Deceleration:

Why is it so important for athletes competing in multi-directional sport?

Dr Damian Harper

Lecturer · University of Central Lancashire, UK

Founder of Human Braking Performance

HumanBrakingPerformance.com

AUT SPRINZ Strength & Conditioning Conference `14-15 November 2024

SPORTS PERFORMANCE RESEARCH INSTITUTE

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HUMAN BRAKING PERFORMANCE

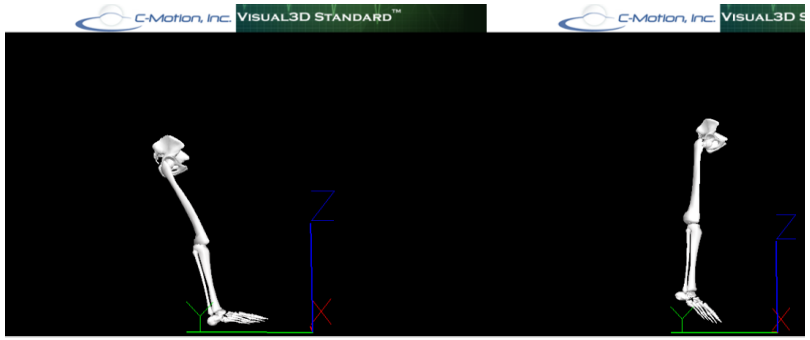
OPTIMISING ATHLETIC **POTENTIAL**

MMU Cheshire
The Manchester Metropolitan University
Department of Sport and Exercise Science

'Vertimax and Soccer Speed'

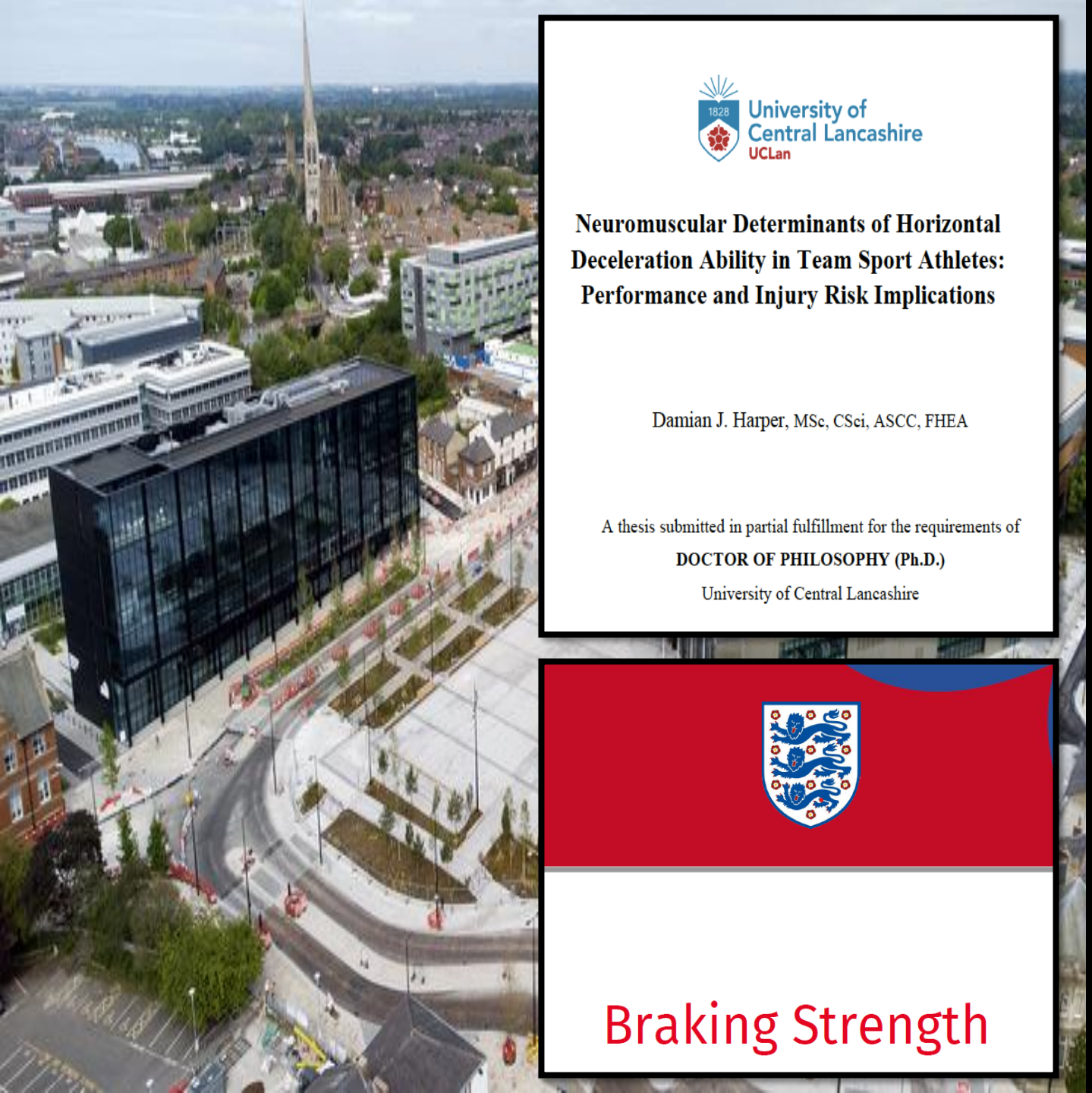
The 10 to 5 repeated jump test: A new test for evaluation of lower body reactive strength

Damian Harper BSc, MSc, Cert Ed
Hobbs, S.J. & Moore, J.
University of Central Lancashire



Reactive Strength vs Power: The Best Predictor of Speed in Elite U'20 Super League Players

St.Helens R.F.C.



University of Central Lancashire
UCLan

Neuromuscular Determinants of Horizontal Deceleration Ability in Team Sport Athletes: Performance and Injury Risk Implications

Damian J. Harper, MSc, CSci, ASCC, FHEA

A thesis submitted in partial fulfillment for the requirements of
DOCTOR OF PHILOSOPHY (Ph.D.)
University of Central Lancashire

Braking Strength

1. **Harper, D.J. et al.** (2024). The braking performance framework. *International Journal of Strength and Conditioning*.
2. **Harper,D.J.,** McBurnie, A.J., Dos'Santos, T., Eriksrud, O., Evans, M., Cohen, D.D., Rhodes, D., Carling, C. & Kiely, J. (2022). Biomechanical and neuromuscular performance requirements of horizontal deceleration: A review with implications for random, intermittent, multi-directional sports. *Sports Medicine* (In press)
3. **Harper, D. J.,** Cohen, D. D., Rhodes, D., Carling, C., Harper, D. J., Cohen, D. D., Rhodes, D., & Carling, C. (2021). Drop jump neuromuscular performance qualities associated with maximal horizontal deceleration ability in team sport athletes. *European Journal of Sport Science*. Online ahead of print.
4. **Harper, D.J.,** Jordan, A. & Kiely, J. (2021) Relationships between eccentric and concentric knee strength capacities and maximal linear deceleration in male academy soccer players. *Journal of Strength & Conditioning Research*.
5. **Harper, D.J.,** Sandford, G.N., Clubb, J., Young, M., Taberner, M., Rhodes, D., Carling, C. & Kiely, J. (2020). Elite football of 2030 will not be the same as 2020: What has evolved and what needs to evolve? *Scandinavian Journal of Medicine & Science in Sports*. 31, 493-494
6. **Harper, D. J.,** Cohen, D. D., Carling, C., & Kiely, J. (2020). Can countermovement jump neuromuscular performance qualities differentiate maximal horizontal deceleration ability in team sport athletes? *Sports*, *8*(6), 1–20.
7. **Harper, D. J.,** Morin, J.B., Carling, C., & Kiely, J. (2020). Measuring maximal horizontal deceleration ability using radar technology: Reliability and sensitivity of kinematic and kinetic variables. *Sports Biomechanics.* Published ahead of print.
8. **Harper, D. J.,** Carling, C., & Kiely, J. (2019). High-intensity acceleration and deceleration demands in elite team sports competitive match play: A systematic review and meta-analysis of observational studies. *Sports Medicine*. 49(12), 1923-1947
9. **Harper, D.J.** & Kiely, J. (2018) Damaging nature of decelerations: Do we adequately prepare players? *British Medical Journal Open Sport & Exercise Medicine*. 4, e000379.

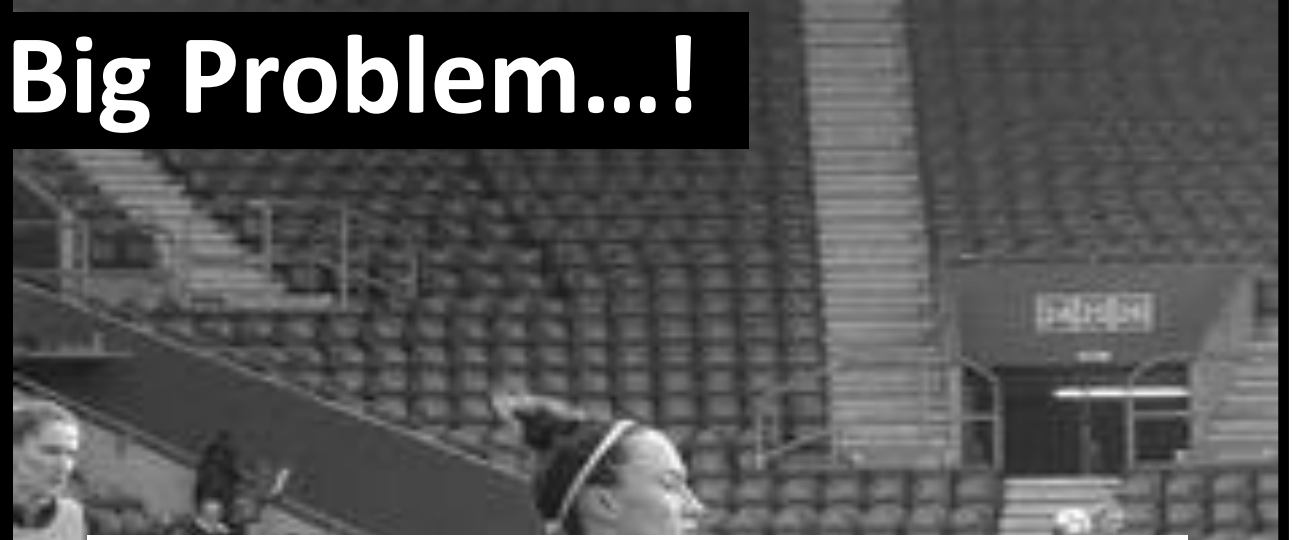
The Big Problem…!

Improving Mechanical Effectiveness During Sprint Acceleration: Practical Recommendations and Guidelines

Dylan Shaun Hicks, MSc,[1] Jake George Schuster, MSc,[2] Pierre Samozino, PhD,[3] and Jean-Benoit Morin, PhD[4]
[1]Exercise Science Department, Flinders University, Adelaide, South Australia, Australia; [2]Vald Performance and Florida State University Institute of Sports Science and Sports Medicine; [3]Univ Savoie Mont Blanc, Laboratoire Interuniversitaire de Biologie de la Motricité, Chambéry, France; [4]Université Côte d'Azur, LAMHESS, Nice, France

Extensive Research

Acceleration & Top Speed



Open access Editorial

BMJ Open Sport & Exercise Medicine

Damaging nature of decelerations: Do we adequately prepare players?

Damian James Harper,[1,2] John Kiely[2]

Little Research!

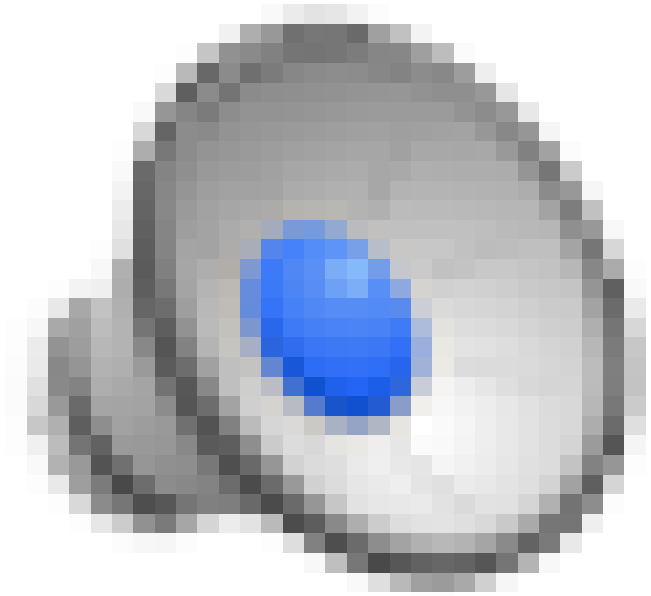
Deceleration

Biomechanics of predator prey arms race in lion, zebra, cheetah and impala

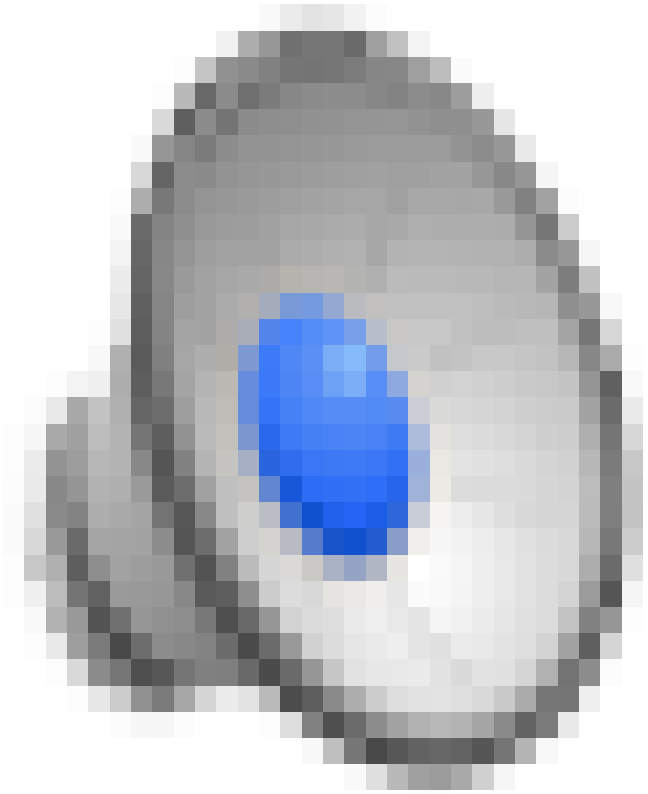
A.M. Wilson[1], T.Y. Hubel[1], S. Wilshin[1], J.C. Lowe[1], M. Lorenc[1] O.P. Dewhirst[1], H.L.A. Bartlam-Brooks[1], R. Diack[1], E. Bennitt[2], K.A. Golabek[3], R. Woledge[1†], J.W. McNutt[3], N.A. Curtin[1] & T. West[1]

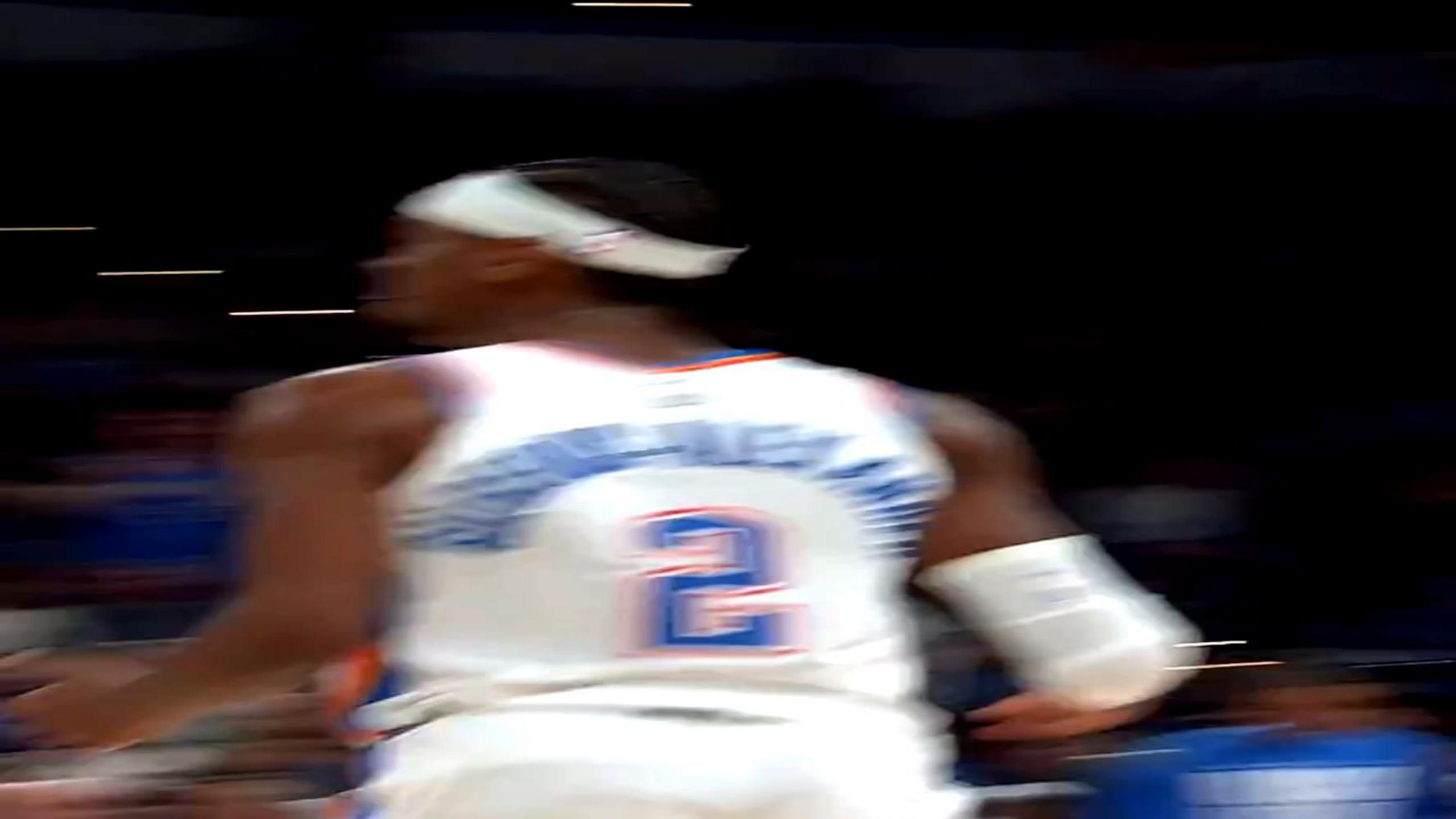
Maximal Acceleration = 9.8 $m.s^{-2}$

Maximal Deceleration = 15.2 $m.s^{-2}$



Performance Implications





Performance Implications

Linear advancing actions followed by deceleration and turn are the most common movements preceding goals in male professional soccer

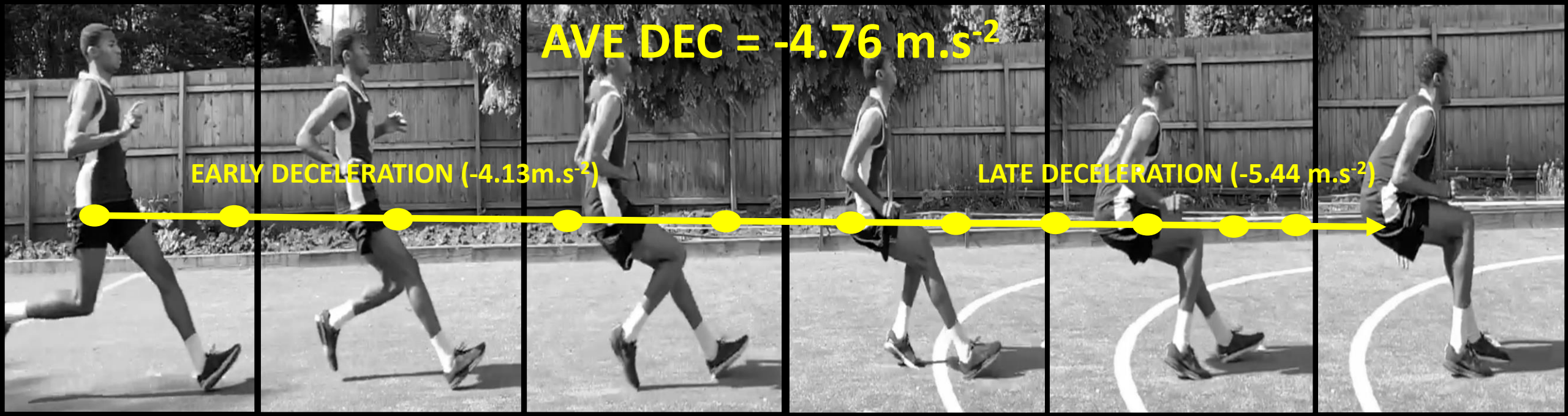
David Martínez-Hernández, Mark Quinn & Paul Jones

Injury-Risk Implications

Injury-Risk Implications

HORIZONTAL DECELERATION

$$Deceleration\ (m/s^2) = \frac{(v_f - v_i)}{(t_f - t_i)}$$



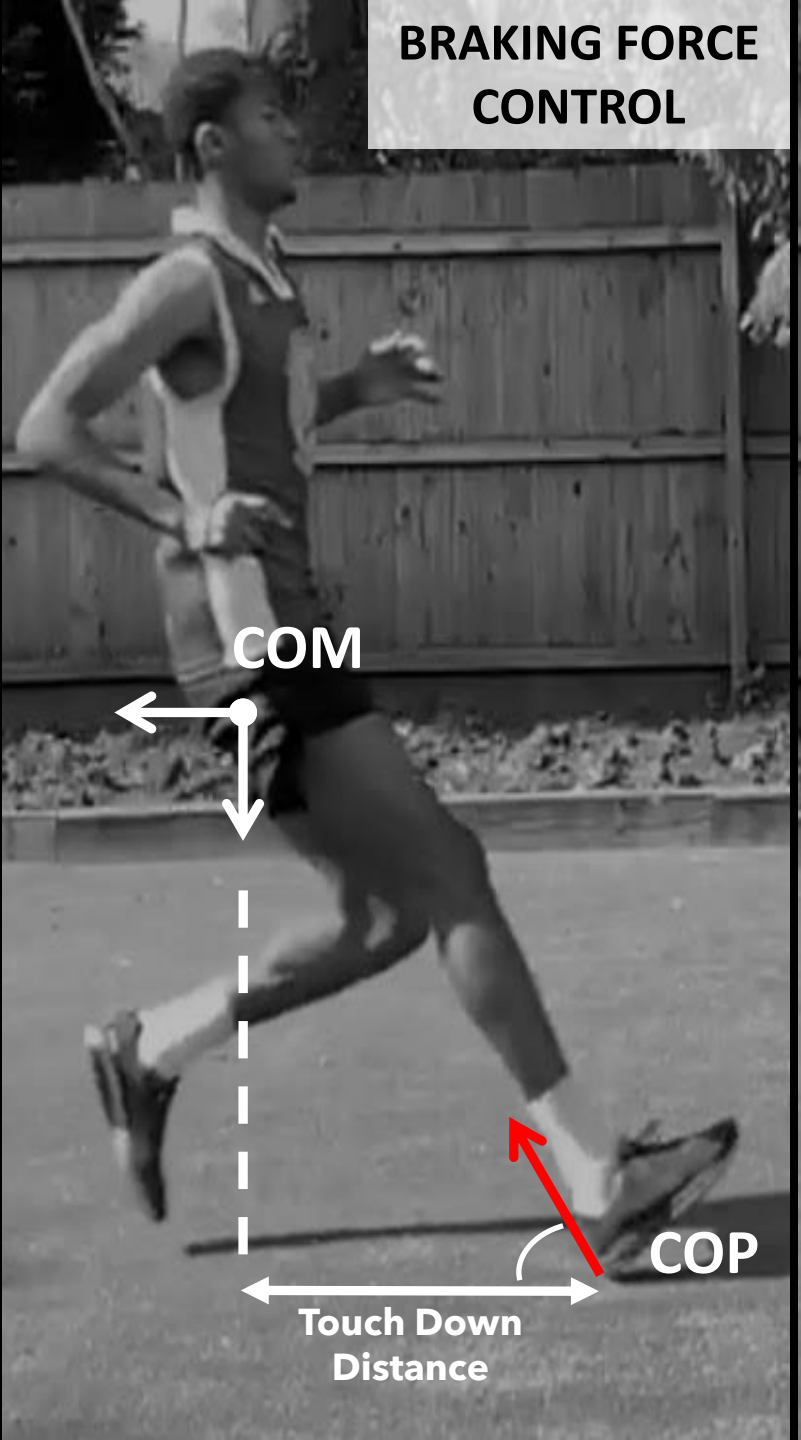
BRAKING STEP 1	BRAKING STEP 2	BRAKING STEP 3	BRAKING STEP 4	BRAKING STEP 5	BRAKING STEP 6
GCT = 160ms	GCT = 150ms	GCT = 170ms	GCT = 225ms	GCT = +225ms	GCT = +225ms

HUMAN BRAKING PERFORMANCE
OPTIMISING ATHLETIC POTENTIAL

“The ability to proficiently reduce whole body momentum, within the constraints, and in accordance with the specific objectives of the task, whilst skilfully attenuating and distributing the forces associated with braking” (Harper et al., 2022; Sports Medicine)

HUMAN BRAKING PERFORMANCE
OPTIMISING ATHLETIC POTENTIAL

Speedworks Training



ARTICLE

How Tendons Buffer Energy Dissipation by Muscle

Thomas J. Roberts and Nicolai Konow

Department of Ecology and Evolutionary Biology, Brown University, Providence, RI

DAMAGE PROTECTION
("Mechanical Buffer")

↓ Lengthening rates
↓ Peak Forces

HUMAN BRAKING PERFORMANCE
OPTIMISING ATHLETIC POTENTIAL


HUMAN BRAKING PERFORMANCE
OPTIMISING ATHLETIC POTENTIAL
31
DECELERATION DEMANDS!

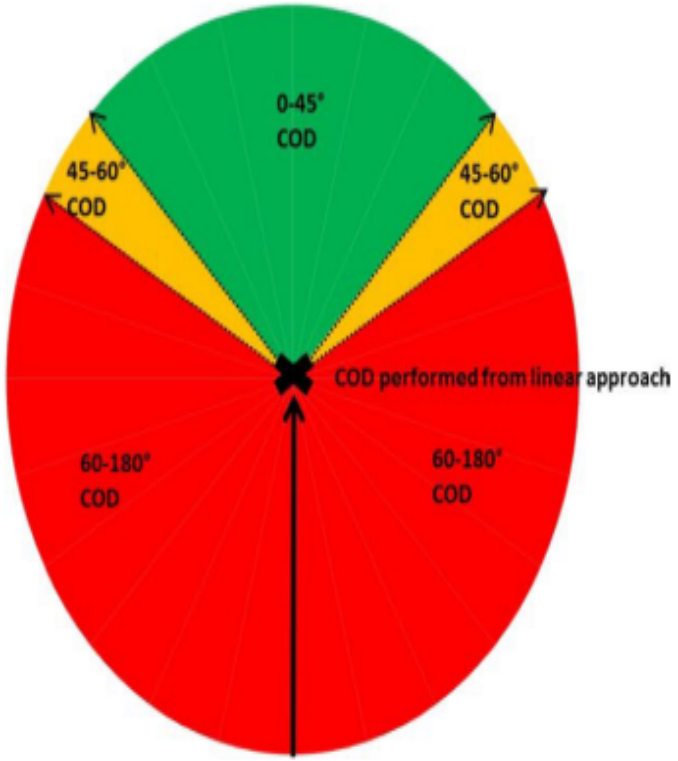
Deceleration Demands: ANGLE Dependent

The Effect of Angle and Velocity on Change of Direction Biomechanics: An Angle-Velocity Trade-Off

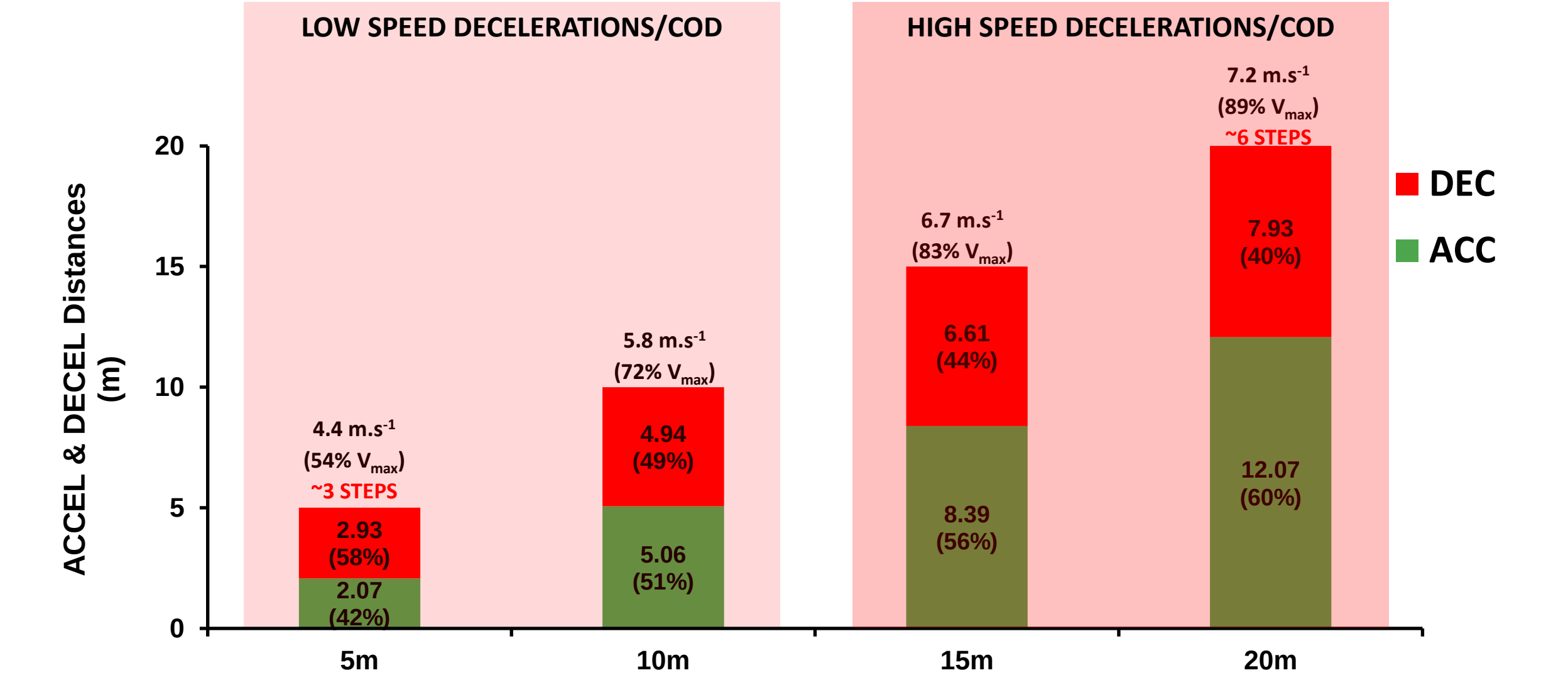
Thomas Dos'Santos[1] · Christopher Thomas[1,2] · Paul Comfort[1] · Paul A. Jones[1]

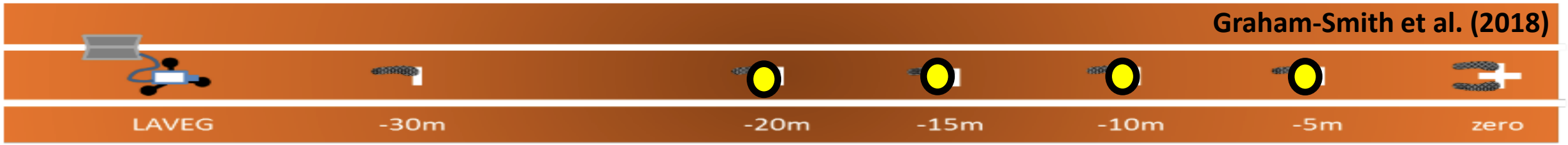
Red *"Slam on the brakes!"*	**Directional changes 60-180°** • Substantial braking over PFC and potentially steps prior to push-off • Side-step or pivot strategy recommended
Amber *"Slowdown"*	**Directional changes 45-60°** • Moderate braking prior to push-off • Possible role of PFC • Side-step strategy recommended
Green *"Go!"*	**Directional changes 0-45°** • Velocity maintenance key • Limited braking requirements, thus PFC not required for braking prior to push-off • XOC strategy faster than sidestep

Key: PFC = Penultimate foot contact; XOC = Crossover cut

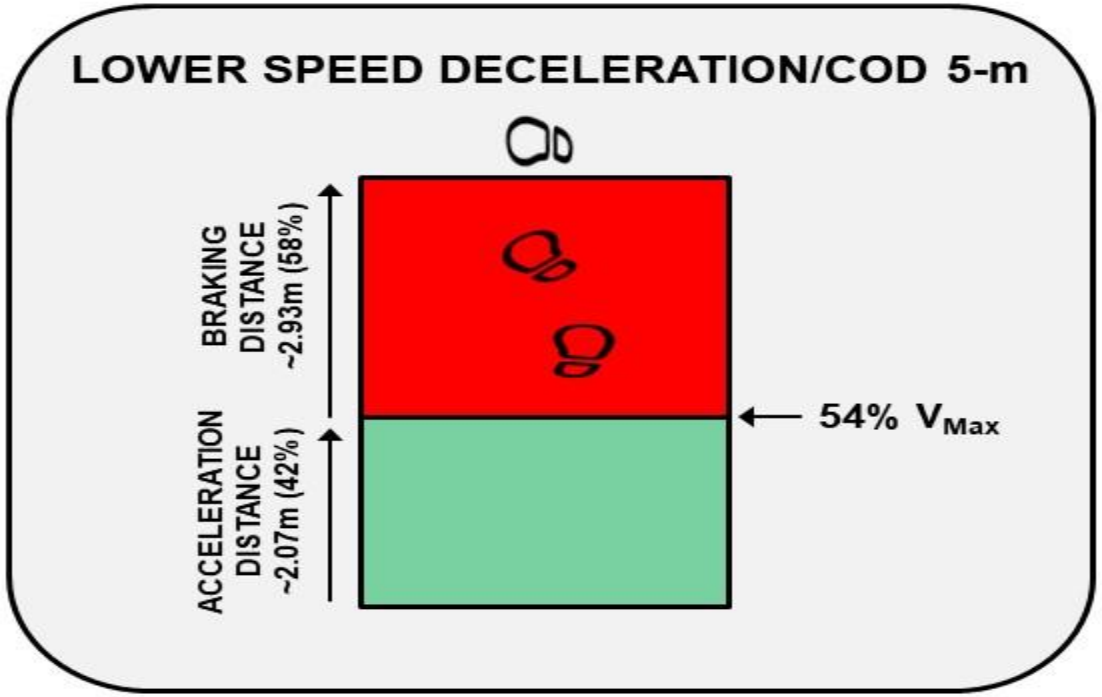


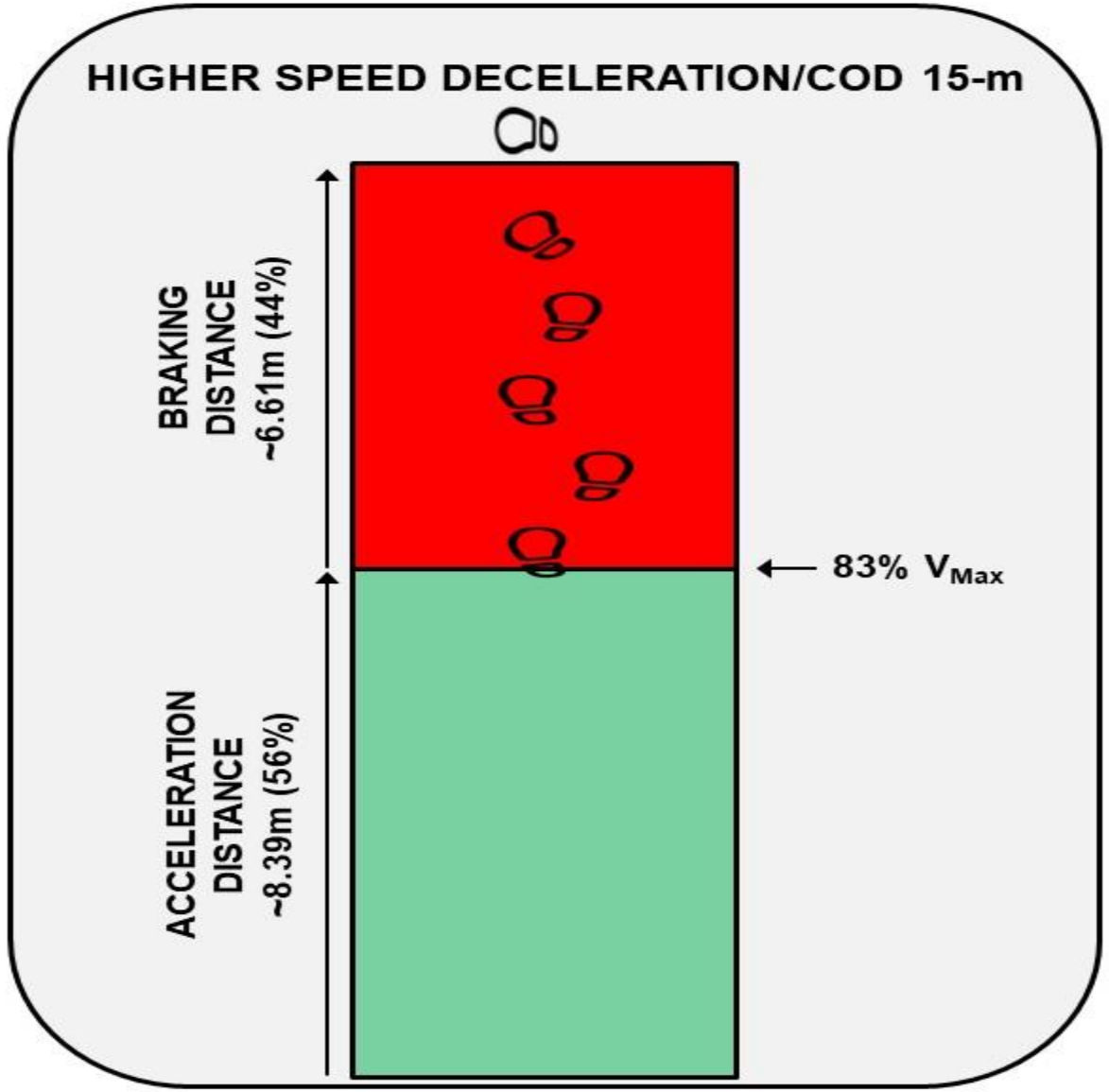
Deceleration Demands: VELOCITY dependent (approach distance)?





Deceleration Demands: Unique to ANGLE + VELOCITY.

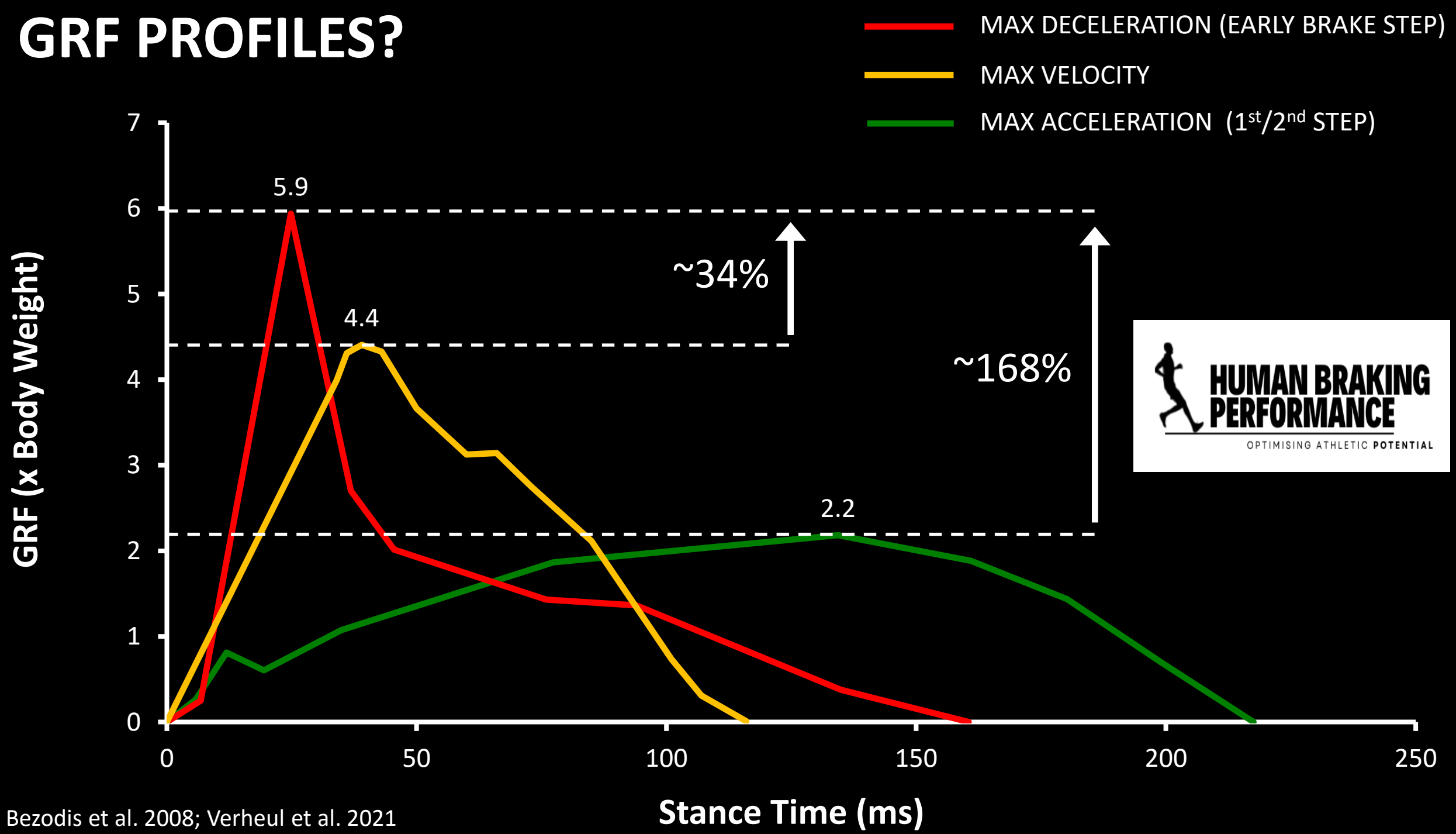




HUMAN BRAKING PERFORMANCE
OPTIMISING ATHLETIC POTENTIAL

Harper et al. (2024).

GRF PROFILES?



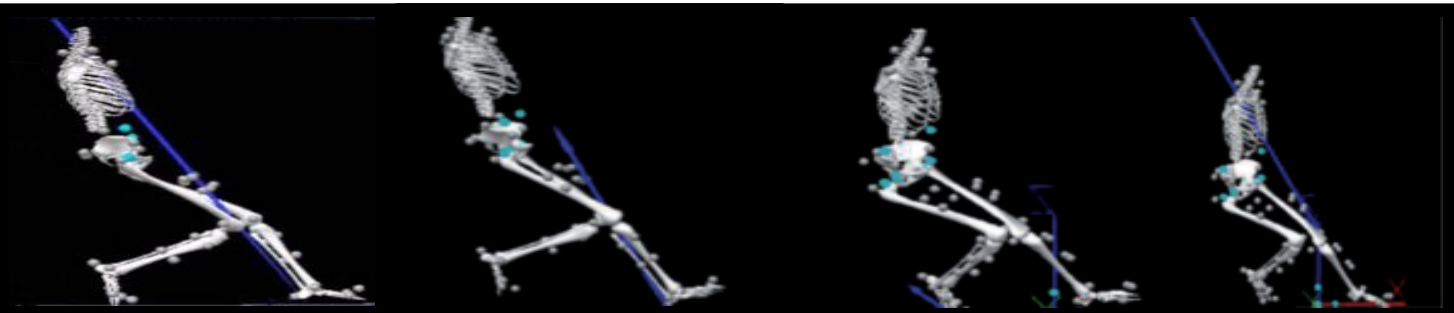
HUMAN BRAKING PERFORMANCE
OPTIMISING ATHLETIC POTENTIAL

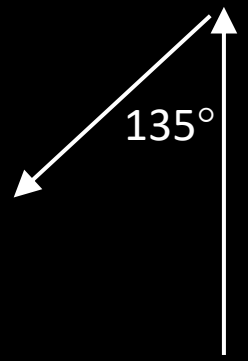
Bezodis et al. 2008; Verheul et al. 2021

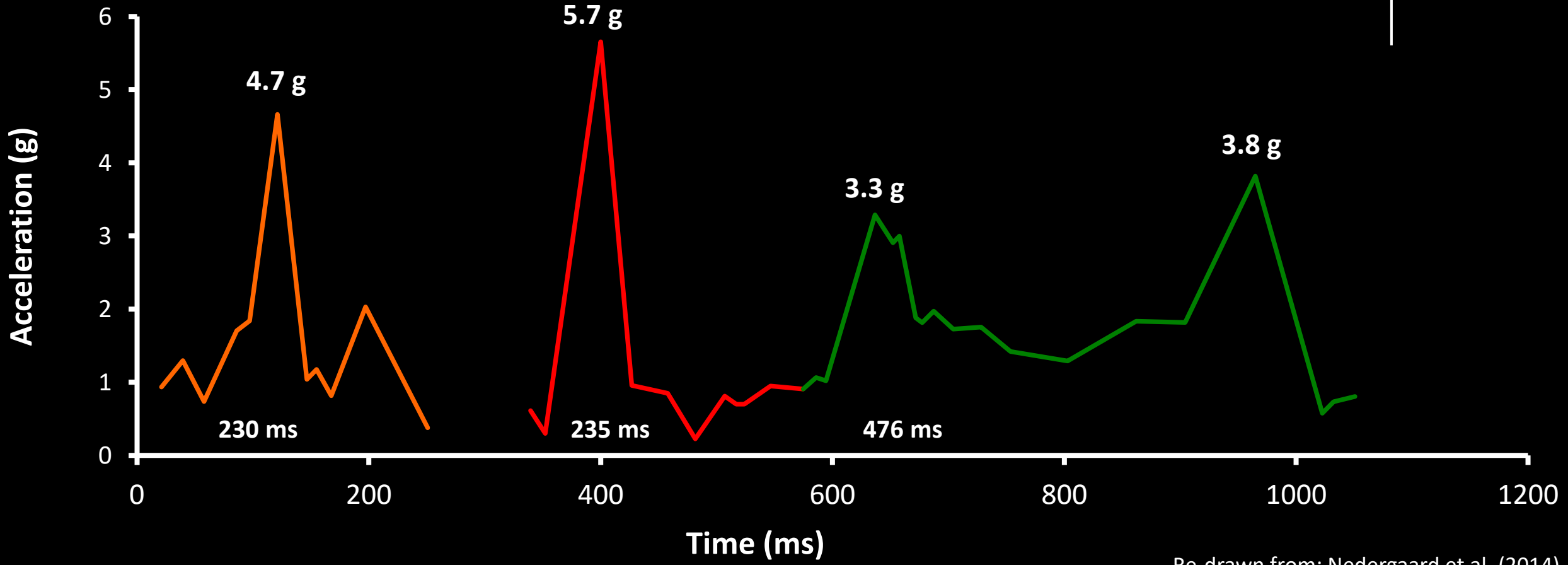
DECELERATION FORCES DURING COD

PREPARATORY DECELERATION STEPS

APFC	PFC	FFC - TURN





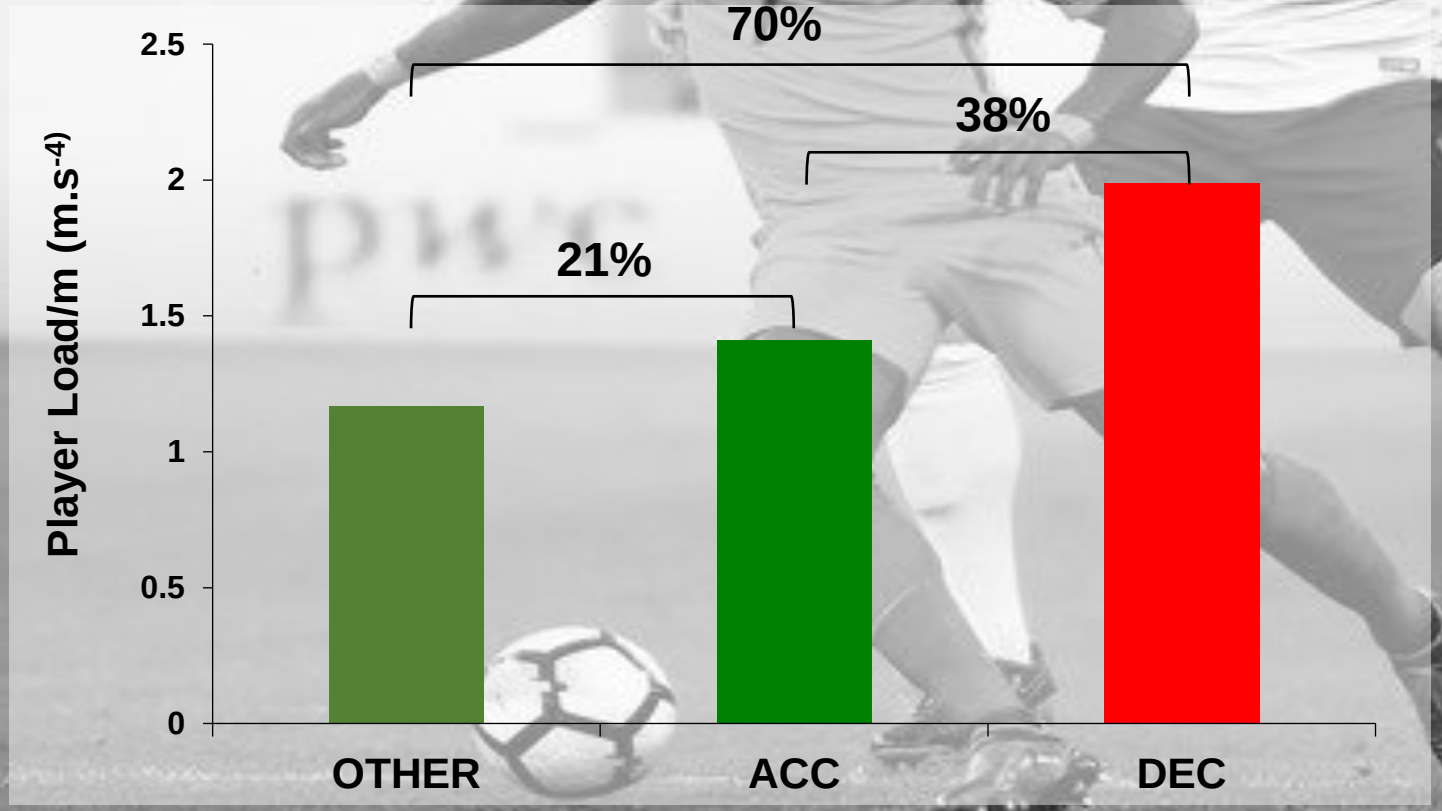


Re-drawn from: Nedergaard et al. (2014).

Deceleration Mechanical Load

Player Load, Acceleration, and Deceleration During Forty-Five Competitive Matches of Elite Soccer

Terje Dalen,[1] Ingebrigtsen Jørgen,[2] Ettema Gertjan,[3] Hjelde Geir Havard,[4] and Wisløff Ulrik[5,6]



- 54 **DECELS**
- 76 ACCELS

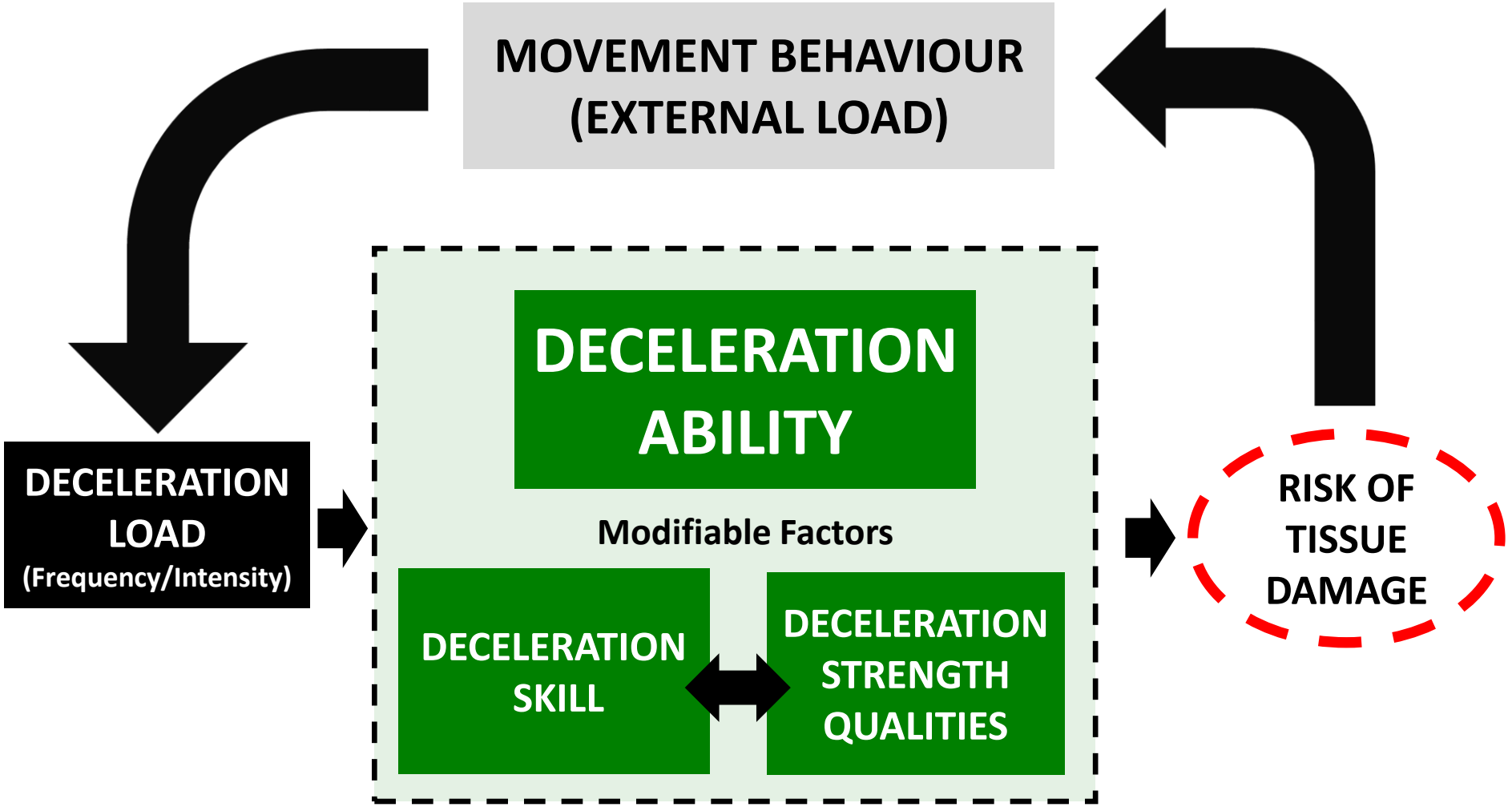
  > 2 $m.s^{-2}$

Open access Editorial

BMJ Open Sport & Exercise Medicine

Damaging nature of decelerations: Do we adequately prepare players?

Damian James Harper,[1,2] John Kiely[2]



What qualities are needed to **decelerate** and **brake** rapidly?

Understanding underpinning qualities requires accurate assessment!

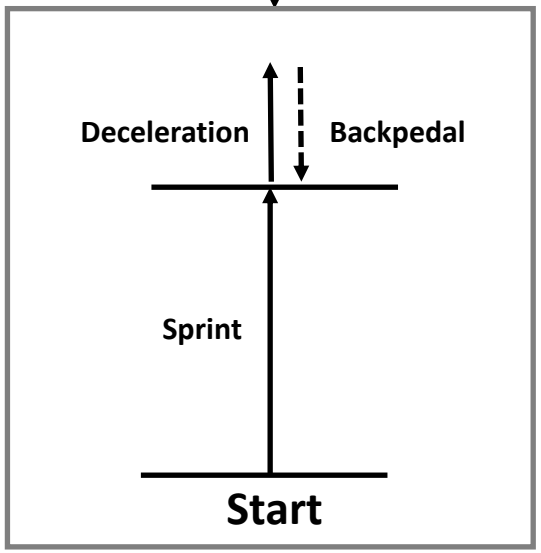
- ACCELERATION 
- TOP SPEED 
- DECELERATION 

Don’t speed up what you can’t slow down!

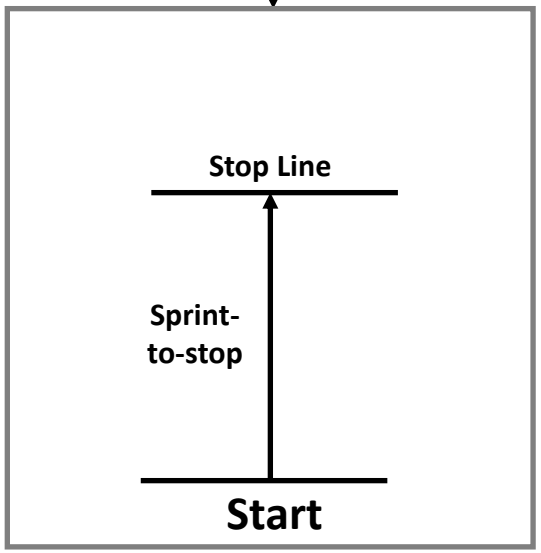
Deceleration Testing Options

Horizontal Acceleration-Deceleration Ability (ADA) Test

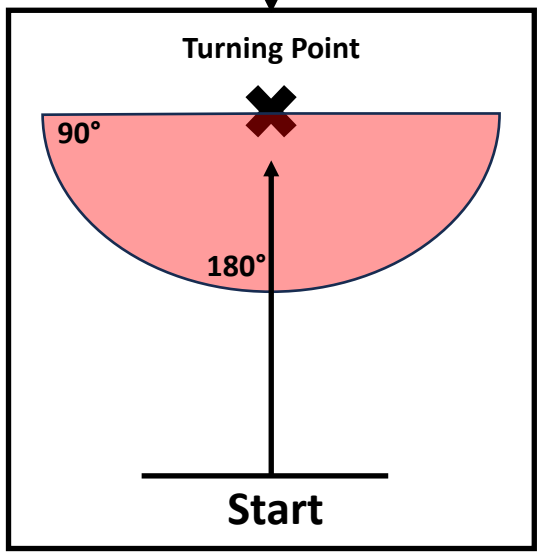
Start Deceleration at Pre-Set Distance



Decelerate to stop at Pre-Set Distance



Change of Direction Tests with whole body rotation (> 90°)



INSTANTANEOUS VELOCITY

- Radar (e.g., Stalker ATS, PhotonSports)
- Laser (e.g., MuscleLab, Laveg)
- Motorised Resistance (e.g., 1080 sprint)
- Video with AI (e.g., VueMotion)

Horizontal Acceleration-to-Deceleration

(ADA Test, Harper et al., 2019)

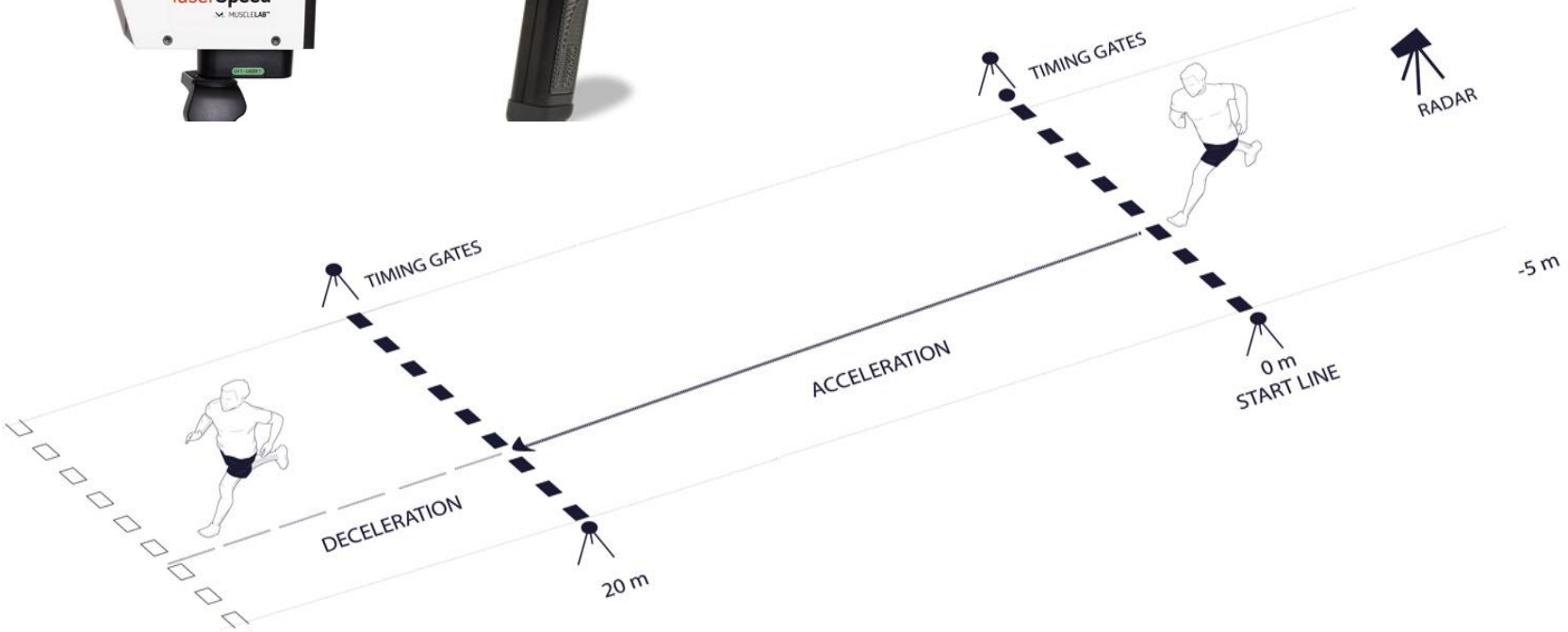
SPORTS BIOMECHANICS
https://doi.org/10.1080/14763141.2020.1792968

Routledge
Taylor & Francis Group

Check for updates

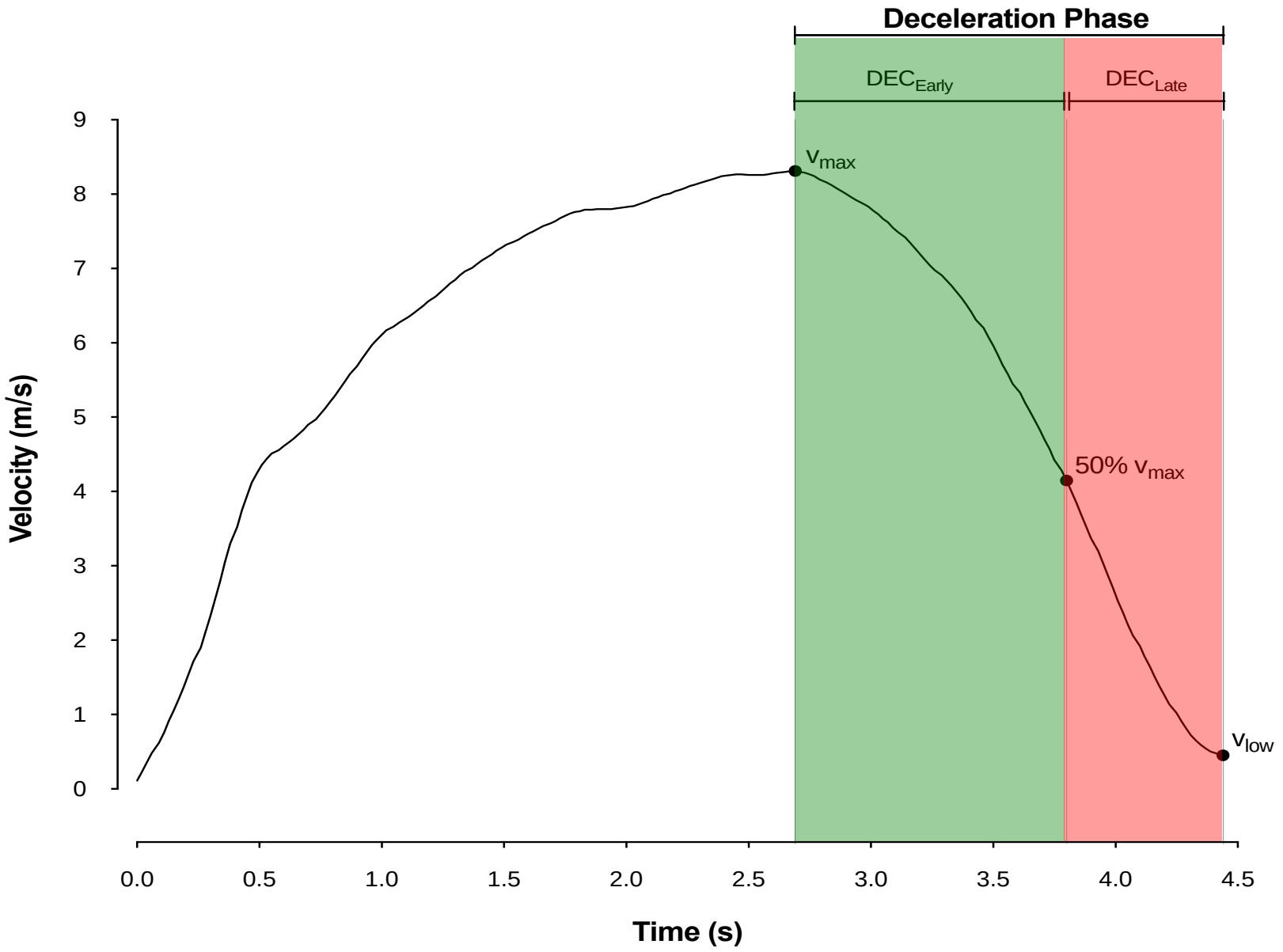
Measuring maximal horizontal deceleration ability using radar technology: reliability and sensitivity of kinematic and kinetic variables

Damian J. Harper [a], Jean-Benoit Morin [b], Christopher Carling [c] and John Kiely [a]

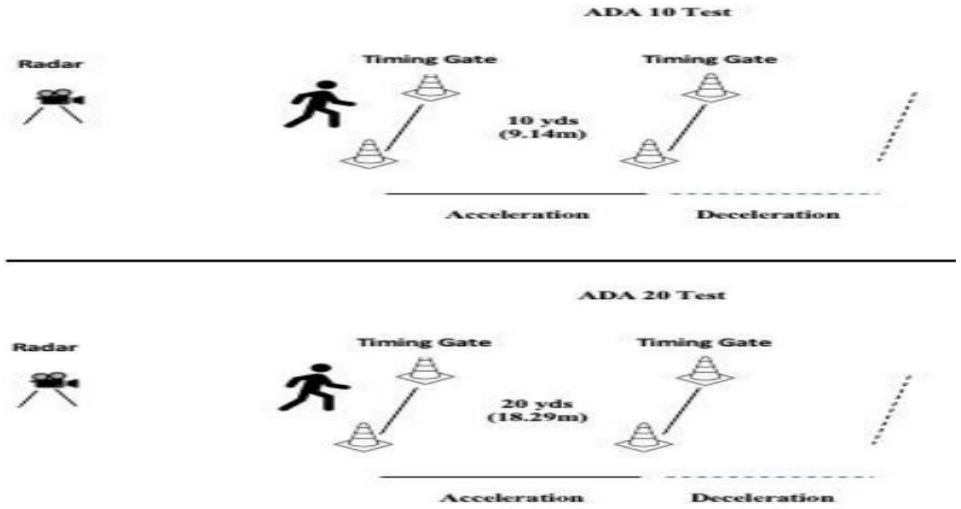


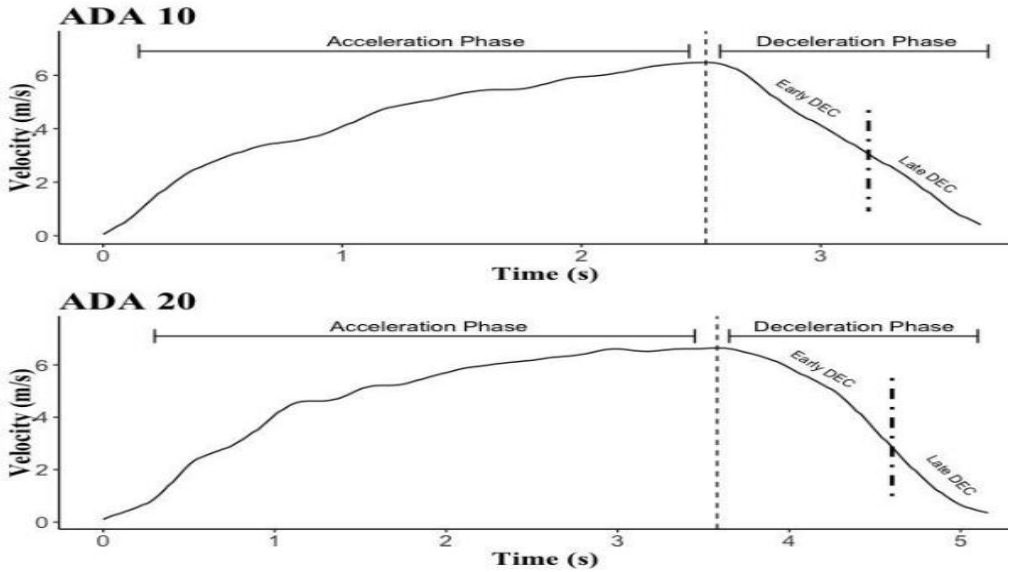
Deceleration Instantaneous Velocity Profile

DECELERATION ABILITY METRICS		CV %
VMAX ($m.s^{-1}$)	8.68	1.4
AVE DEC ($m.s^{-2}$)	-5.28	5.2
PEAK DEC ($m.s^{-2}$)	-10.25	9.6
DEC_{Early} ($m.s^{-2}$)	-4.73	8.8
DEC_{Late} ($m.s^{-2}$)	-6.15	9.7
DEC Ratio (Early/Late)	0.77	
DTS (m)	7.62	7.2
TTS (s)	1.52	5.3
HBP (W/kg)	-23.72	5.7
HBF (N/Kg)	-5.17	5.5



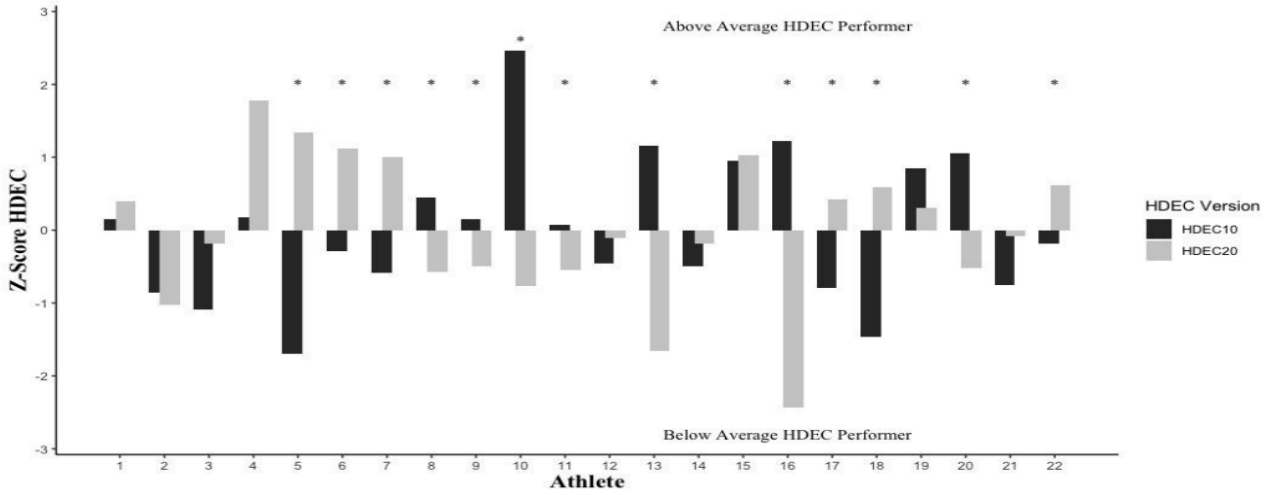
Acceleration-Deceleration Ability (ADA) Test (Modified Distances)





Variable	Comparison			
	ADA_{10}	ADA_{20}	*p*-value	ES
Max Approach Velocity	6.20 ± 0.35	7.06 ± 0.36	**<.001**	2.71
Max Approach Momentum	457.01 ± 71.95	521.14 ± 82.78	**<.001**	2.65
HDEC	-3.26 ± 0.30	-4.16 ± 0.36	**<.001**	1.60
HBI	-411.12 ± 60.41	473.16 ± 84.93	**<.001**	1.50
TTS	1.46 ± 0.16	1.70 ± 0.36	**.003**	0.73
Early:Late DEC Ratio	0.30 ± 0.05	0.31 ± 0.06	.573	0.12

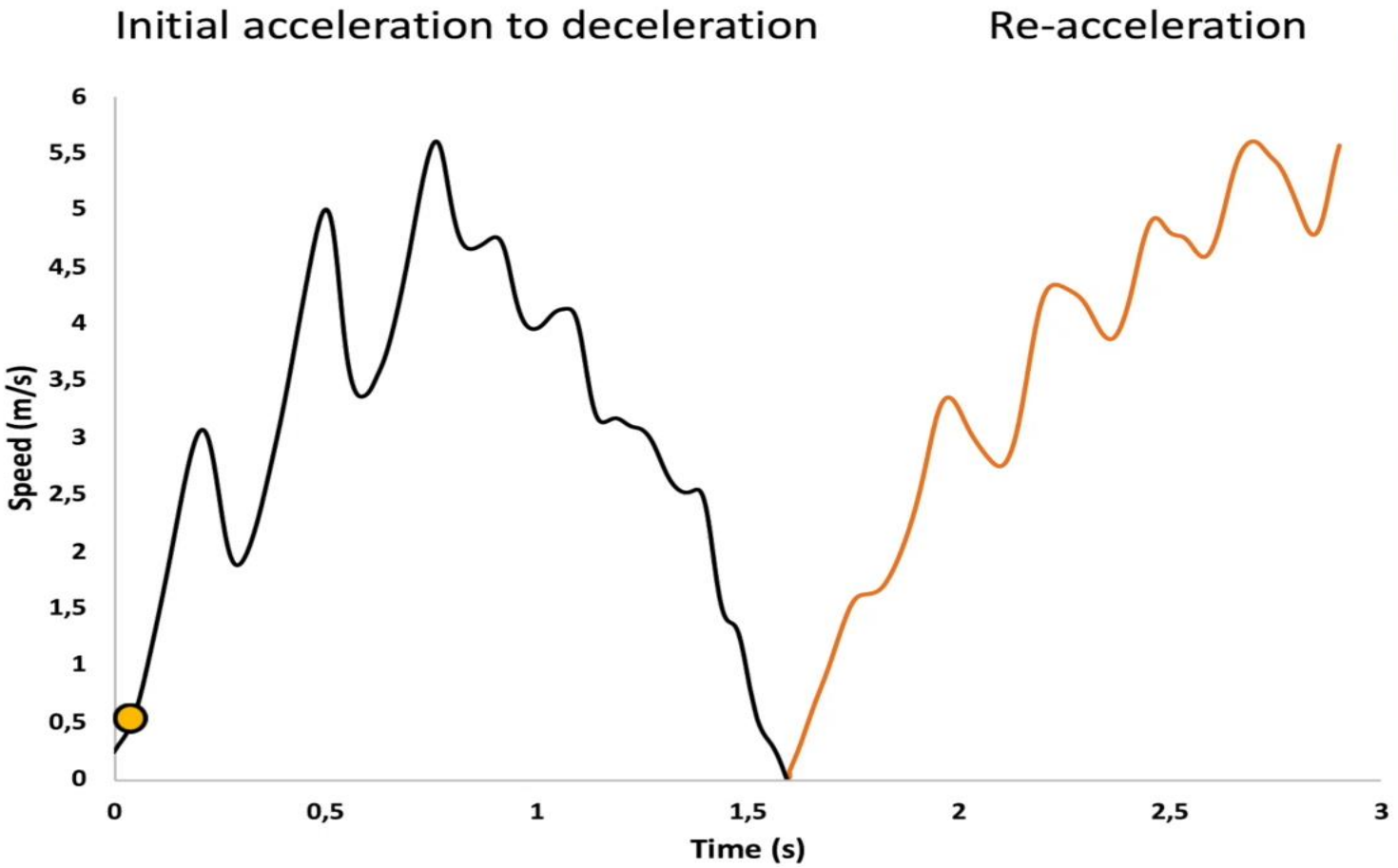
Note: DEC = Deceleration, ACC = Acceleration. HDEC = Average Horizontal Deceleration, HBI = Average Horizontal Braking Impulse, TTS = Time to Stop, DEC = Deceleration. Bold text denotes statistically significant differences or correlations between groups.



REFERENCE: Philipp et al. (2023)

Validity of Velocity Measurements of a Motorized Resistance Device During Change of Direction

Ola Eriksrud[1], Fredrik Ahlbeck[1], Damian Harper[2] and Øyvind Gløersen[1]*



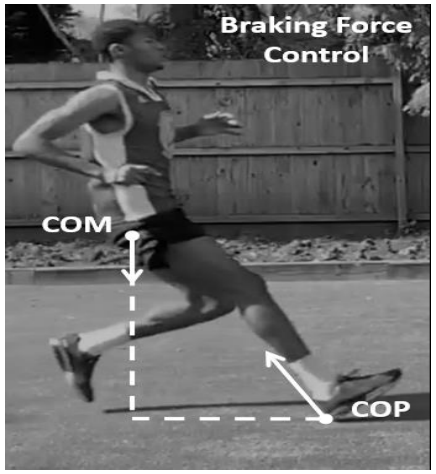
What qualities are needed to **decelerate** and **brake** rapidly?

International Journal of Strength and Conditioning

Harper, D. J., Cervantes,C., Van Dyke, M., Evans, M., McBurnie, A. J., Dos Santos, T., Eriksrud, O., Cohen, D. D., Rhodes, D., Carling, C., & Kiely, J. (2024). The Braking Performance Framework: Practical Recommendations and Guidelines to Enhance Horizontal Deceleration Ability in Multi-Directional Sports. International Journal of Strength and Conditioning
https://doi.org/10.47206/ijsc.v4i1.351

The Braking Performance Framework: Practical Recommendations and Guidelines to Enhance Horizontal Deceleration Ability in Multi-Directional Sports

Damian J. Harper[1], Chris Cervantes[2], Matt Van Dyke[2], Martin Evans[3], Alistair J. McBurnie[4], Thomas Dos' Santos[5], Ola Eriksrud[6], Daniel D. Cohen[7,8], David Rhodes[9], Christopher Carling[10,11] and John Kiely[7]

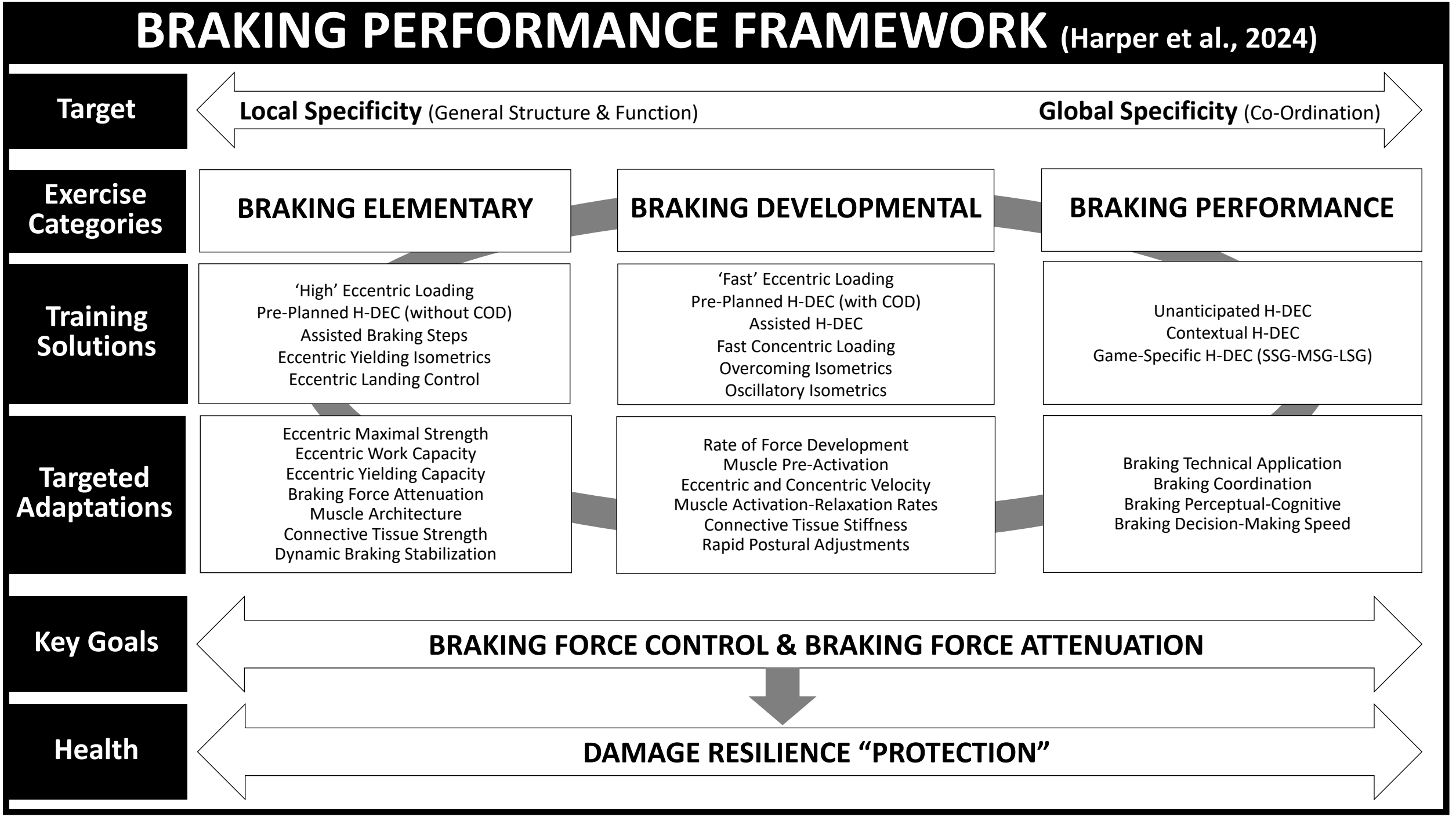


DECELERATION

- NEUROMUSCULAR
- IMPULSE-MOMENTUM RELATIONSHIP
- BIOMECHANICAL
  - Strength Capacities
    - Eccentric
      - Eccentric Peak Force
        - Eccentric RFD
          - Eccentric Velocity
    - Isometric
      - Reactive (Braking Load Tolerance)
        - Pre-Impact Activation
    - Concentric
      - Concentric Peak Force
        - Concentric Peak Velocity
  - Inter/Intra-Limb Coordination
  - Technical Ability
    - Orientation of Braking Force
    - Magnitude of Braking Force
    - Rapid Postural Adjustments
      - Lower COM
        - Increased Dynamic Stability
      - Anterior Foot Placement Precision
        - Posterior COM (Increased COM to COP Distance)

Harper et al (2022, Sports Medicine)

BRAKING PERFORMANCE FRAMEWORK (Harper et al., 2024)



Braking Elementary Exercises

FLYWHEEL: HORIZONTAL/VERTICAL FOCUS

HEAVY ASSISTED BRAKING STEPS

Braking Developmental Exercises

FAST ECCENTRIC

ACCENTUATED ECCENTRIC LOADING (AEL)

BRAKING SPECIFIC ISOMETRICS

ASSISTED DECELERATIONS (1080)

Braking Performance Exercises

CONTEXTUAL DECELERATIONS

SIDED GAMES

Received: 7 September 2020 | Revised: 16 October 2020 | Accepted: 4 November 2020

DOI: 10.1111/sms.13876

Damian J. Harper[1]
Gareth N. Sandford[2,3]
Jo Clubb[4]
Megan Young[5]
Matt Taberner[6]
Dave Rhodes[1]
Chris Carling[7]
John Kiely[1]

WILEY

LETTER TO EDITOR

Elite football of 2030 will not be the same as that of 2020: What has evolved and what needs to evolve?

In summary…

…1

DECELERATING IS THE **MOST** MECHANICALLY DEMANDING TASK IN TERMS OF IMPACT FORCE CHARACTERISTICS

…2

INCREASING PLAYER DECELERATION ABILITY CAN HAVE **SIGNIFICANT** IMPACT ON SPEED PERFORMANCE AND INJURY RISK REDUCTION

…3

DECELERATING FOCUSED TRAINING STRATEGIES SHOULD FORM A **‘CORNERSTONE’** OF MDS SPEED DEVELOPMENT PROGRAMMES

HUMAN BRAKING PERFORMANCE

OPTIMISING ATHLETIC **POTENTIAL**

...4

DESPITE THE IMPORTANCE OF **DECELERATION**, WE STILL KNOW LITTLE IN COMPARISON TO TRAINING **ACCELERATION** & **TOP SPEED!**

THANK YOU!

Mission…

“ Further develop and disseminate information on the importance of deceleration and braking for sports performance and injury-risk reduction”

HUMAN BRAKING PERFORMANCE

OPTIMISING ATHLETIC POTENTIAL

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