.52) 4.90 (0.07) 5.27 (0.21) -7.6 1.48 Value 3.98 (0.33) 1.02 4 (0.19) 9.33 (0.31) 8.9 3.84 Value 3.98 (0.33) 3.76 (1.3) 4.12 (36) -9.6 1.99 Maximal contact time (ms) 1.93 (28) 1.91 (18) 1.93 (30) -1.0 0.07 Minimize contact time (ms) 9.4 (4) 9.4 (5) 9.4 (4) 0.0 0.0 |
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| 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 9.32 (0.31) 10.24 (0.19) 9.33 (0.31) 8.9 3.64 Contact time 9.95 (33) 3.76 (13) 412 (36) -9.6 1.99 Maximal contact time (ms) 193 (28) 191 (18) 193 (30) -10.0 0.07 Minimic contact time (ins) 94 (4) 94 (5) 94 (4) 0.0 0.0 |
| 40 m maximal velocity (m/s) Spatiotemport Janzmeters 9.78 (0.52) 10.24 (0.19) 9.33 (0.31) 8.9 3.64 Spatiotemport Janzmeters 296 (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 |
| Spatiotemporal parameters Spatiotemporal parameters Contact time (ms) 396 (33) 76 (13) 412 (36) -9.6 109 Lesser (ms) 153 (20) 191 (18) 193 (20) -10.0 0.07 Minimal contract time (ms) 94 (4) 94 (5) 94 (4) 0.0 0.0 |
| Lines 396 (33) 376 (13) 412 (36) -9.6 1.09 Maximal contact time (ms) 193 (25) 191 (18) 193 (30) -1.0 0.07 Minimal contact time (ms) 94 (4) 94 (5) 94 (4) 0.0 0.0 |
| 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 |
| Minimal contact time (ms) 94 (4) 94 (5) 94 (4) 0.0 0.0 |
| |
| Aerial time |
| |
| t _{a breas} (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 tooks (Hz) 2.14 (0.17) 2.20 (0.12) 2.09 (0.21) 5.0 0.64 |
| ST tacks (12) 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 |
| Maximina frequency (Hz) 3.52 (0.54) 3.54 (0.44) 3.50 (0.44) 1.0 0.11 Maxima frequency (Hz) 4.87 (0.23) 4.95 (0.12) 4.80 (0.30) 3.0 0.61 |
| Maximal inductory (nz) 4.07 (0.23) 4.55 (0.12) 4.00 (0.50) 5.0 0.05 Step length |
| S/ _{max} (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 _Y (N/kg) 3.3 (0.3) 3.5 (0.6) 3.1 (0.2) 9.7 1.75 |
| Averaged P _Y (W/kg) 20.8 (2.2) 22.5 (1.1) 19.4 (1.9) 13.9 1.99 |
| Averaged RF (% Front) 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 |
| Fy0 (N) 776 (93) 855 (60) 744 (90) 13.0 1.19 Relative Fy0 (N/kg) 9.77 (0.84) 9.95 (0.67) 9.62 (1.06) 3.3 0.39 |
| Relative Fv0 (N/kg) 9.77 (0.84) 9.95 (0.67) 9.62 (1.06) 3.3 0.39 Theoretical Pyrag (W) 2328 (295) 2550 (283) 2150 (158) 15.7 1.35 |
| Ineoretical Primas (W) 2328 (295) 2550 (283) 2150 (158) 15.7 1.35 Measured Primas (W) 2421 (321) 2695 (244) 2201 (158) 18.3 1.53 |
| WeakSured Provak (W) 2421 (321) 2093 (244) 2201 (150) 10.3 1.53 Relative Provak (W) 29.3 (2.3) 31.1 (0.8) 27.8 (2.2) 10.6 1.43 |
| Predative Prima (W/Kg) 29.3 (2.3) 31.1 (0.6) 27.6 (2.2) 10.6 1.43 Relative Prima (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 0.9 |
| Day -0.067 (0.007) -0.064 (0.003) -0.069 (0.009) -7.8 0.71 |
| Mean difference RF _{sp2} - RF _{sp} (% RF _{sp2}) 0.25 (0.06) 0.29 (0.03) 0.21 (0.03) 27.6 1.33 |





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

G. Rabita¹, S. Dorel², J. Slawinski³, E. Sàez-de-Villarreal⁴, A. Couturier¹, P. Samozino⁵, J-B. Morin⁶

Maximal contact time (ms) Minimal contact time (ms) Minimal aerial time (ms) Minimal aerial time (ms) Minimal frequency (Hz) Maximal frequency (Hz) Minimal step length (m) Maximal step length (m) Averaged F₂ (N/kg) Averaged F₂ (N/kg) Averaged P₄ (W/kg) Averaged RF (% F₁₀₂)

| No Difference | 0.07 |
|--|------|
| Much Lower | 1.14 |
| Somewhat Faster | 0.11 |
| Somewhat to Much Further | 1.00 |
| <u>Vertical</u> = Much Greater <u>Horizontal</u> = Substantially Greater | 0.59 |
| Substantially greater | 1.99 |

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 15 Ground Reaction Force (N.kg⁻¹) 10 10 5 5 0 0 STEP #1 STEP #3 STEP #5 STEP #7 STEP #9 STEP #1 -5 -5 -10 High-lever World-Class -10 -15 -20 Time (s)

Push harder, not longer during early acceleration

Brake less and push fast during mid to late acceleration





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. Bundle³

"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 How should athletes maximise on the ground applying force or their time on the ground to get off the ground quicker to prepare for the next step? prepare for the next step?





Provide extremely high magnitudes of orientationspecific 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







Excessive Backside Mechanics

Causes: Poor Coordination Weak Hip Flexors

Concerns: High Braking Forces Hamstring Strain

Goals: Improve Switch Time 个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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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 Tantrunx







Overstriding





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Overstriding







Thank You





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