



2022 NSCA *NATIONAL* CONFERENCE

July 6-9, 2022 | New Orleans & Online
#NSCACon22

› *KNOWLEDGE*
› *ADVANCEMENT*
› *COMMUNITY*

ANGULAR SPEED

TRAINING APPLICATIONS FOR NON-LINEAR ACCELERATION

A key area of opportunity for exploring new gains in performance and movement competency can be found in specifically training elements of Angular Speed. Attendees to this workshop will:

- Experience practical angular speed training.
- Learn key performance indicators of successful angular speed training.
- Learn how to setup and execute angular acceleration drills.

CONFLICT OF INTEREST STATEMENT

I currently have, or I have had in the past 2 years an affiliation or financial interest with Michael Johnson Performance around this presentation, including:

- Employment
- Stockholder or stock options

Why Acceleration Training?

Propulsive Intent

Attack the ground!

Vectorize RFD

Create propulsive vectors!

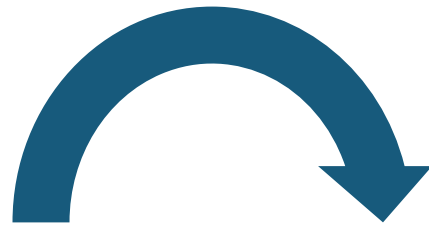
Accelerate RFD

Develop propulsive force at higher entry-velocities?

DEFINING ANGULAR ACCELERATION

ANGULAR ACCELERATION

The ability to move rapidly, effectively, and efficiently in non-linear (non-cursorial) locomotion patterns.



CURVILINEAR



BACKPEDAL



SHUFFLE

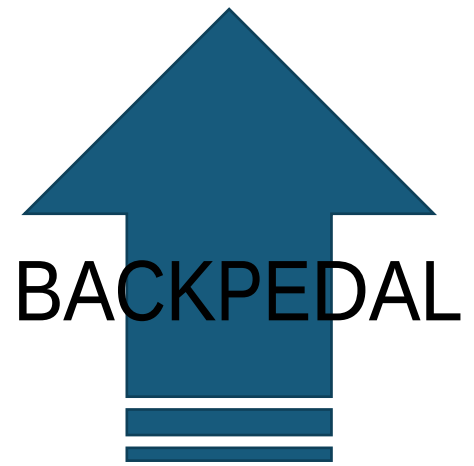


CROSSOVER

MULTIDIRECTIONAL

CURVILINEAR









Deceleration or Acceleration?

2.9 times more decelerations vs. accelerations in soccer.

De Hoyo et al., 2016

Mechanical load per meter of deceleration is 65% greater than any other match play activity in soccer; 37% more than when accelerating.

Harper & Kiely, 2018

Acceleration = higher metabolic cost

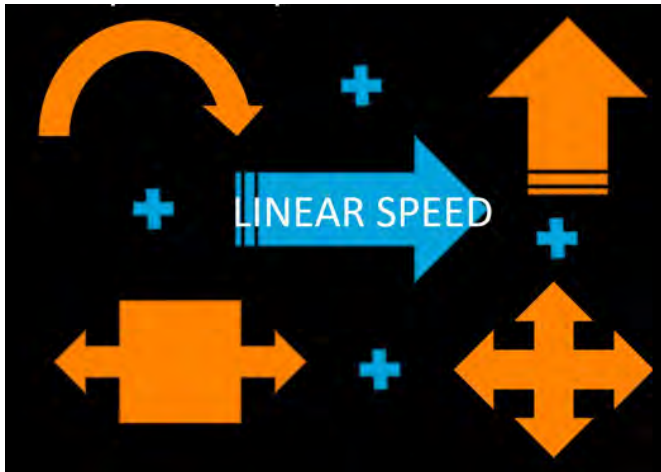
Hader et al., 2016

Deceleration = higher mechanical load

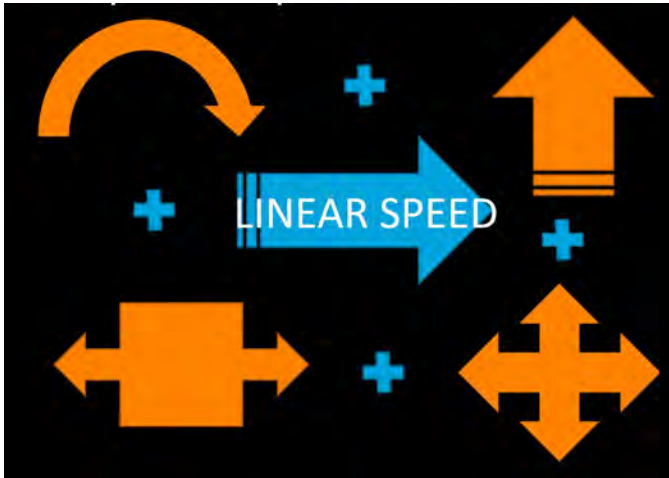
Dalen et al., 2016

Deceleration or Acceleration?

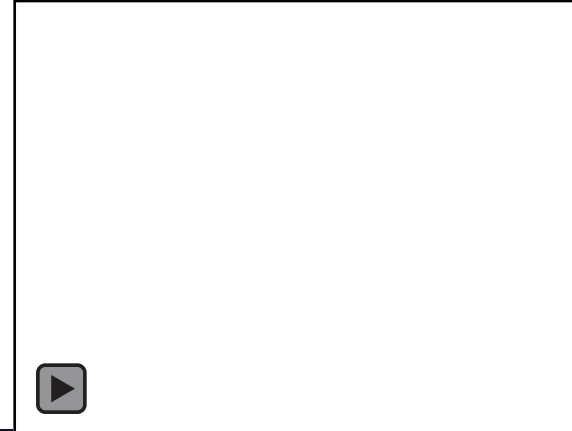
Deceleration or Acceleration?

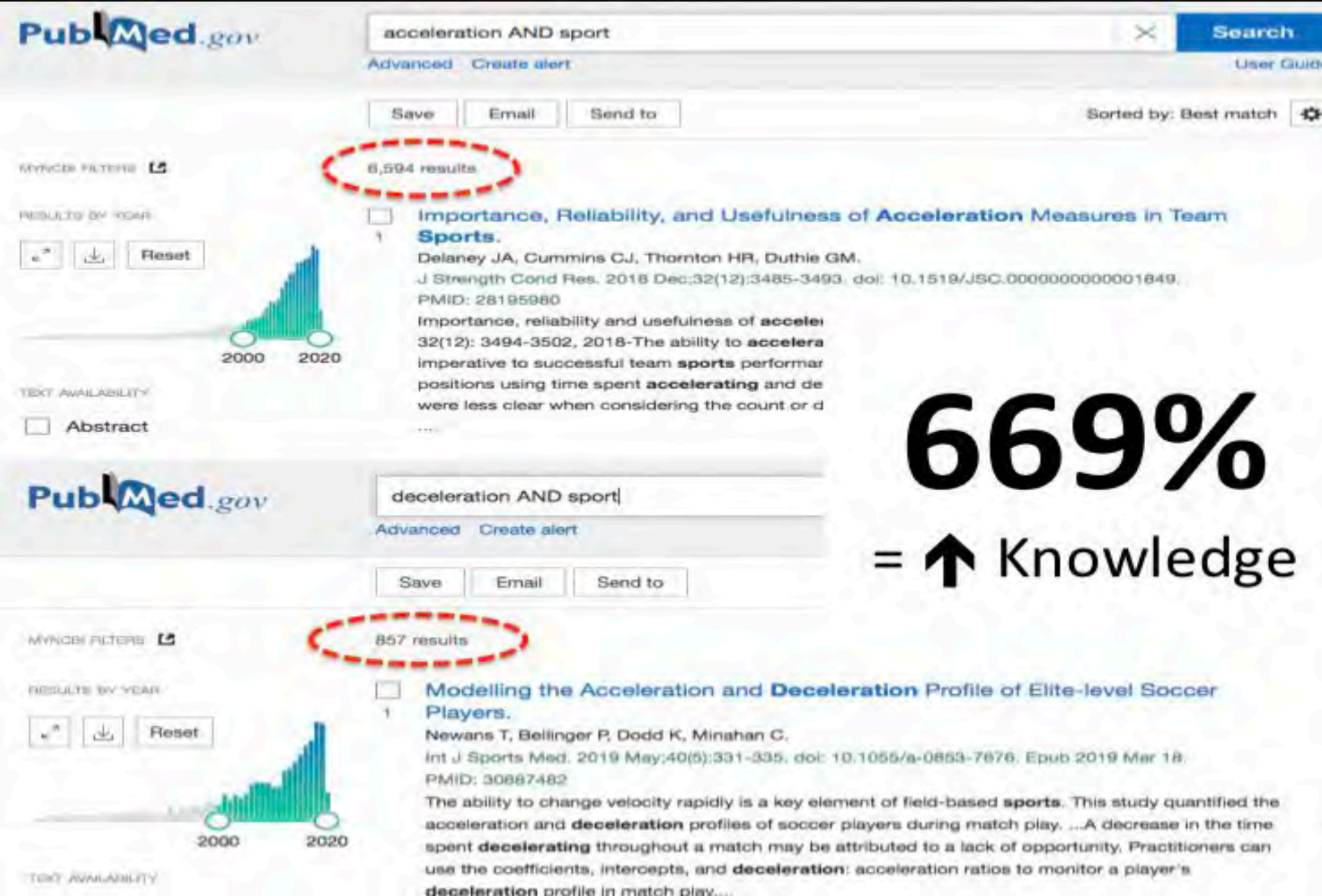


Deceleration or Acceleration?



Deceleration or Acceleration?





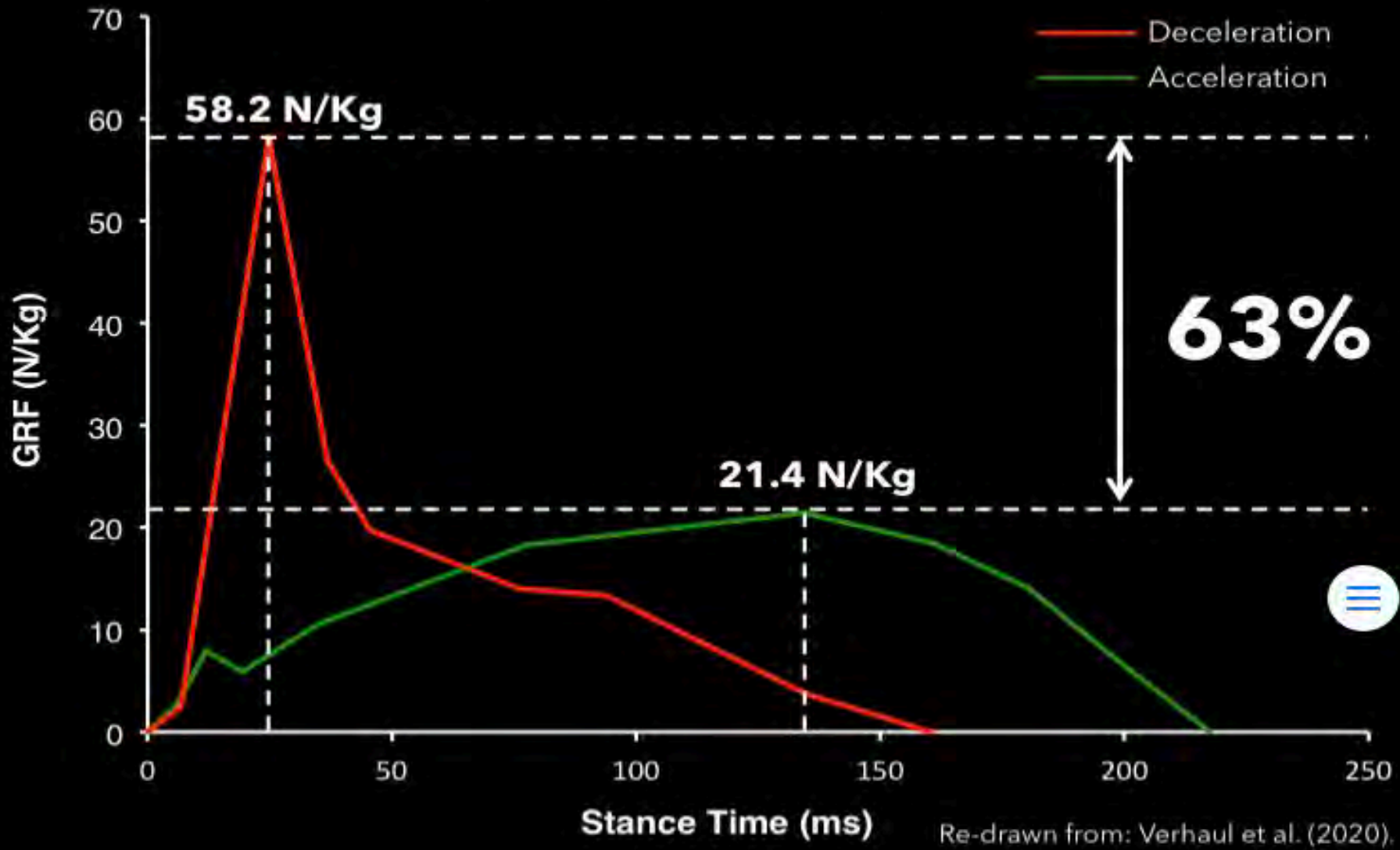
669%
= ↑ Knowledge

Deceleration or Acceleration?

Table 1 Kinematic differences between the ground contacts of the acceleration and deceleration phases of sprinting		
Kinematic characteristic	Acceleration phase (0–10 m)	Deceleration phase (0–5 m)
COM in relation to point of contact	Anterior	Posterior
Step length	Short	Short
Step width	Wide	Wide
Step frequency	High	High
Braking phase	Minimized/eliminated	Maximized
Propulsive phase	Maximized	Minimized/eliminated
Joint stiffness	Increased	Decreased
Support phase	Lengthened	Lengthened
Landing Distance	Minimized	Maximized
Ground contact time	Long	Long
Predominant muscle action through support phase	Concentric	Eccentric
Flight phase	Minimized	Minimized/eliminated
Information obtained from Andrews et al. (1), Dintiman et al. (5), Weaver (13).		

Speedworks.training

ACCEL vs. DECEL – GRF Profile



WHAT DO WE CURRENTLY KNOW?

Limited studies that have examined underlying technical and neuromuscular-tendon properties required for maximal horizontal deceleration.

Perceptual awareness of braking load tolerance (6).

Lower Centre of Mass (7).

Technical orientation of braking force (8).



Quadriceps & Hamstring Pre-Activation (5).

Isokinetic Eccentric quadriceps peak torque @60°/s (1,2,3).

Isokinetic Concentric Hamstring & Quadriceps peak torque @180°/s (2,4,5).

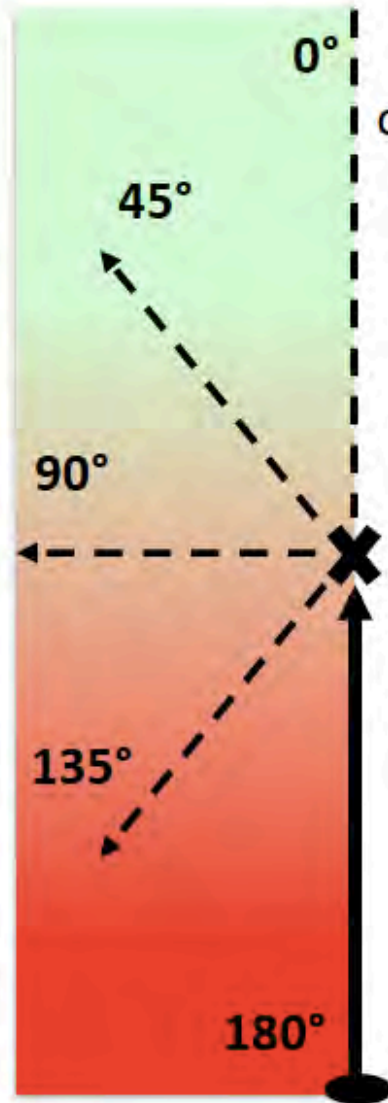
Tendon Buffering (9).

REFERENCES:

(1) Graham Smith et al. 2018, (2) Harper et al., 2018, (3) Jones et al., 2017, (4) Greig & Naylor, 2019, (5) Colby et al. 2000, (6) Nyland et al. 1994, (7) Cesar & Sigward, 2015, (8) Dos Santos et al. 2019, (9) Roberts & Konow, 2013.

Damian Harper
@DHMov

Braking > Velocity Velocity > Braking



Change of direction requires rapid and coordinated force application during the **braking**, plant and propulsive phases of the movement whilst maintaining optimal body positioning”
(Dos Santos, Jones & Comfort, 2016)

Research Note

Journal of Strength and Conditioning Research

Change of Direction Performance in Elite Players From Different Team Sports

Irineu Loturco,^{1,2,3} Lucas A. Pereira,^{1,2} Valter P. Reis,¹ César C. C. Abad,¹ Tomás T. Freitas,^{2,4} Paulo H. S. M. Azevedo,² and Sophia Nimphius⁵



Reduced ability to deal with faster entry velocity or unable to counterbalance the associated mechanical consequences of being faster and more powerful!

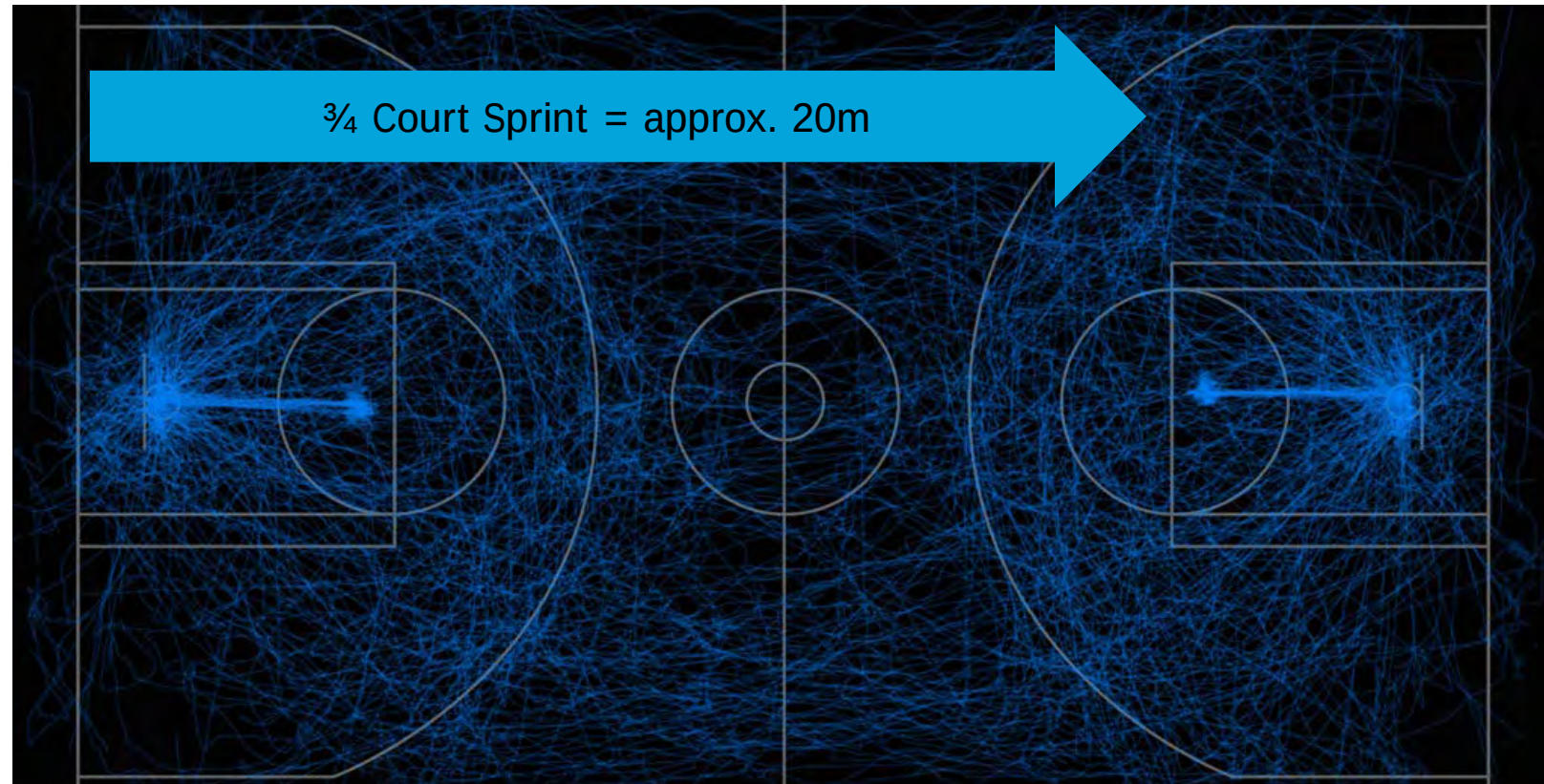
“Increasing volume or intensity of deceleration activity contributes to a vicious cycle of ever-increasing fatigue, diminishing coordinative proficiency, and subsequent risk of accumulating tissue damage.”

Harper & Kiely, 2018

Deceleration or Acceleration?

Deceleration or Acceleration?

ANGULAR ACCELERATION: TRAINING BENEFITS



Start >> Accelerate >> Decelerate / COD / Action

ANGULAR ACCELERATION: TRAINING BENEFITS

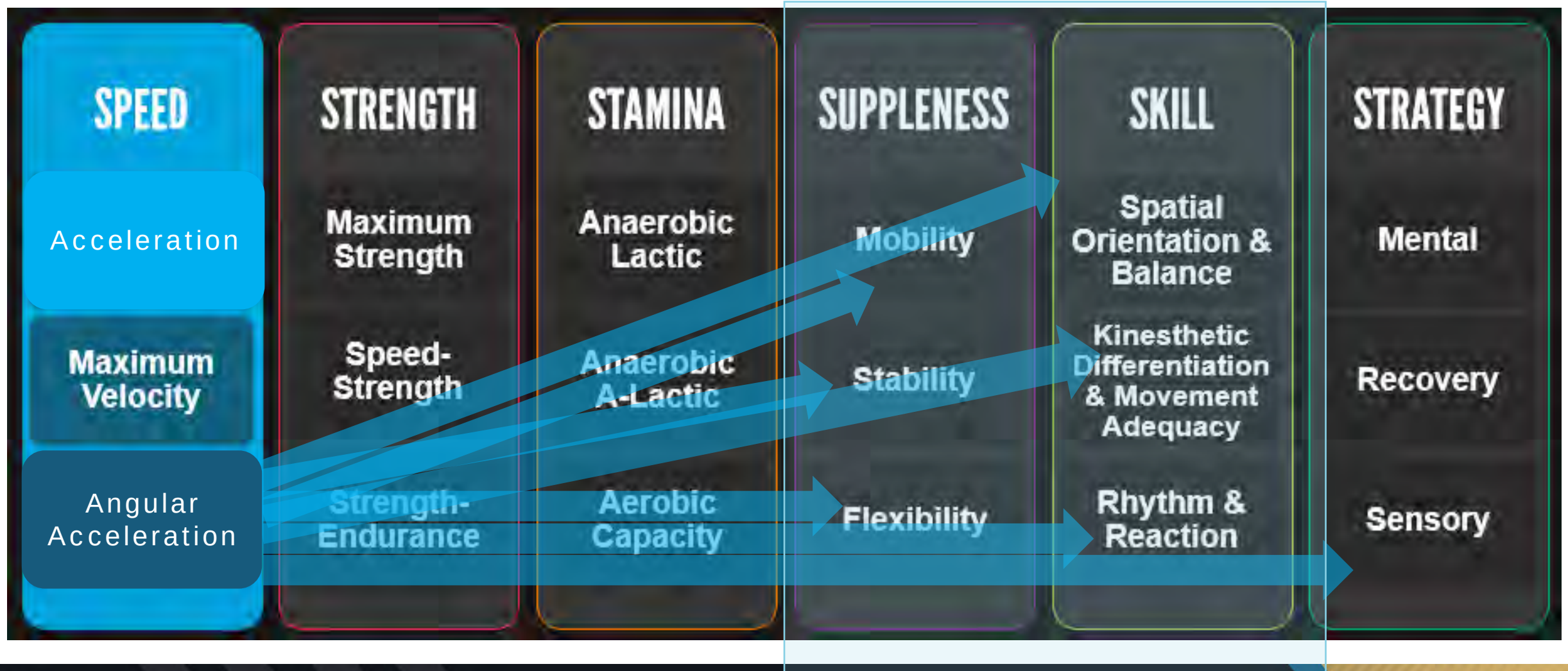
Why **Angular** Acceleration
Training?

Propulsive Intent
Attack the ground!

Vectorize RFD
Create propulsive vectors!

Accelerate RFD
Develop propulsive force at higher
entry-velocities?

ANGULAR ACCELERATION: TRANSFER EFFECTS-ATHLETICISM



ANGULAR ACCELERATION: TRAINING BENEFITS

Injury
“Prevention”

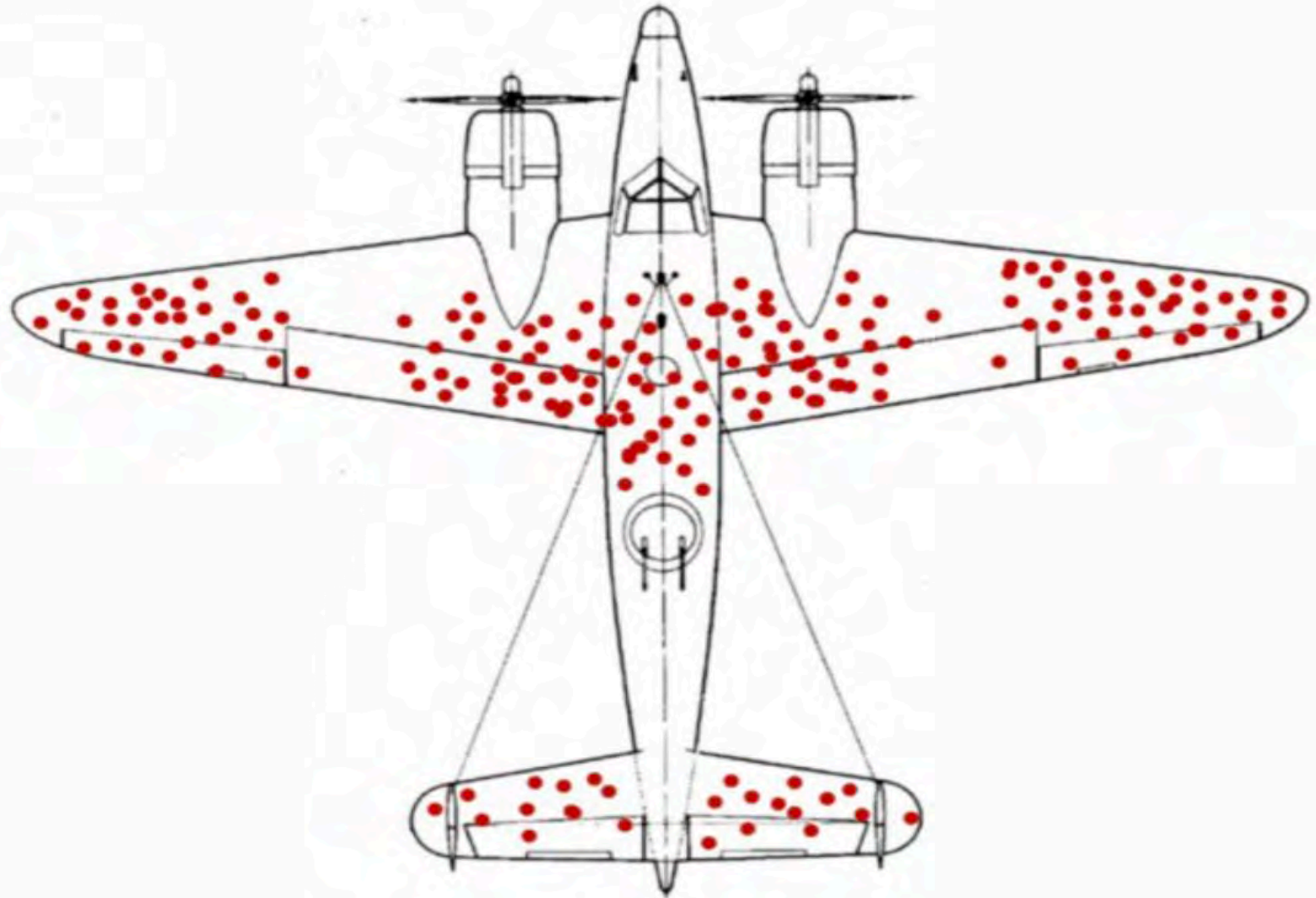
Take the red pill, you stay in Wonderland and I show you how deep the rabbit hole COULD go...



Take the blue pill, the story ends (skip next 10 slides). You wake up in your bed and believe whatever you want to believe...

Decelerating or Accelerating?

Deceleration or Acceleration?



Deceleration or Acceleration?

Professor Banaszak Holl said the results of this latest research throw into serious doubt the argument that most ACL injuries are caused by single force events. This could lead to different ways of managing athletes of all ages and levels.

"What we found from the tested cadaver knees was chemical and structural evidence of micro-damage of the ACL femoral enthesis, which is where the ligament attaches to the thigh bone and where the ACL typically tears," he said.

Junjie Chen, Jinhee Kim, Wenhao Shao, Stephen H. Schlecht, So Young Baek, Alexis K. Jones, Taeyong Ahn, James A. Ashton-Miller, Mark M. Banaszak Holl, Edward M. Wojtys. **An Anterior Cruciate Ligament Failure Mechanism.** *The American Journal of Sports Medicine*, 2019; 47 (9): 2067 DOI: [10.1177/0363546519854450](https://doi.org/10.1177/0363546519854450)

Human ankle plantar flexor muscle–tendon mechanics and energetics during maximum acceleration sprinting

Adrian Lai^{1,2}, Anthony G. Schache¹, Nicholas A. T. Brown³
and Marcus G. Pandy¹

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²Neuromuscular Mechanics Laboratory, Department of Biomedical Physiology and Kinesiology, Simon Fraser University, Burnaby, British Columbia, Canada V5A1S6

³Performance Science and Innovation, Australian Institute of Sport, Belconnen 2617, Australia

 AL, 0000-0002-8931-0878

Tendon elastic strain energy is the dominant contributor to muscle–tendon work during steady-state running. Does this behaviour also occur for sprint accelerations? We used experimental data and computational modelling to quantify muscle fascicle work and tendon elastic strain energy for the human ankle plantar flexors (specifically soleus and medial gastrocnemius) for multiple foot contacts of a maximal sprint as well as for running at a steady-state speed. Positive work done by the soleus and medial gastrocnemius muscle fascicles decreased incrementally throughout the maximal sprint and both muscles performed more work for the first foot contact of the maximal sprint (FC1) compared with steady-state running at 5 m s^{-1} (SS5). However, the differences in tendon strain energy for both muscles were negligible throughout the maximal sprint and when comparing FC1 to SS5. Consequently, the contribution of muscle fascicle work to stored tendon elastic strain energy was greater for FC1 compared with subsequent foot contacts of the maximal sprint and compared with SS5. We conclude that tendon elastic strain energy in the ankle plantar flexors is just as vital at the start of a maximal sprint as it is at the end, and as it is for running at a constant speed.

The mechanical energetic demands placed on human lower limb MTUs are fundamentally different between the steady-state and acceleration phases of running. When running at a steady-state speed, the lower limb muscles act in a spring-like manner absorbing and recovering the mechanical energy of the body [12–14]. The kinetic and potential energy of the body that is lost during the first half of stance is largely stored as elastic strain energy in compliant tissues

Acceleration = tendon stiffness + iso-e-concentric mm actions producing **positive work** (less “absorbing”?)

Deceleration = tendon stiffness + isometric mm “**abosorbing**” mechanical energy (and what else is “absorbing”?)

Kinetic Determinants of Reactive Strength in Highly Trained Sprint Athletes

Jamie Douglas^{1 2}, Simon Pearson^{1 3}, Angus Ross², Mike McGuigan^{1 4}

Affiliations + expand

PMID: 28930875 DOI: [10.1519/JSC.0000000000002245](https://doi.org/10.1519/JSC.0000000000002245)

Abstract

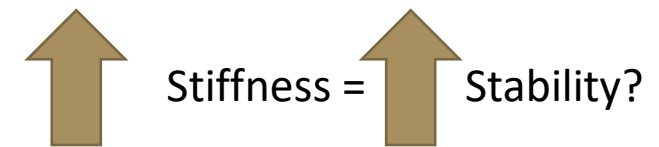
Douglas, J, Pearson, S, Ross, A, and McGuigan, M. Kinetic determinants of reactive strength in highly trained sprint athletes. J Strength Cond Res 32(6): 1562-1570, 2018-The purpose of this study was to determine the braking and propulsive phase kinetic variables underpinning reactive strength in highly trained sprint athletes in comparison with a nonsprint-trained control group. Twelve highly trained sprint athletes and 12 nonsprint-trained participants performed drop jumps (DJs) from 0.25, 0.50, and 0.75 m onto a force plate. One familiarization session was followed by an experimental testing session within the same week. Reactive strength index (RSI), contact time, flight time, and leg stiffness were determined. Kinetic variables including force, power, and impulse were assessed within the braking and propulsive phases. Sprint-trained athletes demonstrated higher RSI vs. nonsprint-trained participants across all drop heights {3.02 vs. 2.02; ES ($\pm 90\%$ confidence limit [CL]): 3.11 ± 0.86 }. This difference was primarily attained by briefer contact times (0.16 vs. 0.22 seconds; effect size [ES]: -1.49 ± 0.53) with smaller differences observed for flight time (0.50 vs. 0.46 seconds; ES: 0.53 ± 0.58). Leg stiffness, braking and propulsive phase force, and power were higher in sprint-trained athletes. Very large differences were observed in mean braking force (51 vs. 38 N·kg; ES: 2.57 ± 0.73) which was closely associated with contact time ($r \pm 90\%$ CL: -0.93 ± 0.05). Sprint-trained athletes exhibited superior reactive strength than nonsprint-trained participants. This was due to the ability to strike the ground with a stiffer leg spring, an enhanced expression of braking force, and possibly an increased utilization of elastic structures. The DJ kinetic analysis provides additional insight into the determinants of reactive strength which may inform subsequent testing and training.

RSI increases with:

- More stiffness at ground strike (co-contraction)
- Better “expression of braking force” (impulse)
- Better utilization of elastic structures (tendon)
- Less “yielding” and more “propulsive” intent?

 Stiffness =  Stability

Muscular stiffness is an important component of lower limb stiffness and includes the ability of muscles to resist movement within the tibiofemoral joint (tibiofemoral shear movements), which prevents passive structures of the knee, such as the ACL, to be under strain (Hughes and Watkins, 2006).



A risk-factor model for anterior cruciate ligament injury. Hughes
G, Watkins J
Sports Med. 2006; 36(5):411-28.

Sagittal plane biomechanics cannot injure the ACL during sidestep cutting

Scott G McLean¹, Xuemei Huang, Anne Su, Antonie J Van Den Bogert

Affiliations + expand

PMID: 15342155 DOI: [10.1016/j.clinbiomech.2004.06.006](https://doi.org/10.1016/j.clinbiomech.2004.06.006)

Abstract

Background: Knee joint sagittal plane forces are a proposed mechanism of anterior cruciate ligament injury during sport movements such as sidestep cutting. Ligament force magnitudes for these movements however, remain unknown. The need to examine injury-causing events suggests elucidation via model-based investigations is possible. Using this approach, the current study determined whether sagittal plane knee loading during sidestep cutting could in isolation injure the anterior cruciate ligament.

A need for multi-planar acceleration training?



Frontal & Transverse Plane Stiffness



Frontal & Transverse Plane Reactive Strength

Is It Time We Better Understood the Tests We are Using for Return to Sport Decision Making Following ACL Reconstruction? A Critical Review of the Hop Tests

William T Davies ¹, Gregory D Myer ^{2 3 4}, Paul J Read ⁵

Affiliations + expand

PMID: 31745732 PMCID: [PMC7018781](#) DOI: [10.1007/s40279-019-01221-7](#)

[Free PMC article](#)

Abstract

There has been a move towards a criterion-based return to play in recent years, with 4 single-leg hop tests commonly used to assess functional performance. Despite their widespread integration, research indicates that relationships between 'passing' hop test criteria and successful outcomes following rehabilitation are equivocal, and, therefore, require further investigation. This critical review includes key information to examine the evolution of these tests, their reliability, relationships with other constructs, and sensitivity to change over time. Recommendations for how measurement and administration of the tests can be improved are also discussed. The evidence presented in this review shows that hop tests display good reliability and are sensitive to change over time. However, the use of more than 2 hop tests does not appear to be necessary due to high collinearity and no greater sensitivity to detect abnormality. The inclusion of other hop tests in different planes may give greater information about the current function of the knee, particularly when measured over time using both relative and absolute measures of performance. It is recommended that the contralateral limb be tested prior to surgery for a more relevant benchmark for performance, and clinicians are strongly advised to measure movement quality, as hop distance alone appears to overestimate the recovery of the knee.

Hop distance is not as valuable indicator of readiness.

Measure loading?

Measure impulse?

Measure stiffness?

Epub 2006 Nov 7.

Mechanisms of anterior cruciate ligament injury in basketball: video analysis of 39 cases

Tron Krosshaug¹, Atsuo Nakamae, Barry P Boden, Lars Engebretsen, Gerald Smith, James R Slauterbeck, Timothy E Hewett, Roald Bahr

Affiliations + expand

PMID: 17092928 DOI: [10.1177/0363546506293899](https://doi.org/10.1177/0363546506293899)

↑ “Yielding” = ↑ Risk

Conclusion: Female players landed with significantly more knee and hip flexion and had a 5.3 times higher relative risk of sustaining a valgus collapse than did male players. Movement patterns were frequently perturbed by opponents.

Changes in Injury Risk Mechanisms after Soccer-Specific Fatigue in Male Youth Soccer Players

Michal Lehnert¹, Mark De Ste Croix², Zuzana Xaverova¹, Michal Botek¹, Renata Varekova¹, Amr Zaatar¹, Ondrej Lastovicka¹, Petr Stastny³

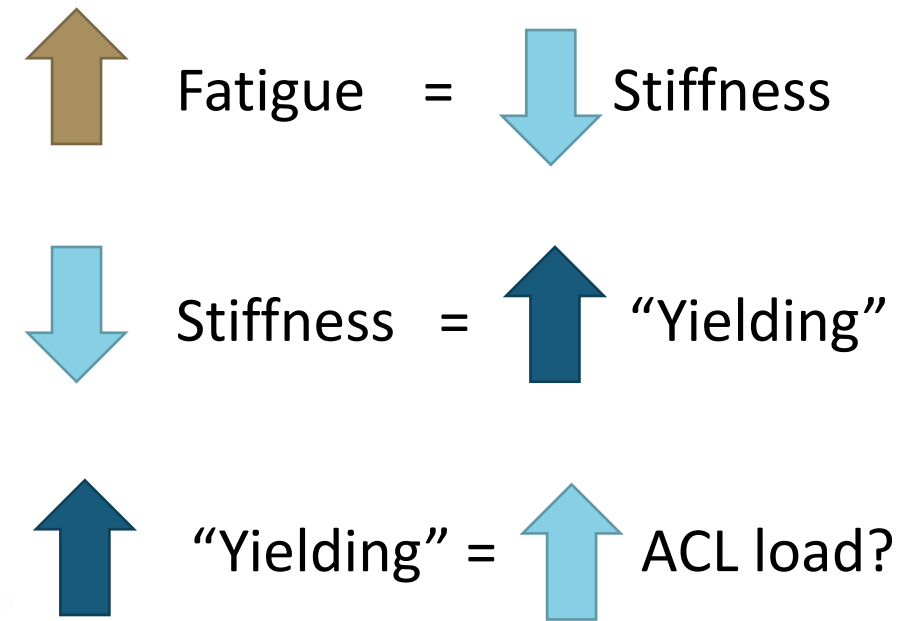
Affiliations + expand

PMID: 29922375 PMCID: PMC6006546 DOI: 10.1515/hukin-2017-0157

[Free PMC article](#)

Stiffness

The results of our study showed a significant decrease ($p < 0.05$) in absolute and relative leg stiffness after a fatigue protocol ([Table 1](#)). The effect size values ($\omega^2 = 0.48$ in both cases) point to a large effect of the fatigue protocol on both absolute and relative leg stiffness. These results suggest that the fatigue protocol compromised neuromuscular pre-activation and neuromuscular feed-forward control as an important indicator of dynamic stability of the knee ([Hughes and Watkins, 2006](#)). The reduction in stiffness by 14.3% and 8.6%, respectively, indicates longer ground contact times and a likely shift in the neural control to a lower contribution from pre-activation and short latency stretch reflexes. This in turn is likely to lead to more of a yielding action with an increase in the centre of mass displacement during ground contact and subsequently an increase in the excessive load of the knee passive structures such as the ACL, and consequently an increase in the relative risk of injury, especially during landing ([De Ste Croix et al., 2015](#); [Hughes and Watkins, 2006](#)). These findings replicate results from a previous study where leg stiffness



If “yielding” increases ACL load...

...why are we teaching “yielding”?

ANGULAR ACCELERATION: REDUCE RISK

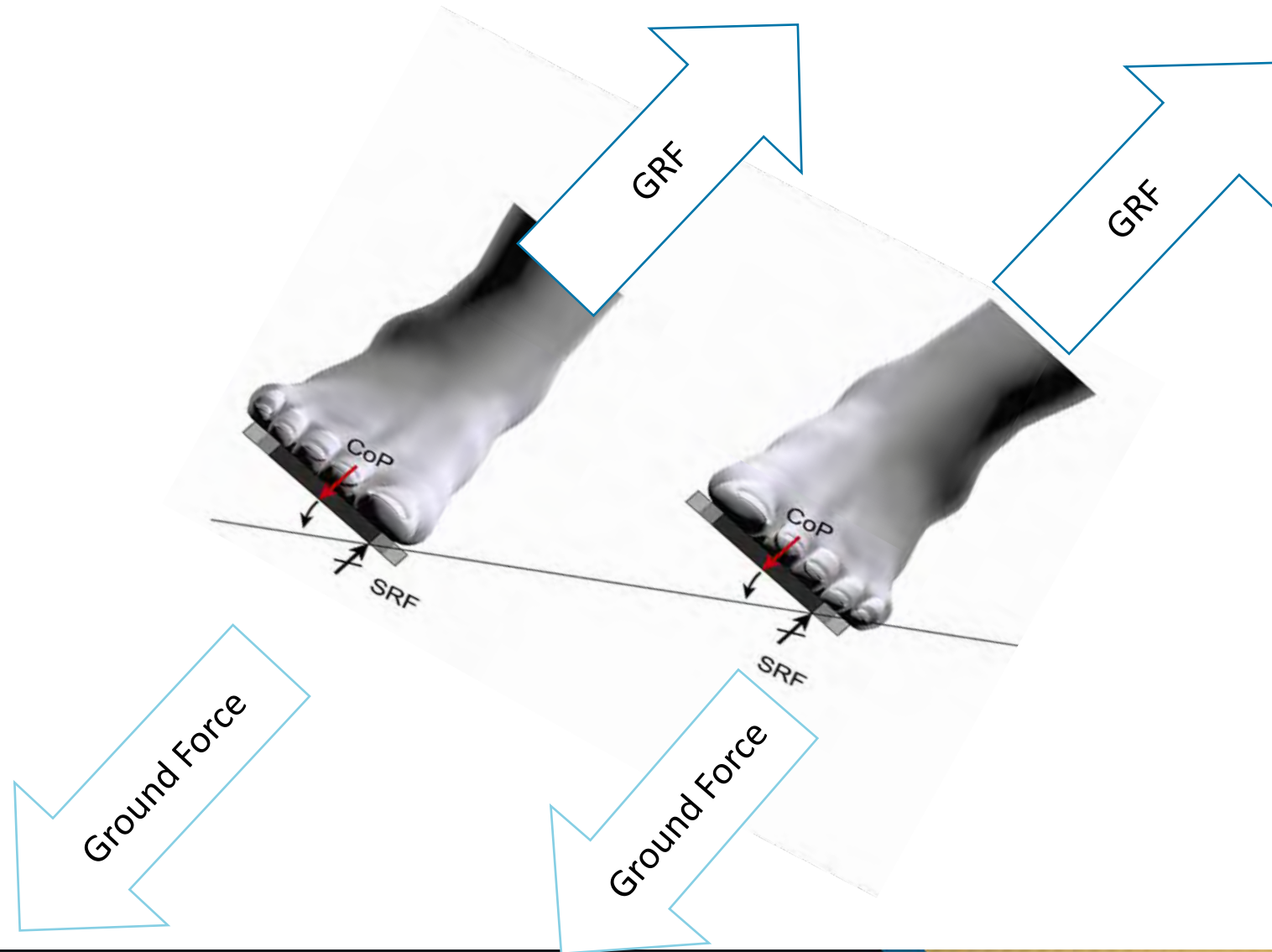
- Center of Mass (COM) Manipulation

Center-of-Mass (COM) in FRONT of Base-of-Support (BOS) = ↑ Horizontal Force Vector



ANGULAR ACCELERATION: REDUCE RISK

- Angles & Edges



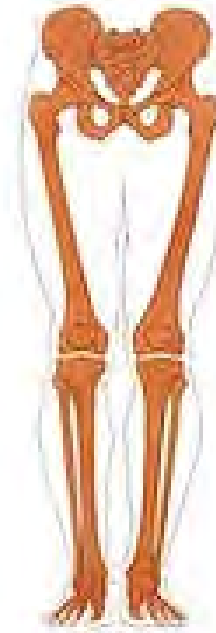
ANGULAR ACCELERATION: REDUCE RISK

- Angles & Edges



ANGULAR ACCELERATION: REDUCE RISK

- Propulsive vs. Absorptive Force Production



Normal



Bowleggedness (Vargus)



Knock Knees (Valgus)

“Landing” Leg Action in UnStacked Ankle-Knee-Hip Position = Producing ↑ Shearing Forces

“Landing” Error Scoring Test? Is “Landing” the real “error” to correct...?

ANGULAR ACCELERATION: REDUCE RISK

They aren't "landing"...they are "taking off"...

Why are we teaching and testing "landing"? Maybe we should never "land"...we should only change-direction?



KEY PERFORMANCE INDICATORS: ANGULAR ACCELERATION

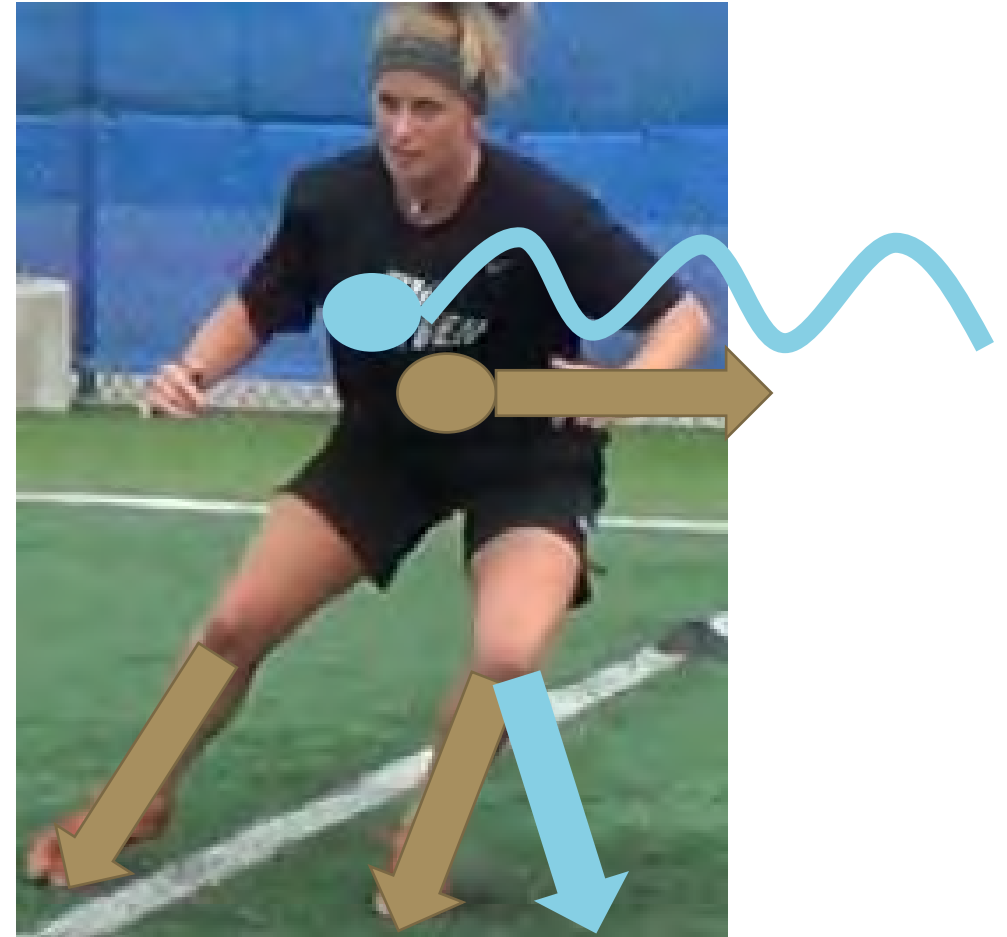
- ✓ COM in front of BOS (in direction of intended movement)
- ✓ Acute Attack Angles & Force Applied on Edges of Feet
- ✓ Piston-Like Leg Action Producing Horizontal Propulsive Force (no reaching)



KEY PERFORMANCE INDICATORS: ANGULAR ACCELERATION

• Key Postures

- ✓ Positive Torso & Shin Angles (acute “attack angles” in intended direction); COM in front of BOS
- ✓ Low COM Leads Motion & Advances Horizontally w/ each step (no “pulsing” or “oscillating” of COM)
- ✓ Body Moves as One Stable/Linear Unit



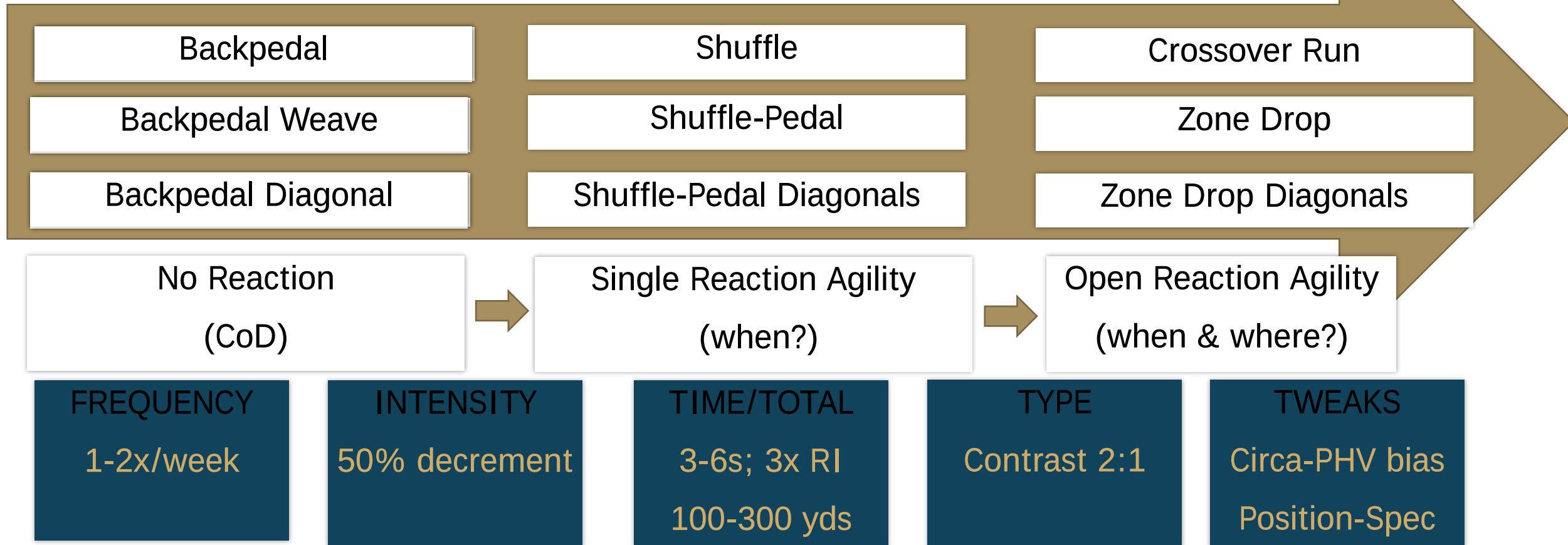
KEY PERFORMANCE INDICATORS: ANGULAR ACCELERATION

• Key Movement Patterns

- ✓ “Piston-Like” Leg Action w/ Positive Shin Angle; no “reaching” or casting of front leg
- ✓ ACTIVE BACK-FORCE (creates force-vector of horizontal propulsion); “Attack the Ground”, “Throw a Punch”
- ✓ COM Stays Low & Moves Horizontally; no “oscillation” or “pulsing”

SPEED TRAINING: ANGULAR ACCELERATION

- PRESCRIPTION: Contrast Acceleration Progression



FOR MORE INFORMATION:

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