Sprint Force-Velocity profile and Hamstring Injuries

Idan Harat, M.Sc.

Based on Dr. JB Morin 2017 workshop

About Me...

- תואר שני Sport and Exercise Science
- תואר ראשון במדעי ההתנהגות
- מאמן כושר מ-2004
- מאמן ספורט תחרותי מ-2013
- מאמן יכולות גופניות באקדמיה לכדורסל בנות
- מדען ספורט/פיזיולוג מאמץ במכון וינגייט
- מרצה בביה"ס למאמנים
- לא פיזיותרפיסט...

- JB Morin’s lecture
- Five years of Hamstring Injury Research in 25 minutes | Dr David Opar
- https://www.youtube.com/watch?v=EijDF2Bl14A

- **No conflict of interest**

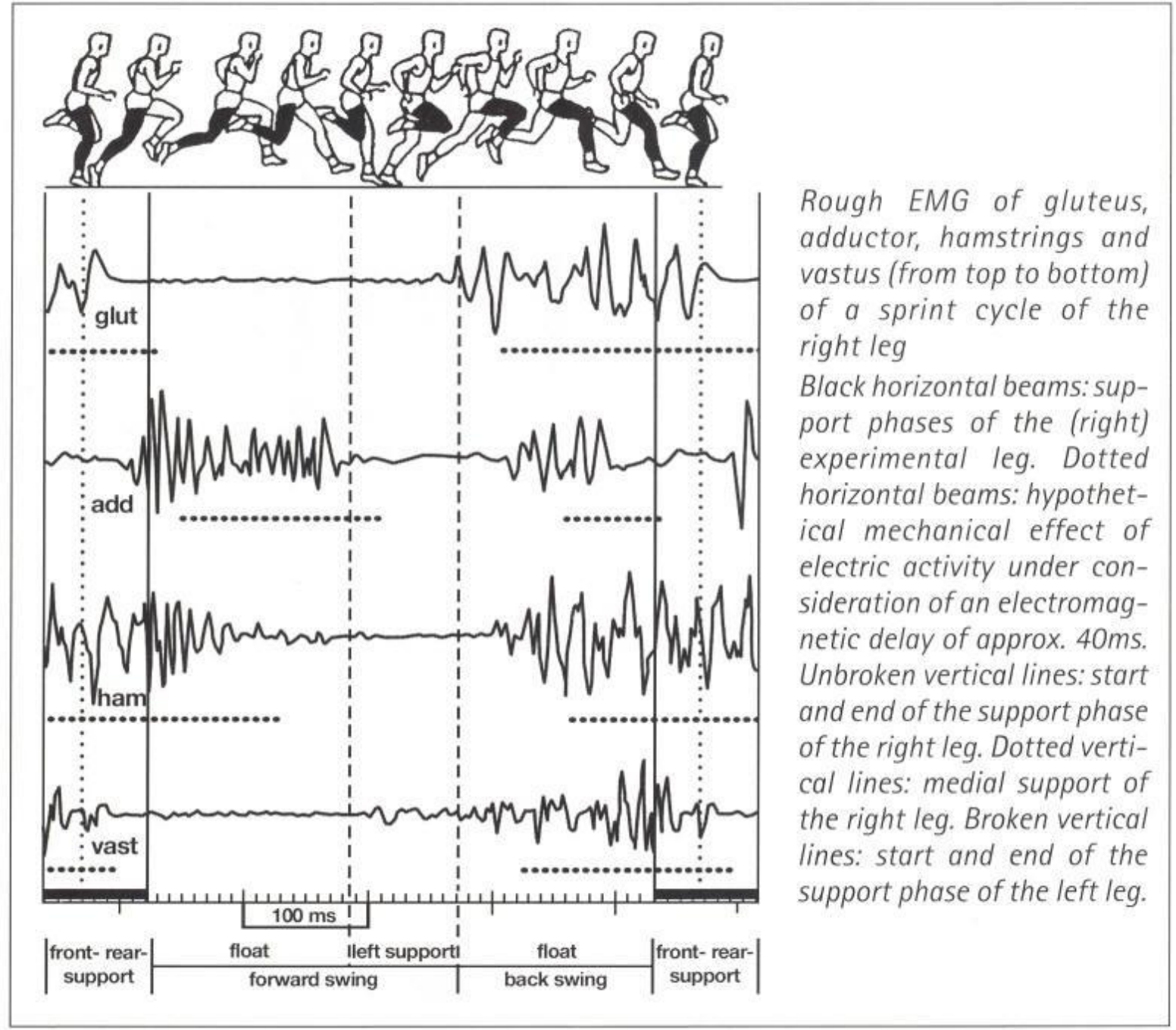
Strength ⟷ **Injury**

Performance

Hamstring’s Role in Performance

- Sprinting
- Gait cycle
- Eccentric portion of decelerating the tibia – Terminal swing phase
  - Greater forces when >60% max speed

Figure 1. EMG Analysis and the Phases of Sprinting. Adapted from Weimann and Tidow (1995)



Rough EMG of gluteus, adductor, hamstrings and vastus (from top to bottom) of a sprint cycle of the right leg

Black horizontal beams: support phases of the (right) experimental leg. Dotted horizontal beams: hypothetical mechanical effect of electric activity under consideration of an electromagnetic delay of approx. 40ms. Unbroken vertical lines: start and end of the support phase of the right leg. Dotted vertical lines: medial support of the right leg. Broken vertical lines: start and end of the support phase of the left leg.

Non-Contact HSI

Common
Of all injuries in team sports
12-16%

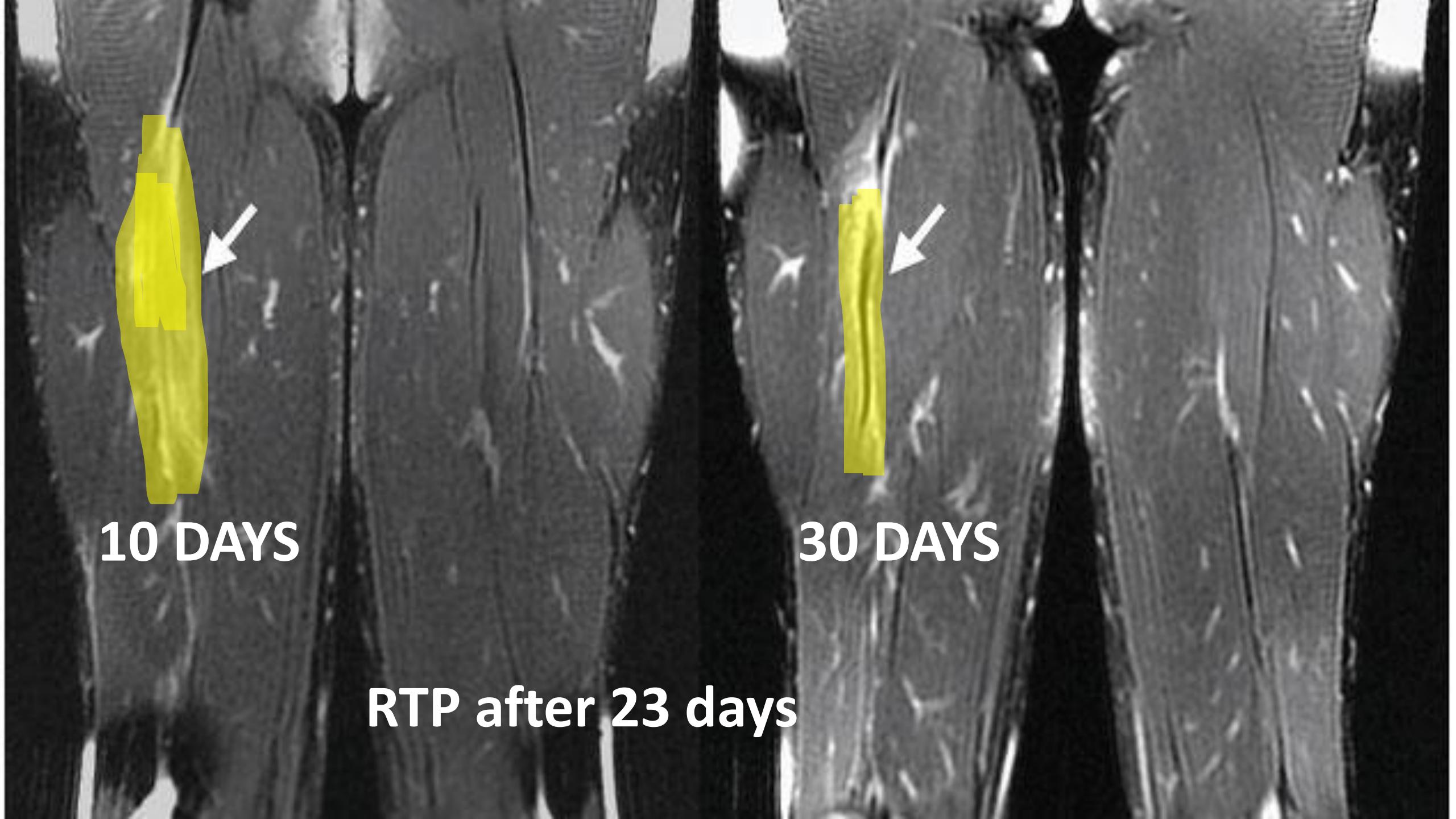
Persistent
Increase each year in soccer
4%

Mechanics
Occur at high-speed sprinting
61-68%

Anatomy
Of injuries are in the Biceps Femoris long head
80%

Reoccurring
Chances of reinjury
30%

Atrophy
Apparent atrophy and scar tissue even after 3 years
3 yrs


10 DAYS
30 DAYS
RTP after 23 days

Non-Contact HSI

- Reduces hamstring strength (Manier et al., 2016)
  - Mostly in end-range, not just peak torque
  - Muscle inhibition
- Weaker hamstrings is related to increased rates of injury
  - Low H\Q ratio\imbalance (weak relationship)
  - Nordic curl strength (Opar et al., 2015; Bourne et al., 2015; Timmins et al., 2016)
  - Nordic interventions reduce injury rates (~60%)

Original article

A comprehensive strength testing protocol offers no clinical value in predicting risk of hamstring injury: a prospective cohort study of 413 professional football players

2017

Nicol van Dyk,[1,2] Roald Bahr,[3,4] Angus F Burnett,[3] Rod Whiteley,[1] Arnhild Bakken,[3,4] Andrea Mosler,[1,5] Abdulaziz Farooq,[3] Erik Witvrouw[2]

Strength Imbalances and Prevention of Hamstring Injury in Professional Soccer Players

A Prospective Study 2008

Jean-Louis Croisier,*† PhD, PT, Sebastien Ganteaume,† PT, Johnny Binet,† PT, Marc Genty,‡ MD, and Jean-Marcel Ferret,§ MD
From the †Department of Motricity Sciences and Rehabilitation, University and CHU of Liege, Belgium, the ‡Clinique Valmont Genolier, Glion, Switzerland, and the §Center of Sports Medicine, Lyon-Gerland, France

TABLE 2
Hamstring Injury Frequency in Professional Soccer Players

Group	Players, n (n = 462)	Injuries, n (n = 35)	Injury Frequency, %
A[a]	246	10	4.1
B[b]	91	15	16.5
C[c]	55	6	11
D[d]	70	4	5.7

[a]Group A had no preseason strength imbalance.
[b]Group B had preseason strength imbalances but no subsequent specific compensating training.
[c]Group C had preseason strength imbalances and subsequent compensating training, but no isokinetic control test aimed at verifying the parameter normalization.
[d]Group D had preseason strength imbalances and a subsequent compensating training until the parameter normalization was proved by repeated isokinetic control tests.

X 4

Original article

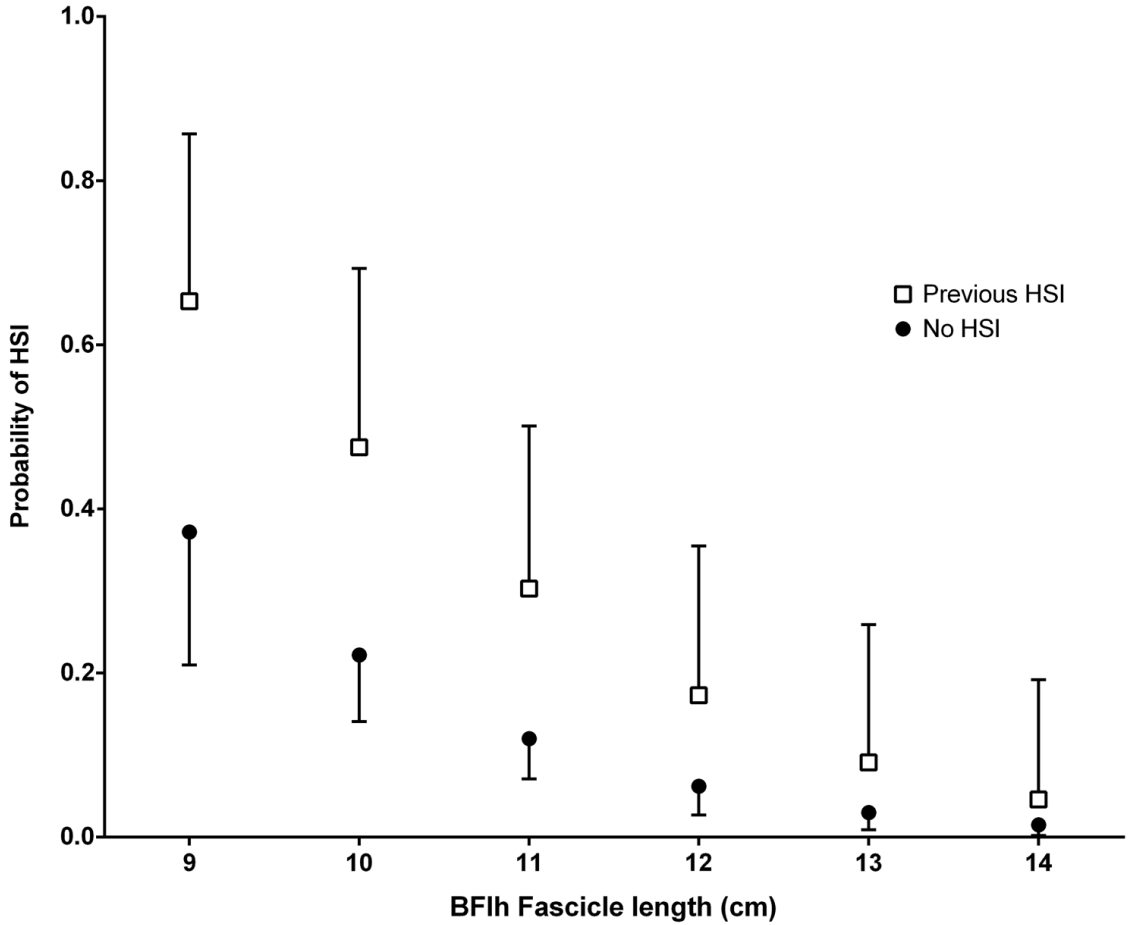
A prospective cohort study of hamstring injuries in competitive sprinters: preseason muscle imbalance as a possible risk factor

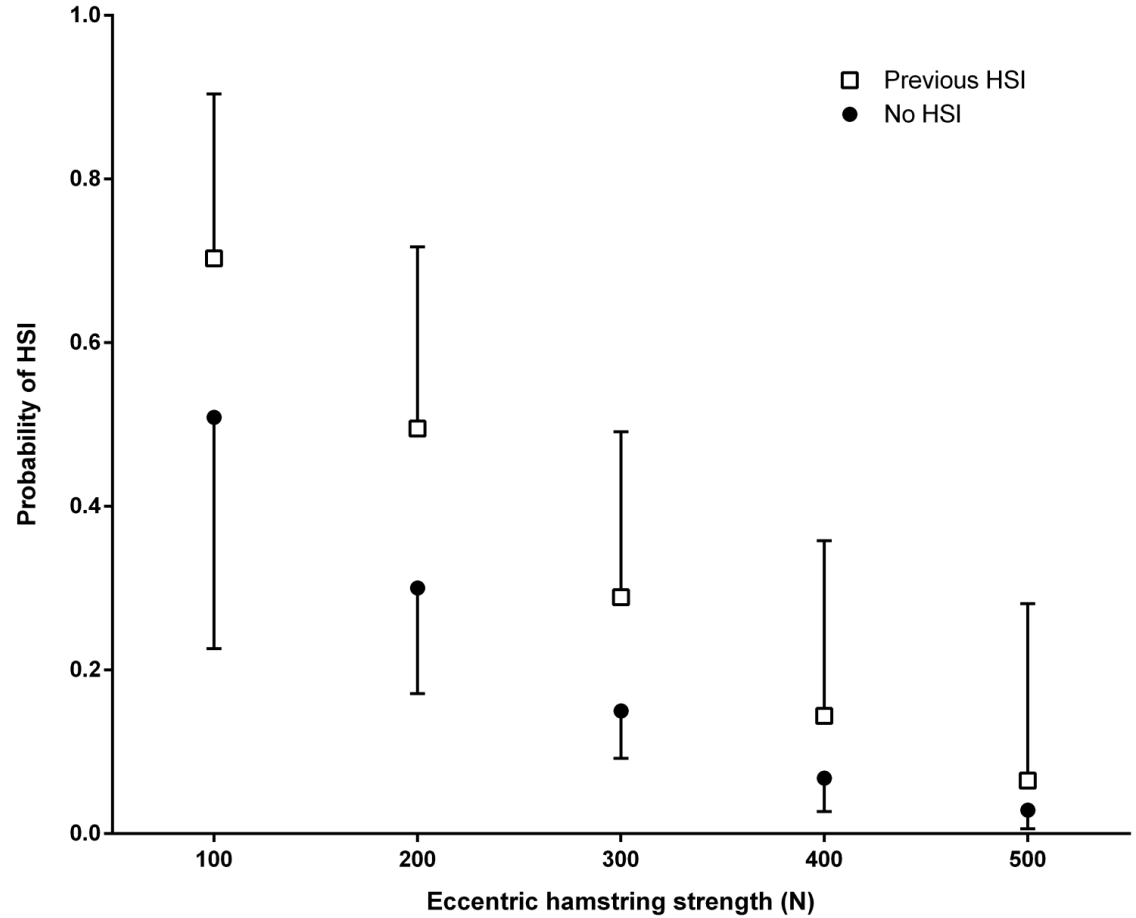
S S Yeung, A M Y Suen, E W Yeung 2009

CONCLUSION

This is a 12-month prospective study undertaken to identify the incidence and the risk factors of hamstring injury in competitive sprinters. The results showed that a preseason hamstring : quadriceps muscle peak torque ratio at 180°/s of less than 0.6 increased the risk of hamstring muscle injury by 17 times. A preseason isokinetic screening will be useful to identify athletes at risk. Any athletes with a strength imbalance could undergo a strengthening programme to decrease the risk of hamstring injury.

X 17 times





(Timmins et al., 2016)

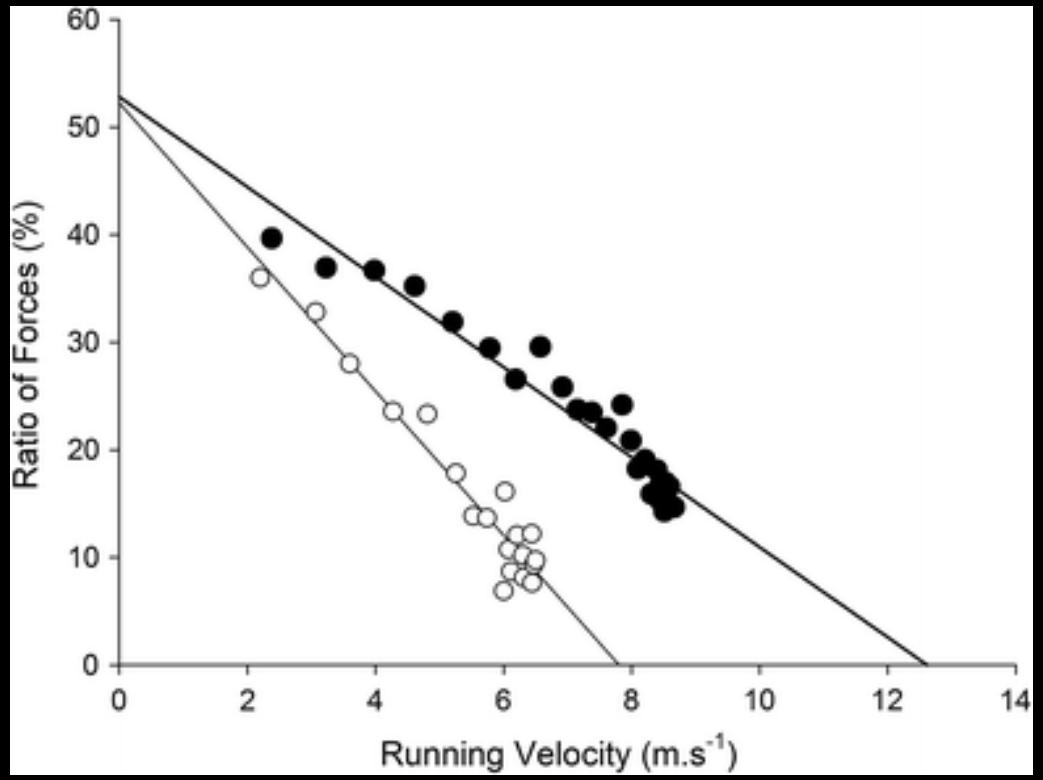
Strength **Injury**

?

Performance

Hamstring and Sprint Performance

- Hip extensors activity increases with speed
- At high speeds elite runners produce greater proportion of HZ force
- HZ ground reaction force is key in acceleration and top speed
- High HZ force was related to high hip extensors force in isokinetic testing
- Glute in CON and HAM in ECC (end of swing phase; 8 x BW forces on HAM)



Morin et al., 2015

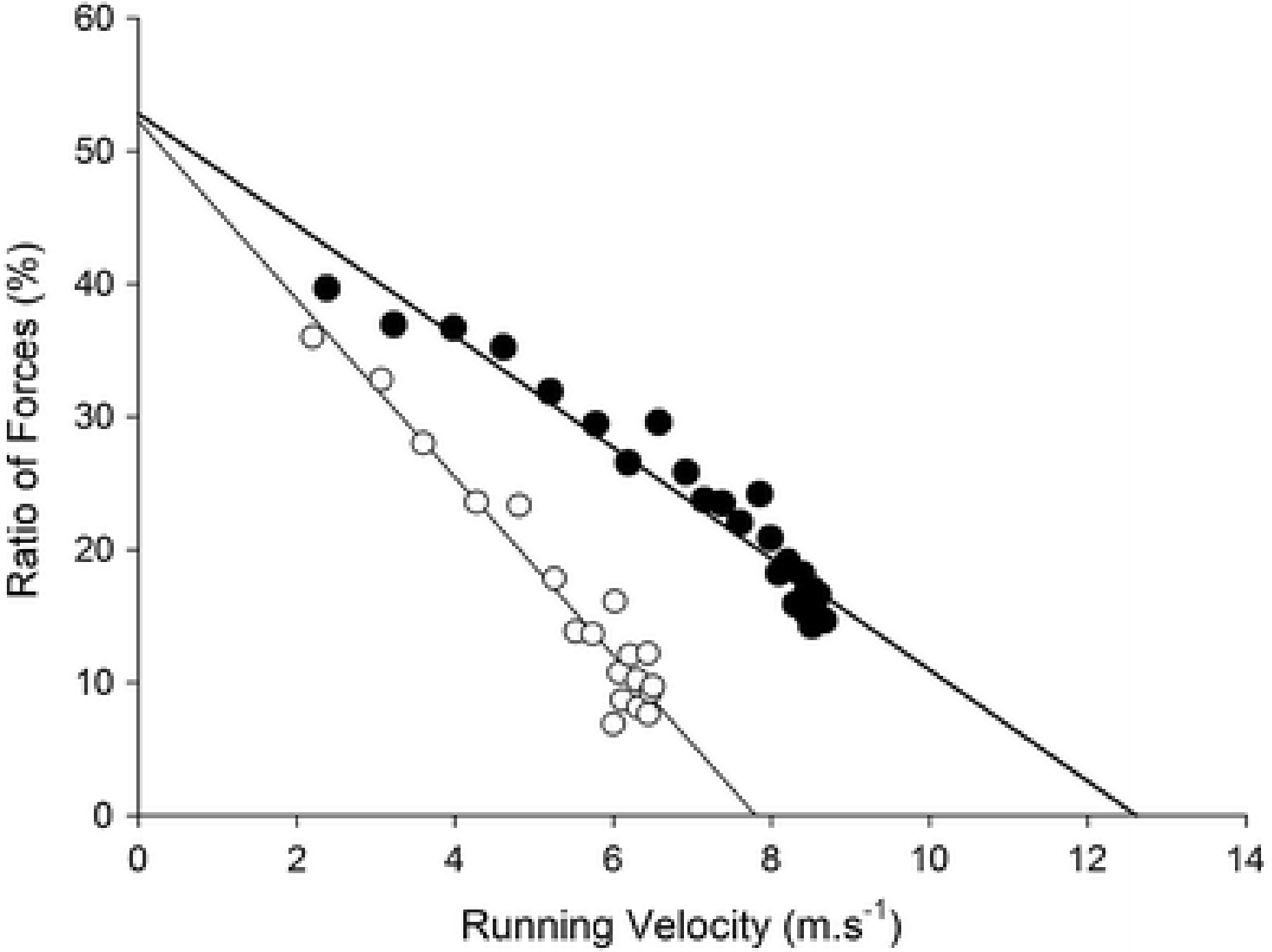
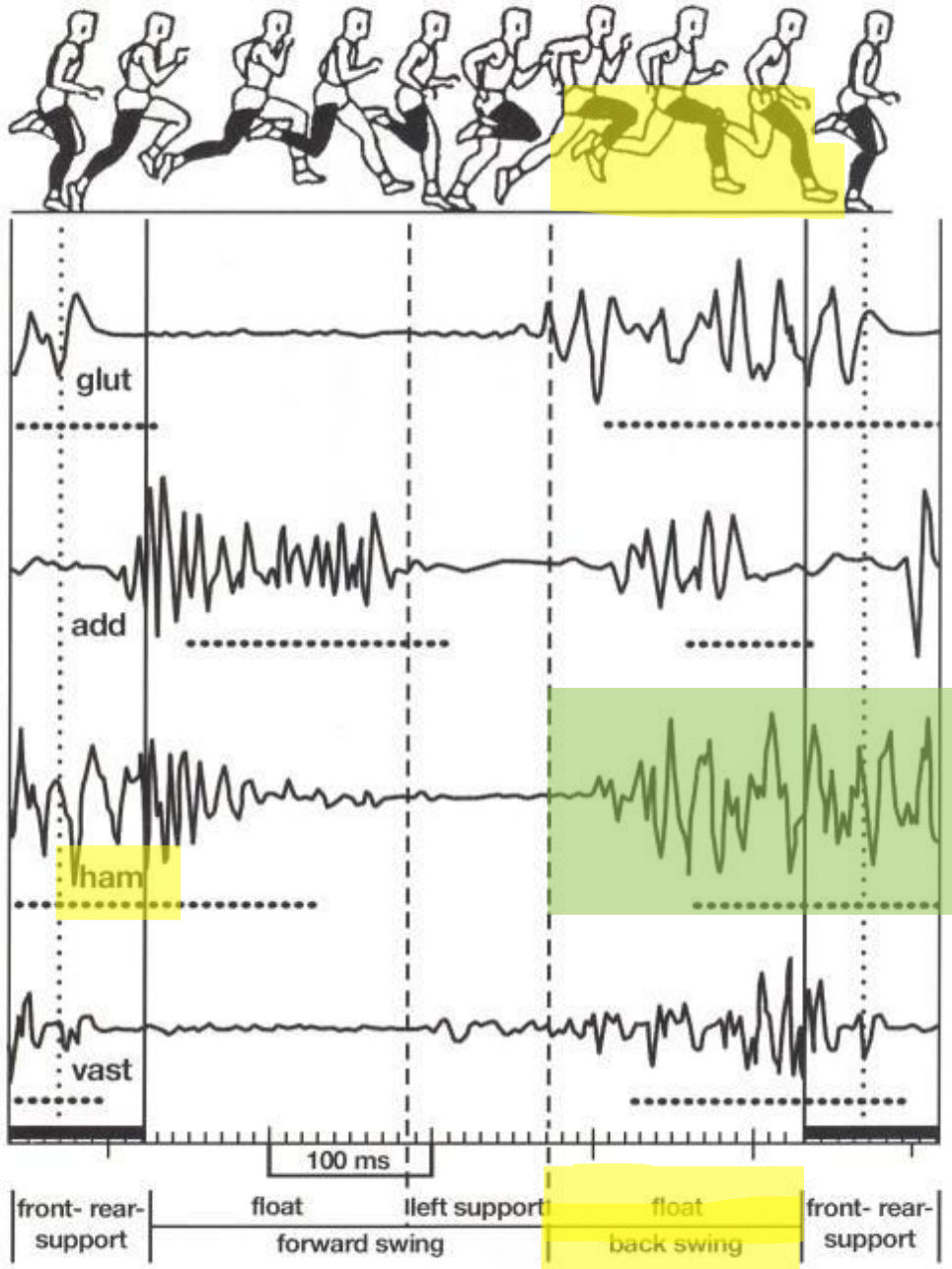

Ratio of Forces (%)
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
Running Velocity (m.s-1)

Figure 1. EMG Analysis and the Phases of Sprinting. Adapted from Weimann and Tidow (1995)



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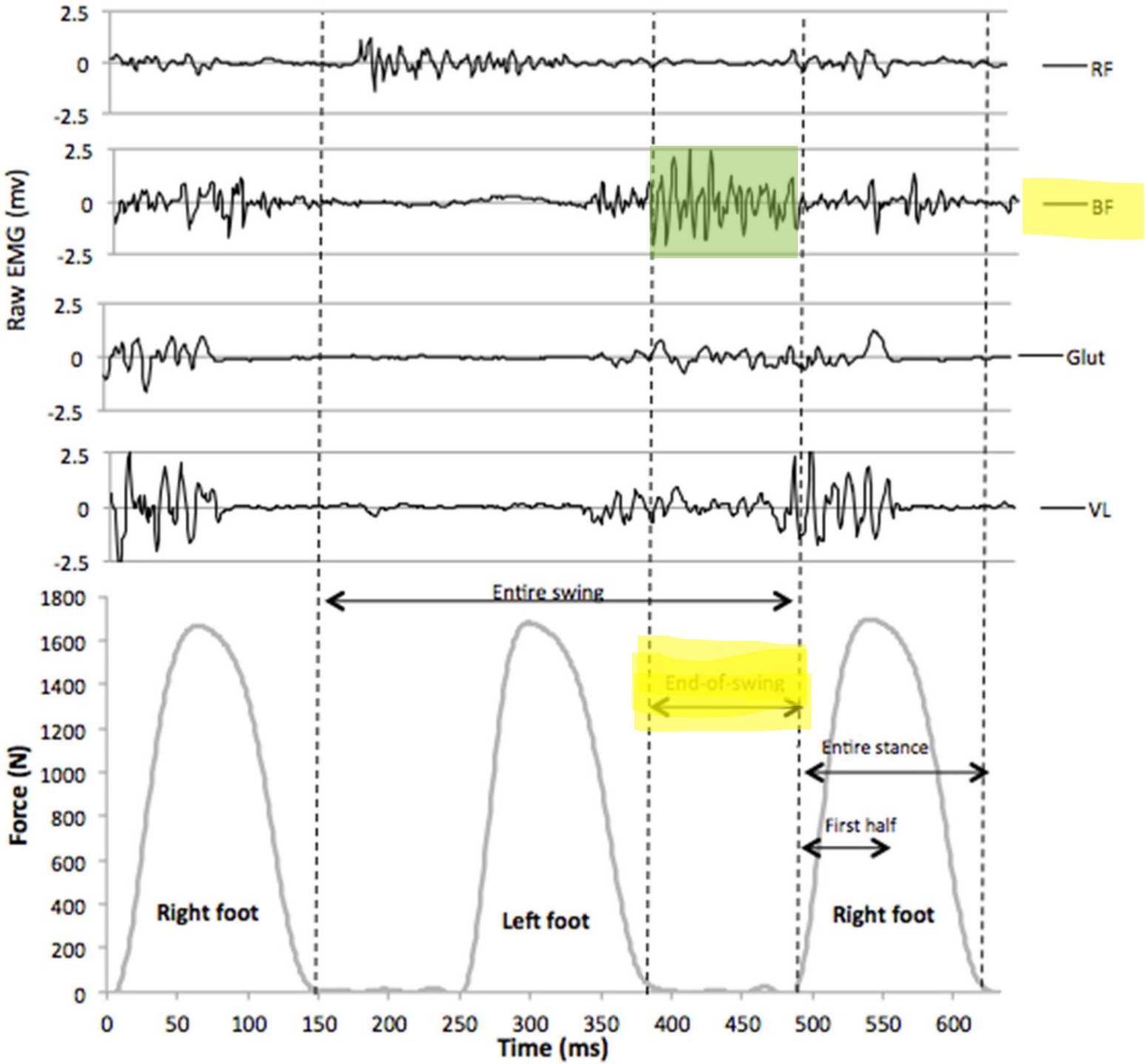


Morin et al., 2015

Hamstring Strength

Strength

Injury

Performance

Force-Velocity Sprinting Profile

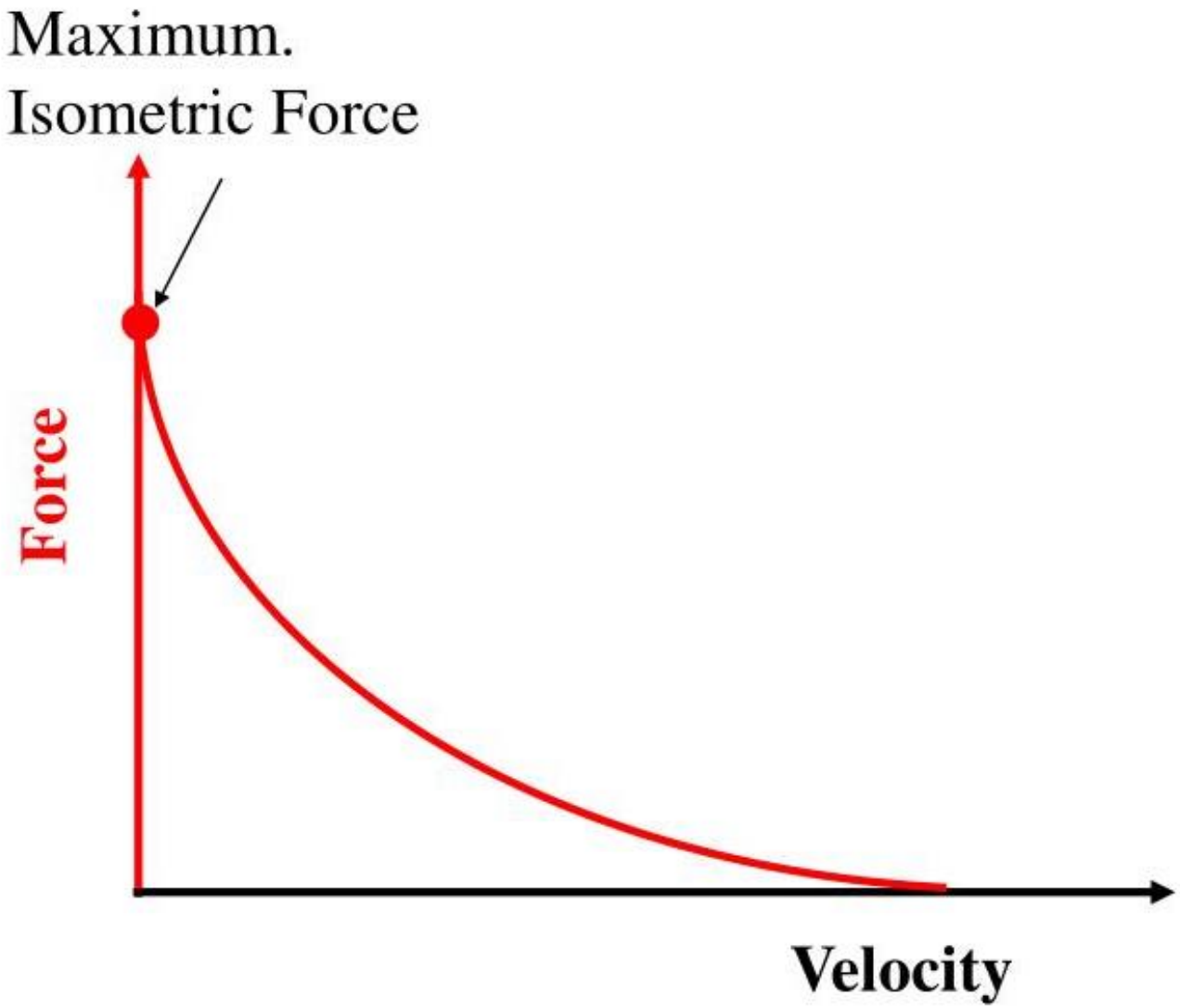
Are you stronger or faster?

Acceleration,
HZ GRF

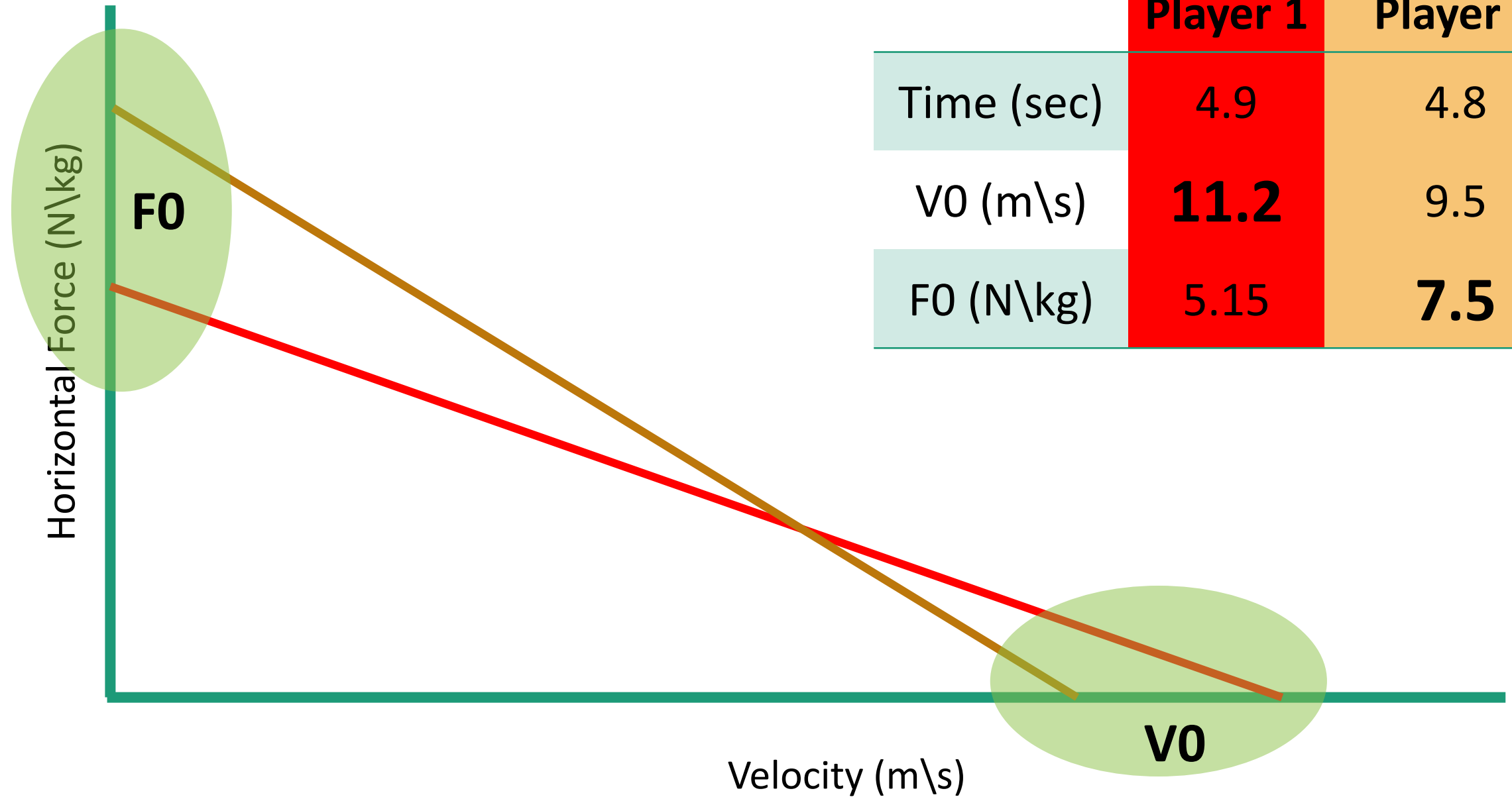
Top speed

Or: WHAT makes you fast?

Concentric Force - Velocity Curve



	Player 1	Player 2
Time (sec)	4.9	4.8
V0 (m\s)	**11.2**	9.5
F0 (N\kg)	5.15	**7.5**



F-V profile

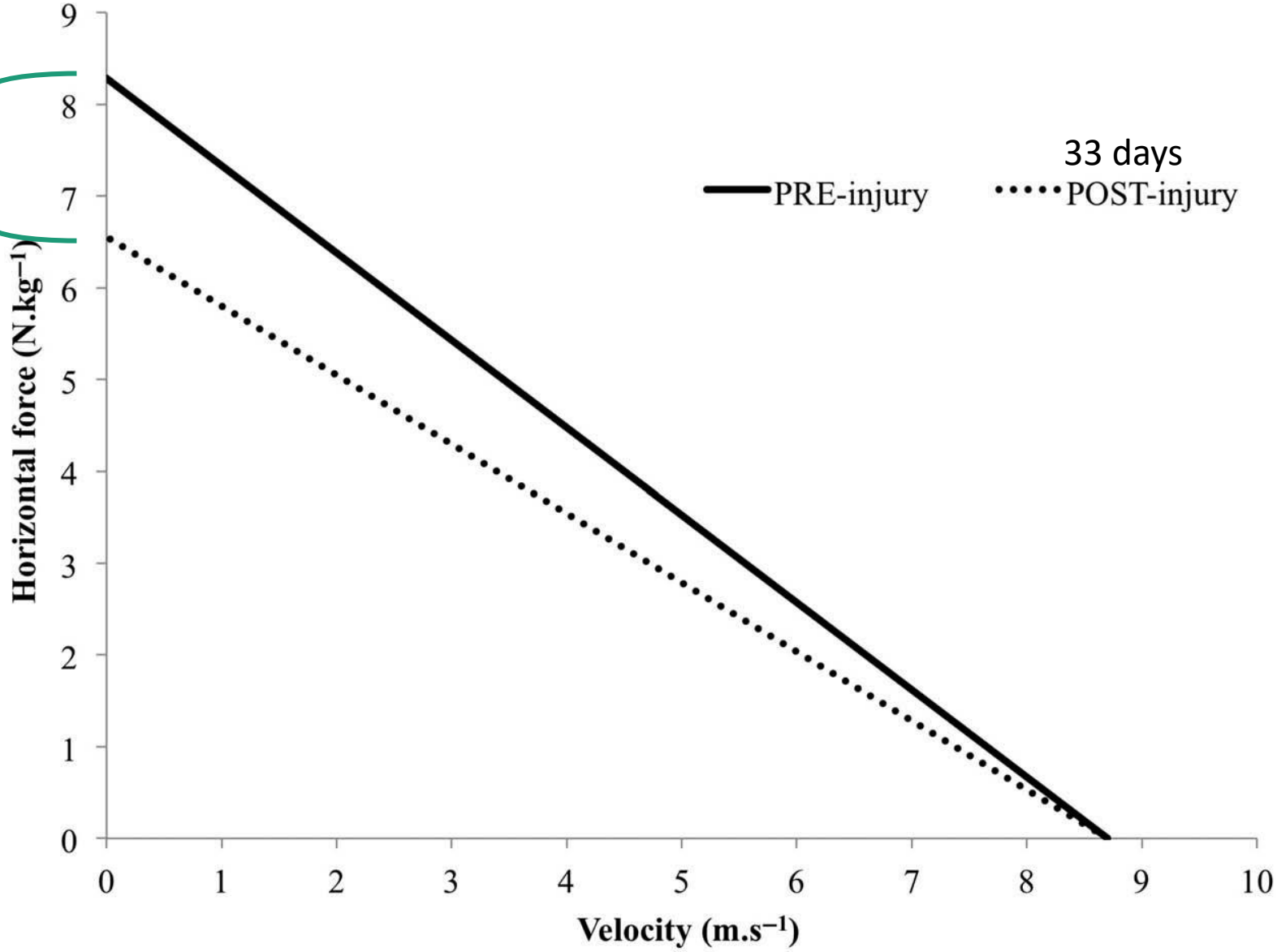
- Are you better at strength or speed?
- Strength = acceleration, HZ GRF
- Speed = top speed
- Two athletes can perform similarly but be very different so training should be different
- The end result (total time) does not tell the whole story
- F-V profile allows us to design our training better (right amount of work can help in prevention)
- Can also help in recovery and RTP decision
  - Still not enough scientific support

Force production after HAM injury

- Strength and Power reduced but not top speed (after RTP approved)
  - Acceleration impaired
  - Players are cleared to RTP with low F0 and low Pmax
- 2 months later returned to normal values (no pre-injury data)
  - Greater risk of re-injury during those 2 months while F0 was low?

(Mendiguchia et al., 2014)

~20%



(Mendiguchia et al., 2014, 2016)

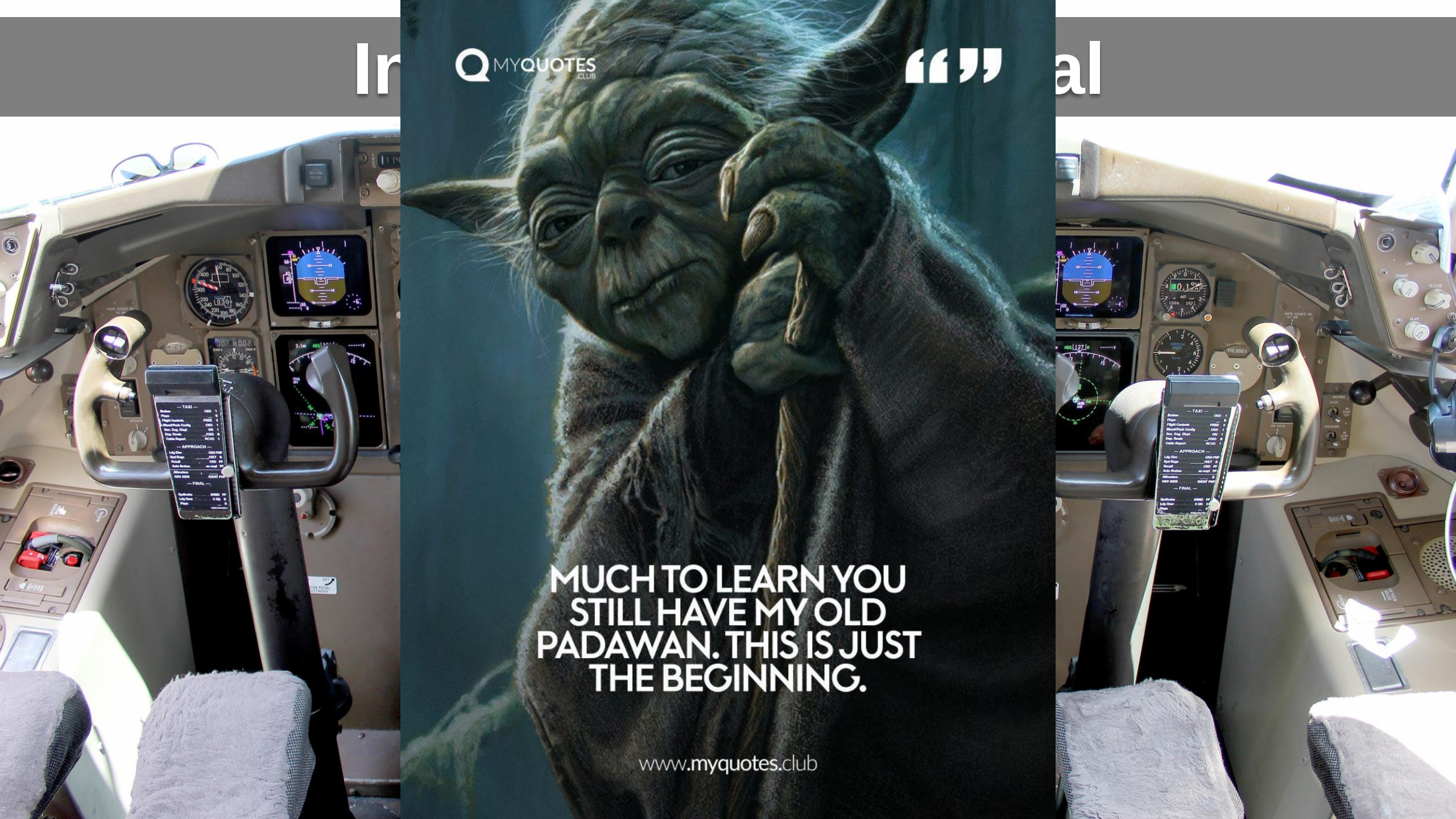
Performance and Prevention: Win-Win

- Hamstring strengthening:
  - Reduce injuries
  - Improve performance?

- F-V profile:
  - To individualize training
  - Screen subjects in RTP?
    - Pilot data suggests that it might

- Injury is multifactorial!

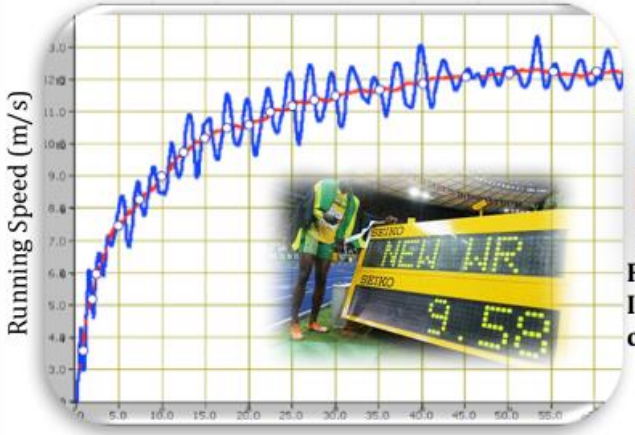
Ir al


MYQUOTES .CLUB
“”
MUCH TO LEARN YOU STILL HAVE MY OLD PADAWAN. THIS IS JUST THE BEGINNING.
www.myquotes.club

HOW?

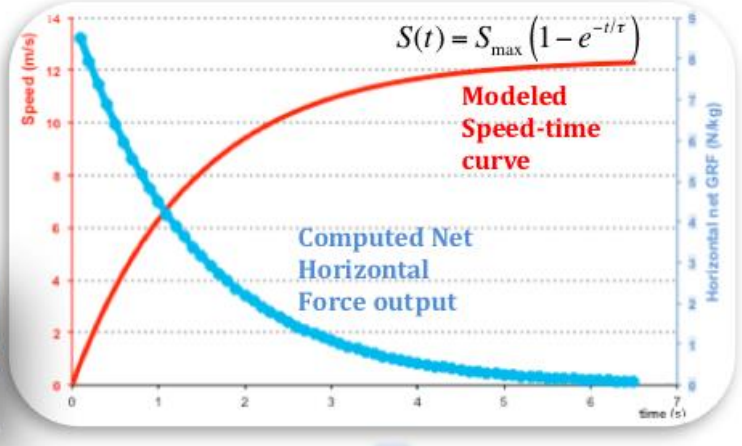
- Calculate HZ force from speed
  - Validated against force plates (2-5% difference)
- Calculate FVP from 30 m sprint, if you have 5 splits
- Mysprint app
  - Validated against radar and timing gates
  - Tutorial 1
  - Tutorial 2
- Excel worksheet

FORCE-VELOCITY-POWER Profile of Usain Bolt's World Record

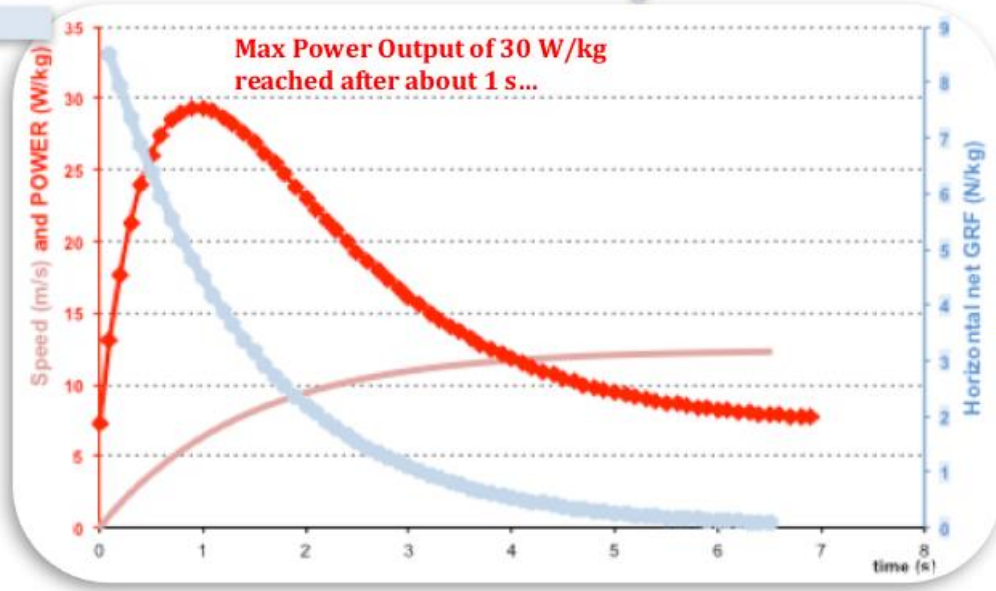


Field Measurements
In competition
conditions

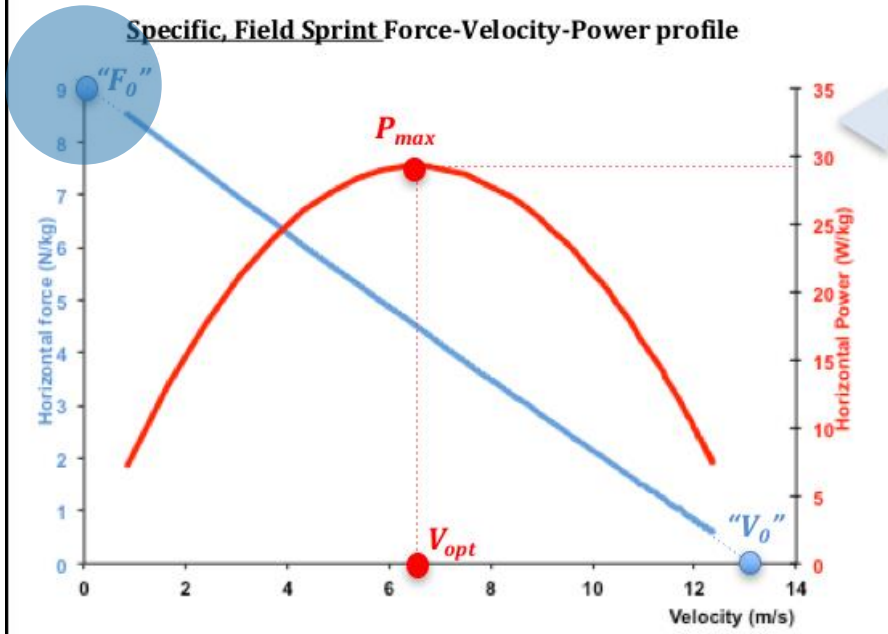
Computing



Power = Force x Speed...



Specific, Field Sprint Force-Velocity-Power profile



F_0 and V_0 are the theoretical maximal outputs of the system
V_{opt} is the speed at which P_{max} is produced
The magnitude of the slope (F_0/V_0) describes the Force-Velocity profile of the athlete

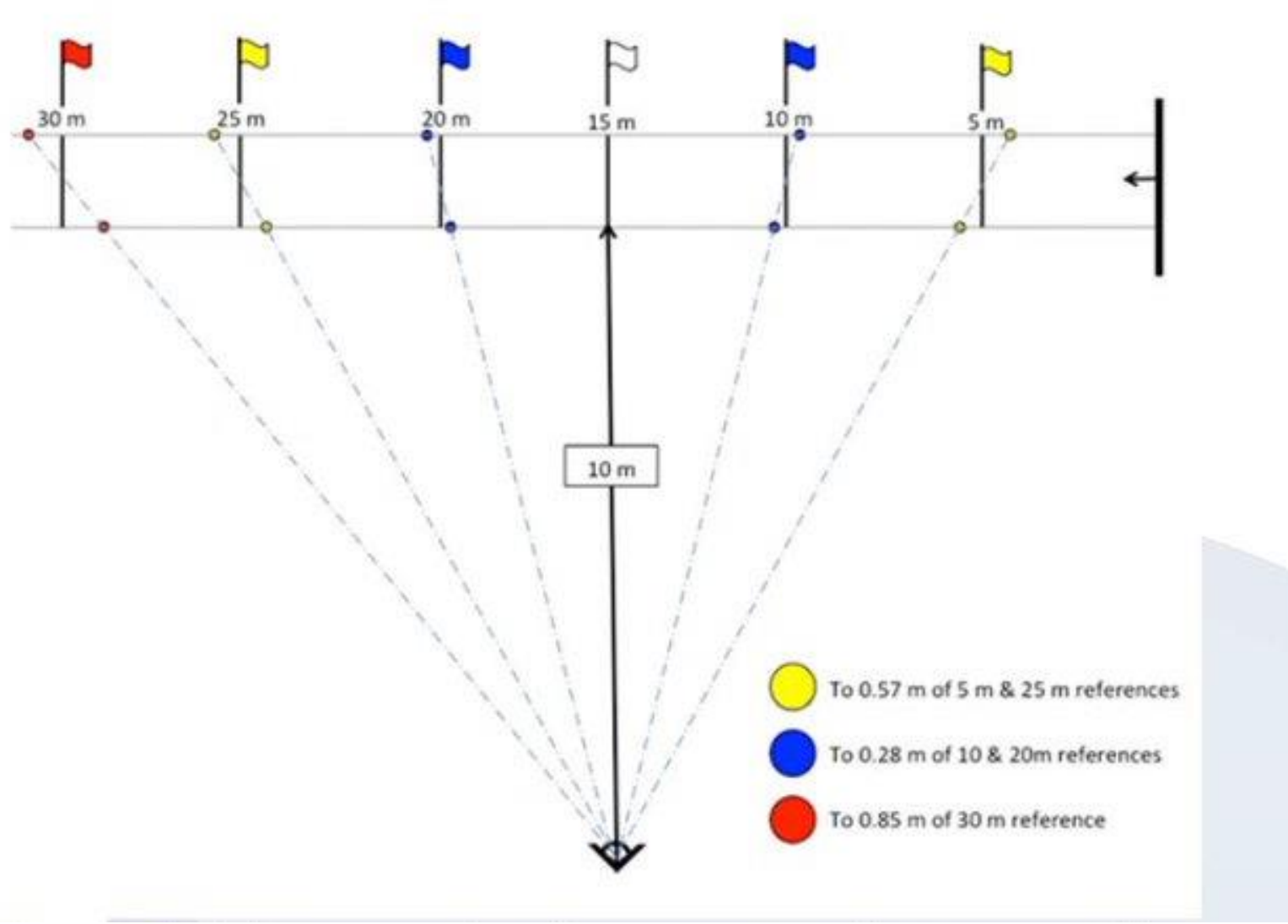
Pierre Samozino, *PhD*
University of Savoy

Jean-Benoit Morin, *PhD*
University of Nice

	Distance (m)	Time (s)	Position model (s)	Square Differences
Vmax (m/s)	**5**	1.501	4.8	0.0
7.35310507	**10**	2.409	10.2	0.0
Tau (s)	**15**	3.142	15.0	0.0
1.18015564	**20**	3.852	20.0	0.0
Stature (m)	**25**	4.548	24.9	0.0
1.78	**30**	5.249	30.0	0.0
Mass (kg)				***Sum***
70				**0.1**
T° (°C)				
20				

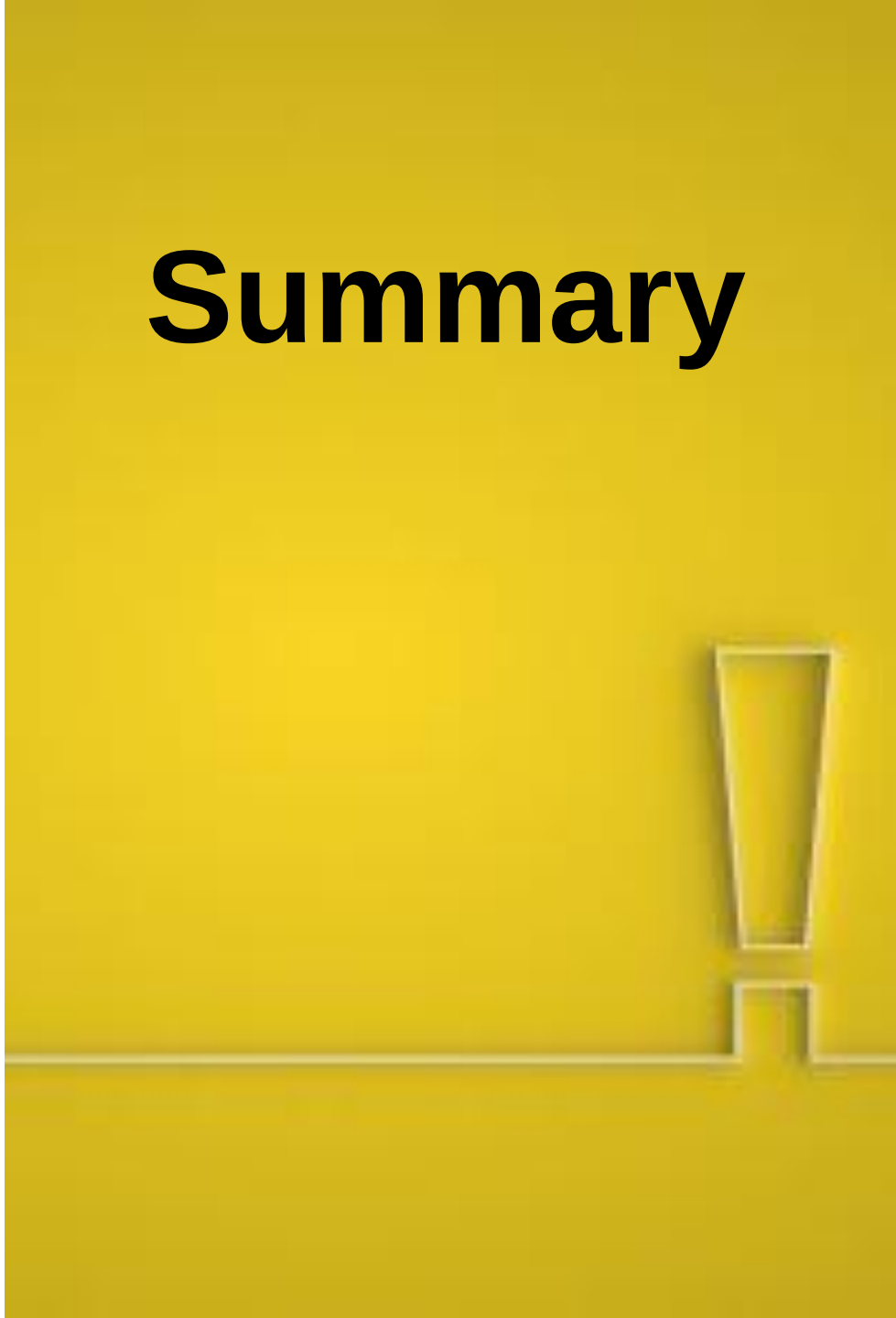
P (hPa)	F0 (N/kg)	V0 (m/s)	Pmax (W/kg)	FV Slope
1000	6.15	7.68	11.81	-0.8
	RF max (%)	Drf (%)	Vopt (m/s)	Max Speed (m/s)
	38%	-7.62%	3.84	7.27


17:55
55 %
My Sprint
Capture


30 m
25 m
20 m
15 m
10 m
5 m
10 m
To 0.57 m of 5 m & 25 m references
To 0.28 m of 10 & 20m references
To 0.85 m of 30 m reference

Summary

- The HAM play a role in sprinting and are often injured (and re-injured)
- Strength seems to be related to HAM injury
  - But remember that injury is multifactorial!
- Injury reduces strength
- FV profile can assist in optimizing training and RTP decision
- FV profile can be assessed with the MySprint app using a 30 m sprint
- There is still much to learn…



Thank you!

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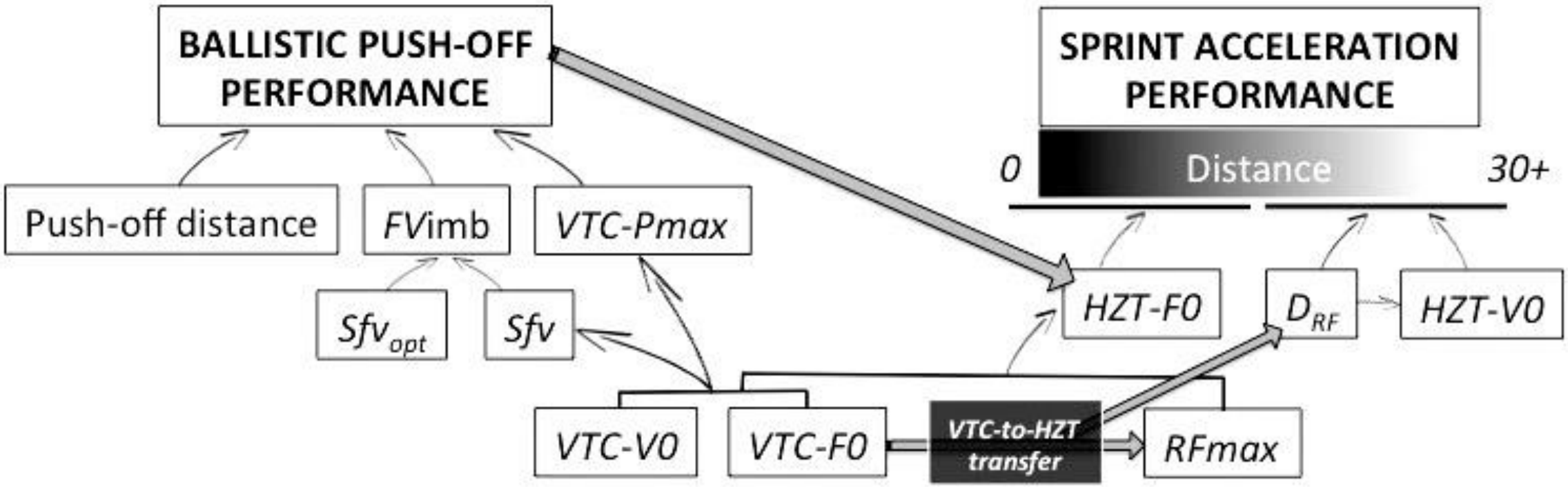
BALLISTIC PUSH-OFF PERFORMANCE
SPRINT ACCELERATION PERFORMANCE
0
Distance
30+
Push-off distance
FVimb
VTC-Pmax
Sfv opt
Sfv
HZT-F0
D RF
HZT-V0
VTC-V0
VTC-F0
VTC-to-HZT transfer
RFmax