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@jb_morin

INDIVIDUAL FORCE-VELOCITY-POWER PROFILING FOR PERFORMANCE AND INJURY MANAGEMENT

Prof J-B Morin

UNIVERSITÉ CÔTE D'AZUR

SPORTS PERFORMANCE RESEARCH INSTITUTE, NEW ZEALAND
AN INSTITUTE OF AUT UNIVERSITY

jbmorin.net

CONFLICT OF INTEREST STATEMENT

I have no actual or potential conflict of interest in relation to this presentation.

Team Work

Teammates & Inputs

P. Samozino, Chambery FR
J. Mendiguchia, Baranain SP
P. Jimenez-Reyes, Madrid SP
M. Brughelli, Auckland NZ
M. Cross, Auckland NZ
Y. LeMeur, Monaco
G. Rabita, Paris FR
S. Brown, Auckland NZ
S. Dorel, Nantes FR
J. Slawinski, Paris FR
A. Couturier, Paris FR
C. Balsalobre-Fernandez, Mardid SP
P. diPrampero, Udine IT
B. Contreras, Phoenix AZ
G. Petrakos, Dublin IRL
J. Lahti, Nice FR
1080 Motion, SW

Field → Maths / Lab / Papers → Field

2007…

Some parts
of all this *might*
lead nowhere (time
will tell)

Until then….

International Journal of Sports Physiology and Performance, 2016, 11, 267-272
http://dx.doi.org/10.1123/ijspp.2015-0638

Human Kinetics
INVITED COMMENTARY

Interpreting Power-Force-Velocity Profiles for Individualized and Specific Training

Jean-Benoît Morin and Pierre Samozino

Player C	2011-12, Club 19 2012, Club 84 2012-13 Club 223	4171 (48 matches)	36
Player D	2011-12 to present, Club 4	5052 (73 matches)	

Based on WHAT?

Training should be individualized…

MACROSCOPIC APPROACH: BIG PICTURE FIRST

Pietro E. di Prampero
Università Degli Studi di Udine (Italy)

R. McNeill Alexander
(1934-2006)
University of Leeds (UK)

THE ROYAL SOCIETY

Published online 6 August 2003

Modelling approaches in biomechanics

R. McN. Alexander

School of Biology, University of Leeds, Leeds LS2 9JT, UK (r.m.alexander@leeds.ac.uk)

Conceptual, physical and mathematical models have all proved useful in biomechanics. Conceptual models, which have been used only occasionally, clarify a point without having to be constructed physically or analysed mathematically. Some physical models are designed to demonstrate a proposed mechanism, for example the folding mechanisms of insect wings. Others have been used to check the conclusions of mathematical modelling. However, others facilitate observations that would be difficult to make on real organisms, for example on the flow of air around the wings of small insects. Mathematical models have been used more often than physical ones. Some of them are predictive, designed for example to calculate the effects of anatomical changes on jumping performance, or the pattern of flow in a 3D assembly of semicircular canals. Others seek an optimum, for example the best possible technique for a high jump. A few have been used in inverse optimization studies, which search for variables that are optimized by observed patterns of behaviour. Mathematical models range from the extreme simplicity of some models of walking and running, to the complexity of models that represent numerous body segments and muscles, or elaborate bone shapes. The simpler the model, the clearer it is which of its features is essential to the calculated effect.

The simpler the model, the clearer it is which of its features is essential
to the calculated effect *(performance)*

140 kW

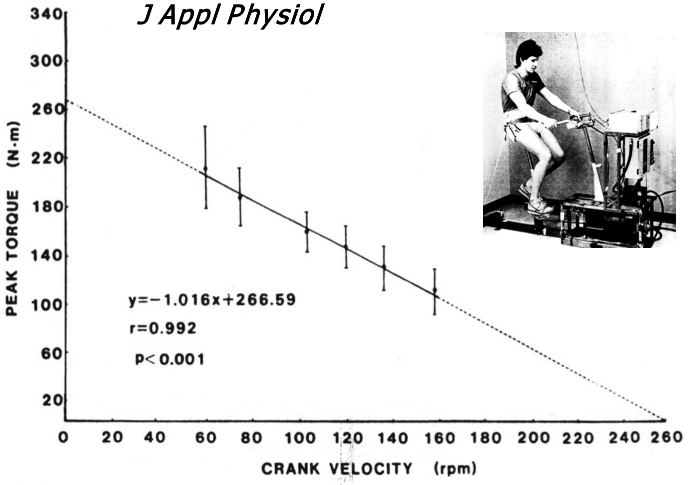
Which one can produce more « force »?

It depends on the velocity…

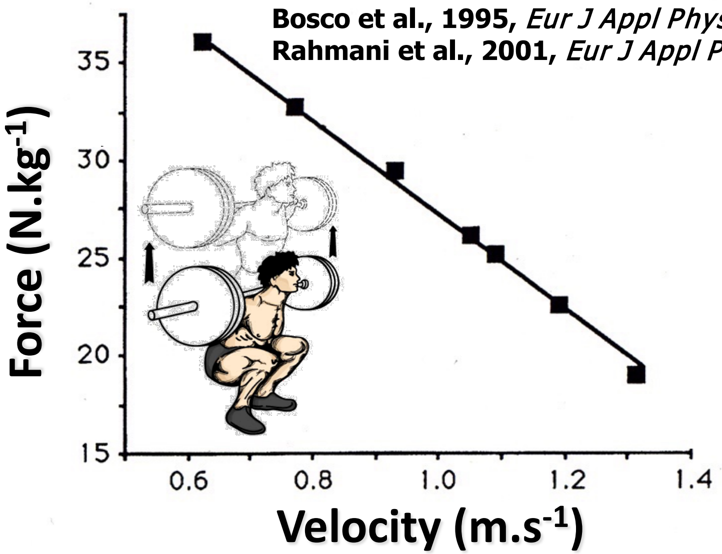
FORCE-VELOCITY Individual Spectrum

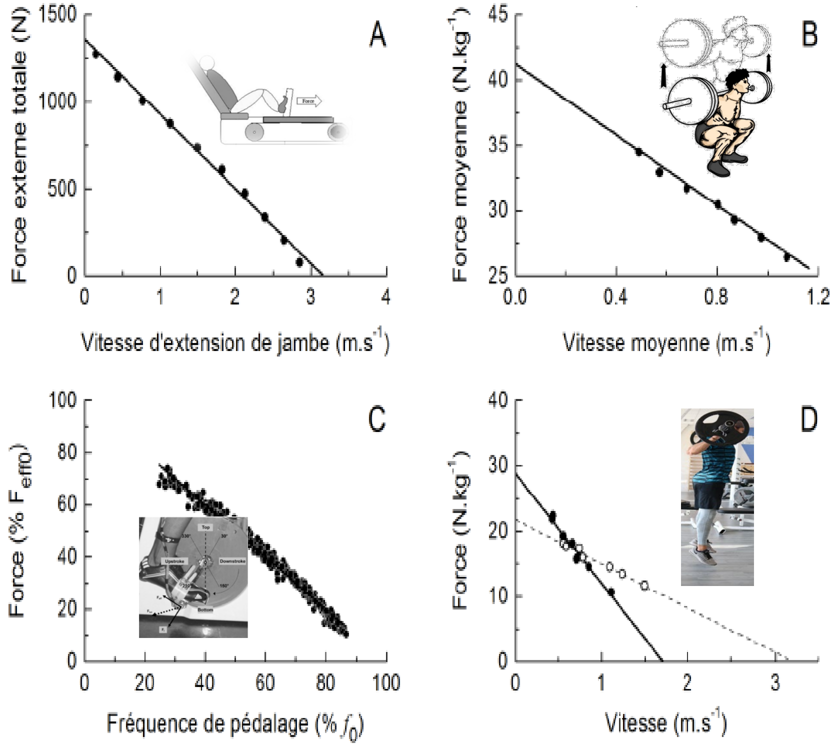
MULTIJOINT EXERCISES: LINEAR F-V RELATIONSHIP

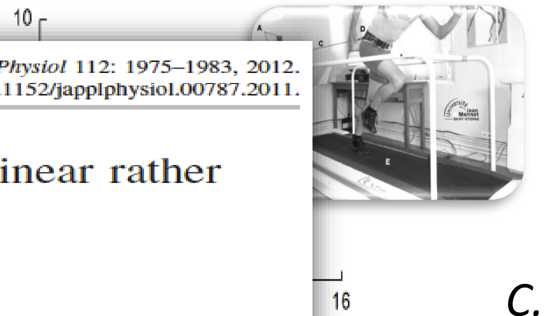
McCartney et al., 1983, *J Appl Physiol*



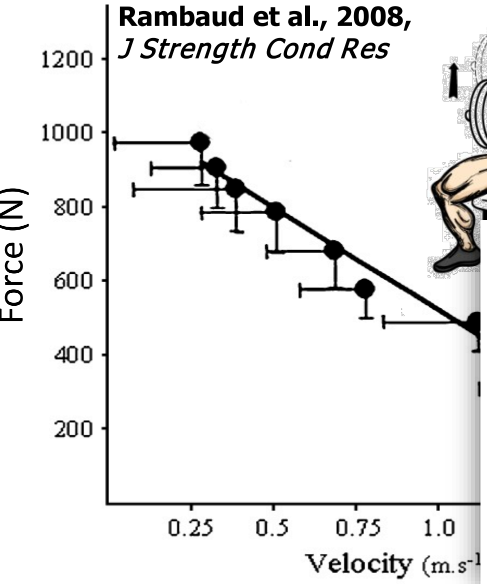
Bosco et al., 1995, *Eur J Appl Physiol*
Rahmani et al., 2001, *Eur J Appl Physiol*

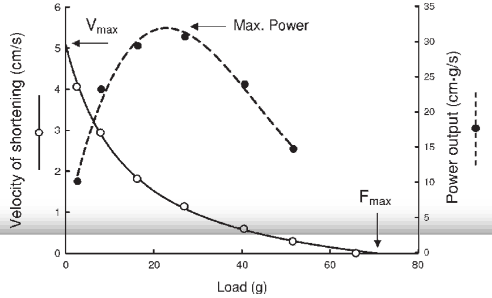


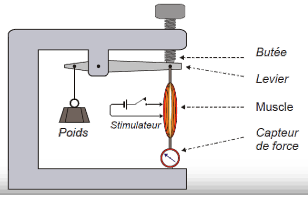




Rambaud et al., 2008, *J Strength Cond Res*







J Appl Physiol 112: 1975–1983, 2012.
First published March 22, 2012; doi:10.1152/japplphysiol.00787.2011.

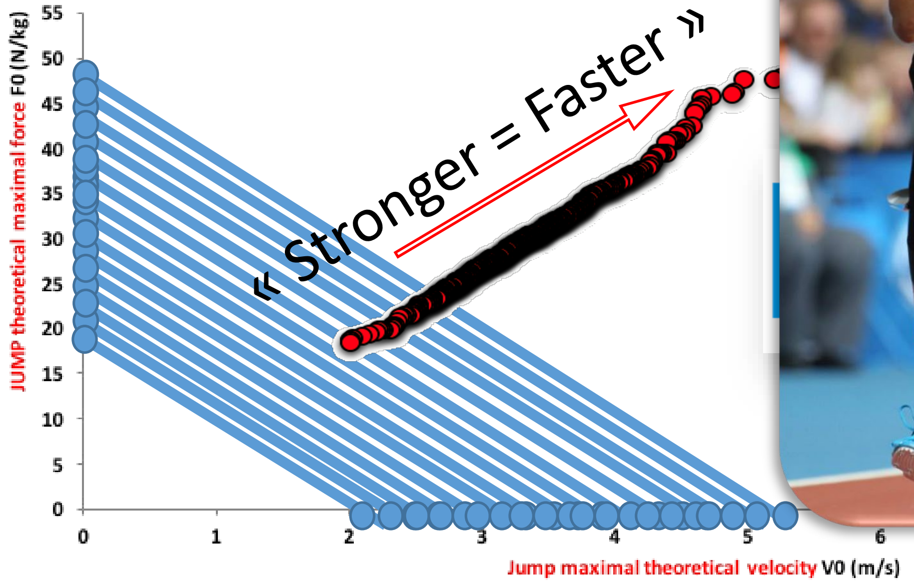
Why is the force-velocity relationship in leg press tasks quasi-linear rather than hyperbolic?

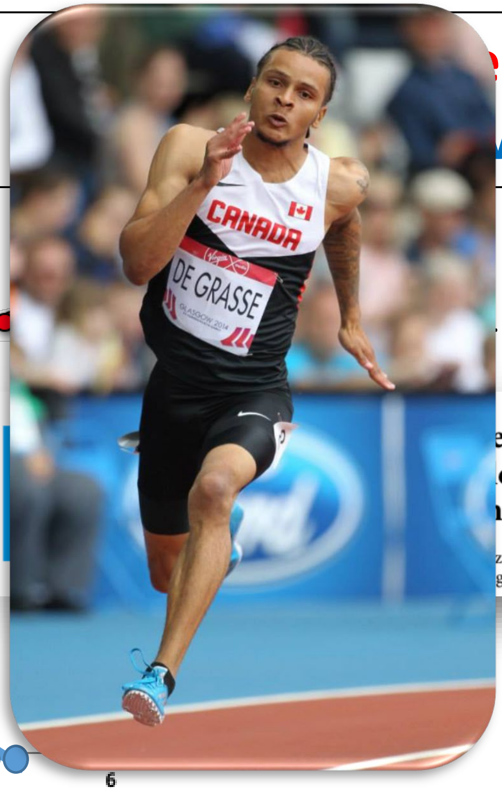
Maarten F. Bobbert
Research Institute MOVE, Faculty of Human Movement Sciences, VU University Amsterdam, Amsterdam, The Netherlands

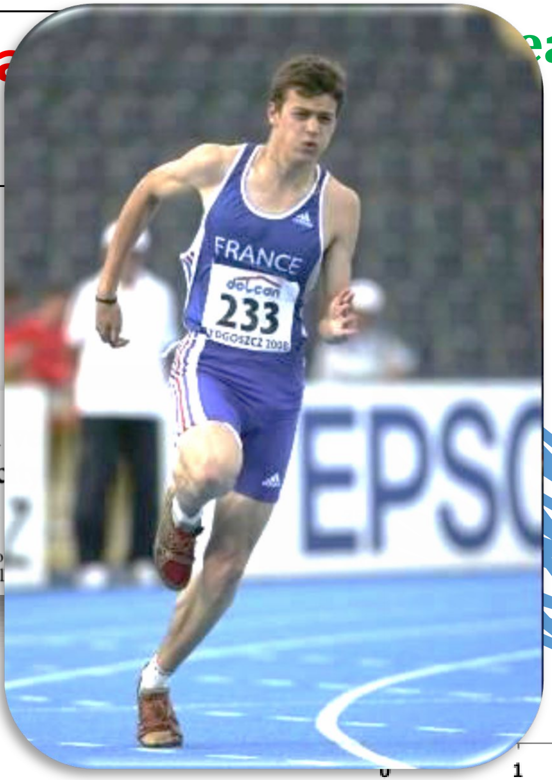
Submitted 27 June 2011; accepted in final form 17 March 2012

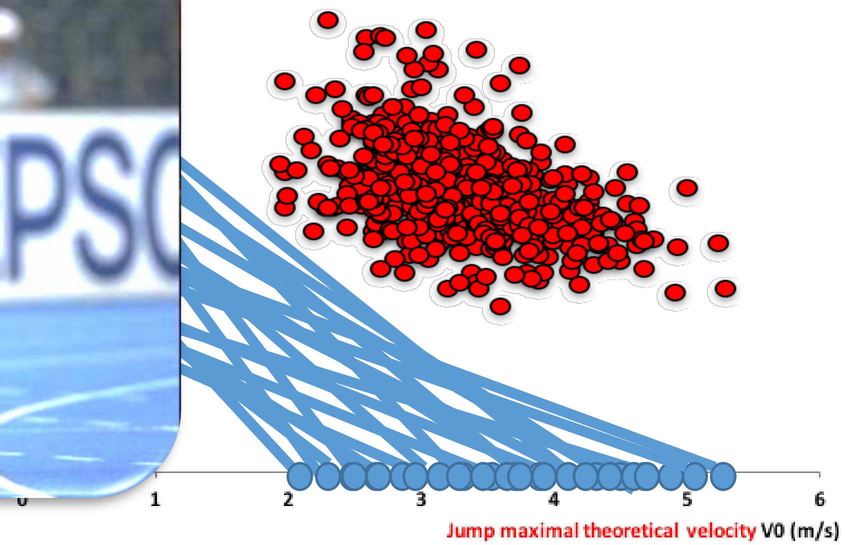
C. Giroux
PhD Thesis, 2014

NOT the reality









« Strong » at Low Velocity ≠ « Strong » at High Velocity

More maximal force ≠ More maximal velocity

14 sports   >500 athletes   Leisure to elite level

No correlation overall, same sub-group outcome for each level and each sport, ***SAME RESULTS FOR SPRINTING***

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« Vertical » FVP Profile

Sports Medicine
https://doi.org/10.1007/s40279-019-01073-1

CURRENT OPINION

Check for updates

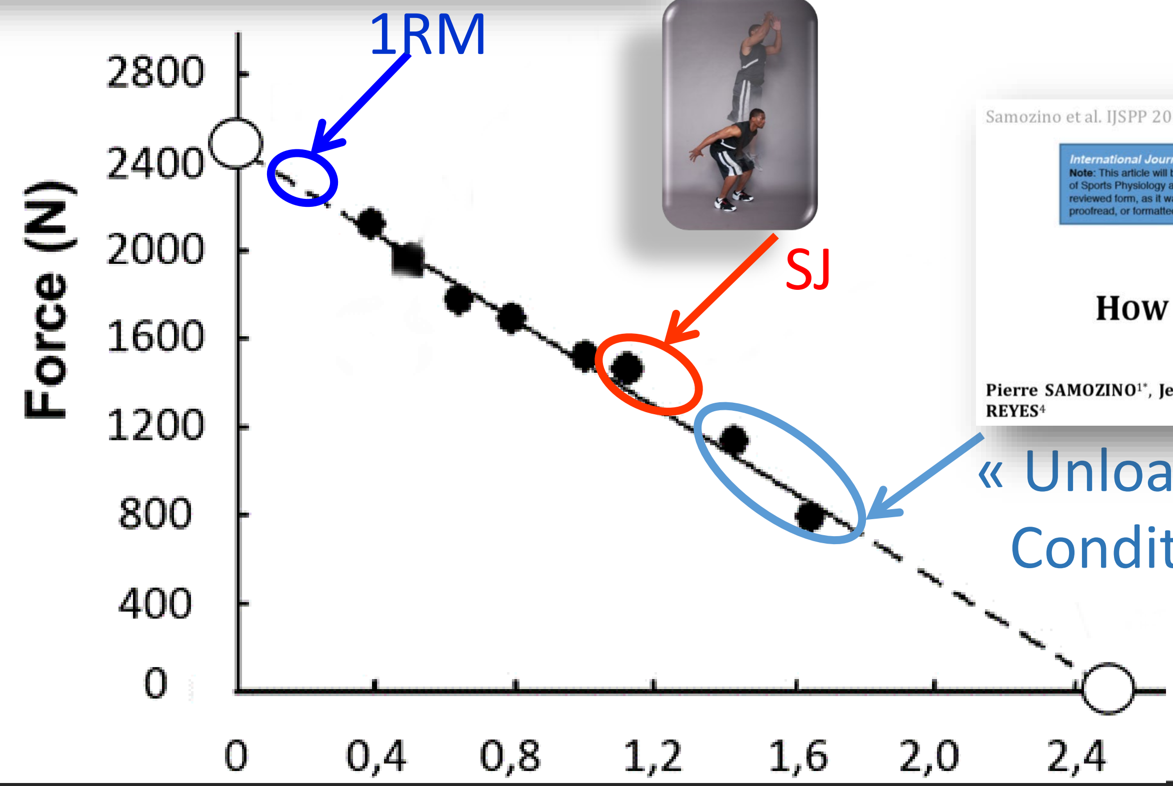
When Jump Height is not a Good Indicator of Lower Limb Maximal Power Output: Theoretical Demonstration, Experimental Evidence and Practical Solutions

Jean-Benoit Morin[1,3] · Pedro Jiménez-Reyes[2] · Matt Brughelli[3] · Pierre Samozino[4]

Orthopedics & Biomechanics
Thieme

Where does the One-Repetition Maximum Exist on the Force-Velocity Relationship in Squat?

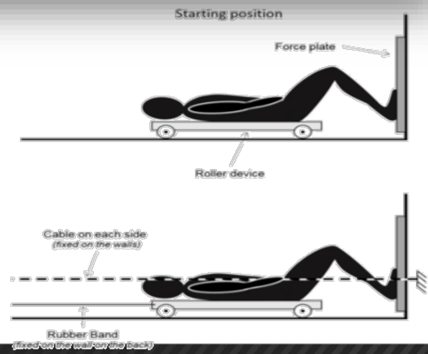
Authors
Jean Romain Rivière[1], Jérémy Rossi[2], Pedro Jimenez-Reyes[3], Jean-Benoit Morin[4], Pierre Samozino[1]



Samozino et al. IJSPP 2017
Horizontal Squat Jump
International Journal of Sports Physiology and Performance, 2017
Note: This article will be published in a forthcoming issue of the International Journal of Sports Physiology and Performance. The article appears here in its accepted, peer-reviewed form, as it was provided by the submitting author. It has not been copyedited, proofread, or formatted by the publisher.
Human Kinetics
ORIGINAL INVESTIGATION

HOW FAST IS A HORIZONTAL SQUAT JUMP?

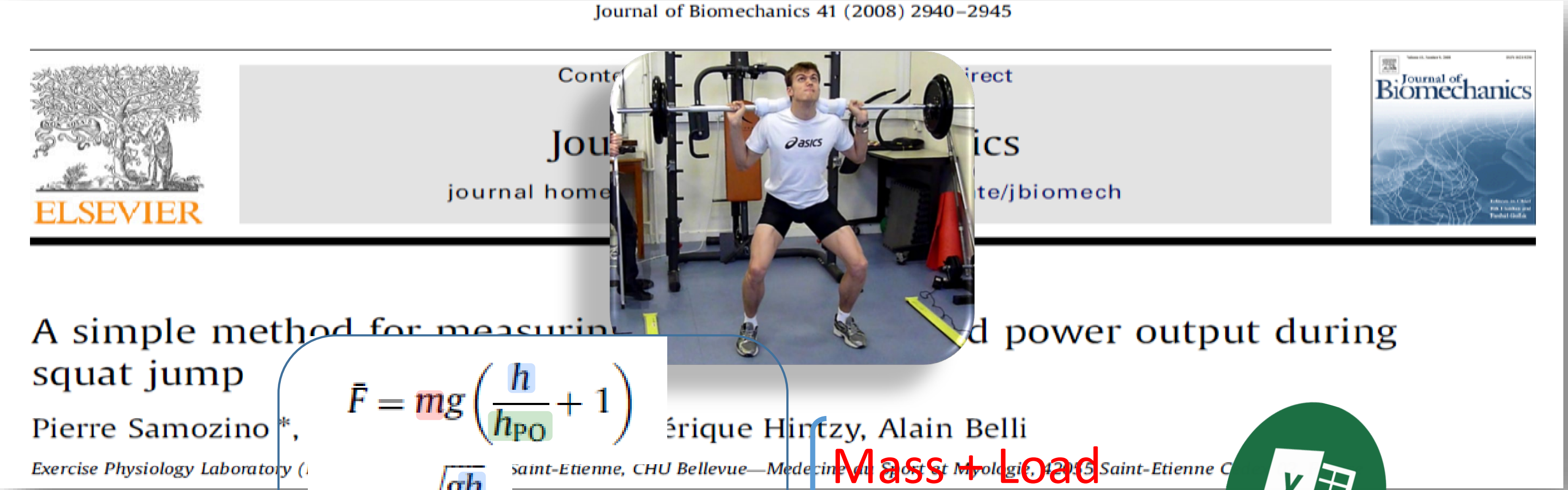
Pierre SAMOZINO[1*], Jean Romain RIVIERE[1], Jérémy ROSSI[2], Jean-Benoît MORIN[3], Pedro JIMENEZ-REYES[4]



OK, How can we do with field devices??

15'

- **Scales –**
- **2-4 goo**
- **Jump h**



Journal of Biomechanics 41 (2008) 2940–2945

ELSEVIER

Conte... irect

Jou... ics

journal home... te/jbiomech

A simple method for measurin... d power output during squat jump

Pierre Samozino *, ... érique Hintzy, Alain Belli

Exercise Physiology Laboratory (... Saint-Etienne, CHU Bellevue—Medecine du Sport et Myologie, 42055 Saint-Etienne C...

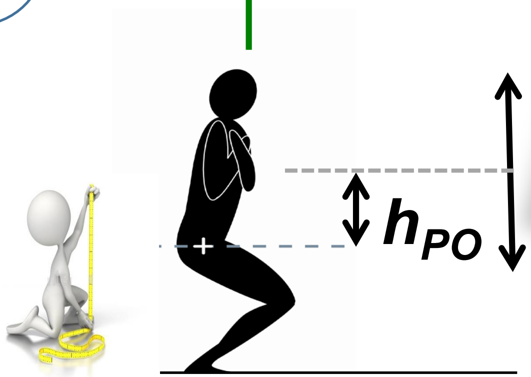
Pierre Samozino
Univ Savoy

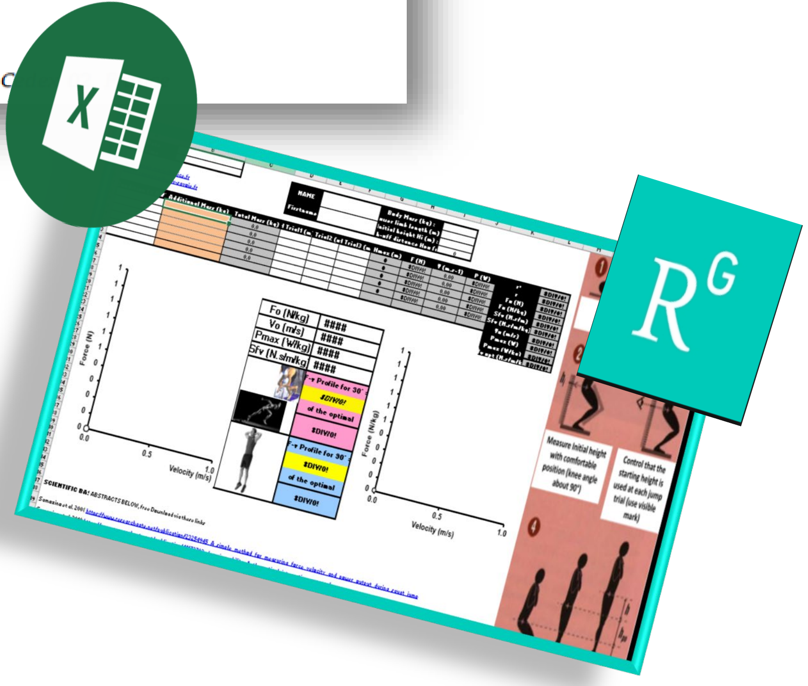
$$\bar{F} = mg\left(\frac{h}{h_{PO}} + 1\right)$$

$$\bar{v} = \sqrt{\frac{gh}{2}}$$

$$\bar{P} = mg\left(\frac{h}{h_{PO}} + 1\right)\sqrt{\frac{gh}{2}}$$

Mass + Load
Jump height
Push-off distance



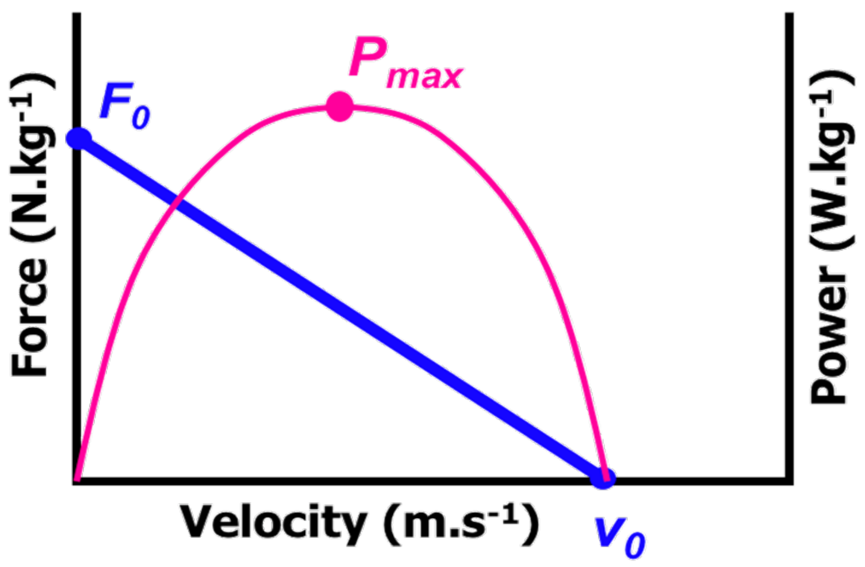


APPROVED

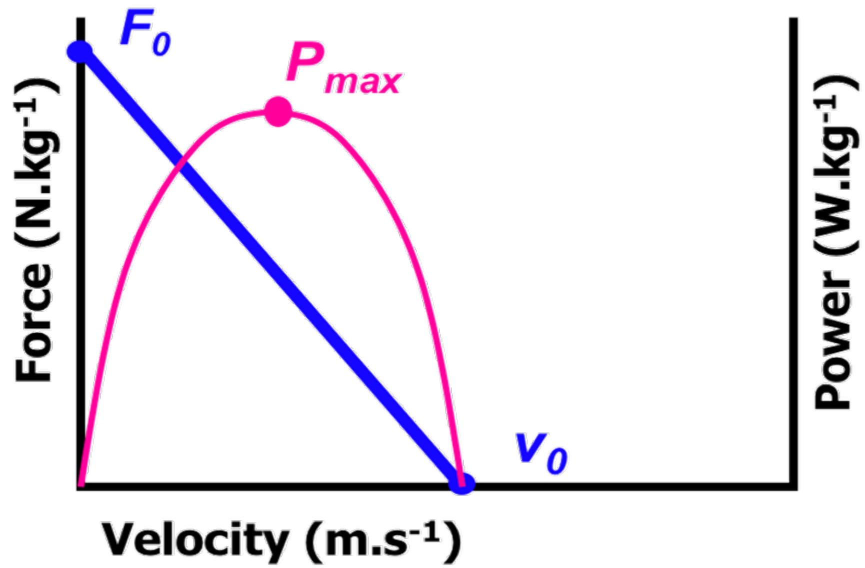
Validity
and reliability
SJ and CMJ

Samozino et al, 2008, J Biomech
Palmieri et al, 2014, CMBBE
Giroux et al, 2015, IJSM
Jimenez et al, 2017, IJSPP

« Velocity » Profile



« Force » Profile



Pierre Samozino
Univ Savoy

Athlete 1

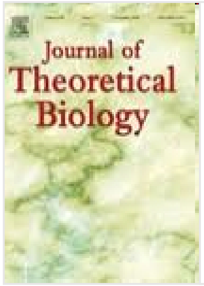
For a same given P_{max},

Athlete 2

Many F-V profiles possible….

Which one(s) maximize Jump Performance ??

All athletes need WATTS
In terms of F and V…who needs WHAT?


Journal of Theoretical Biology

Journal of Theoretical Biology 264 (2010) 11–18
Contents lists available at ScienceDirect
Journal of Theoretical Biology
journal homepage: www.elsevier.com/locate/yjtbi
ELSEVIER

Jumping ability: A theoretical integrative approach

Pierre Samozino *, Jean-Benoît Morin, Frédérique Hintzy, Alain Belli
Laboratory of Exercise Physiology (EA4338), University of Lyon, F-42023, Saint-Etienne, France

A MACROSCOPIC BIOMECHANICAL MODEL

Samozino et al, 2012, MSSE

Optimal Force–Velocity Profile in Ballistic Movements—*Altius*: *Citius* or *Fortius*?

PIERRE SAMOZINO[1], ENRICO REJC[2], PIETRO ENRICO DI PRAMPERO[2], ALAIN BELLI[3], and JEAN-BENOÎT MORIN[3]

[1]*Laboratory of Exercise Physiology (EA4338), University of Savoy, Le Bourget du Lac, FRANCE;*
[2]*Department of Biomedical Sciences and Technologies, University of Udine, Udine, ITALY; and*
[3]*Laboratory of Exercise Physiology (EA4338), University of Lyon, Saint Etienne, FRANCE*

$$v_{TO_{max}} = h_{PO}\left(\sqrt{\frac{S_{Fv}^2}{4}+\frac{2}{h_{PO}}\left(2\sqrt{P_{max}S_{Fv}}-g\sin\alpha\right)}+\frac{S_{Fv}}{2}\right)$$

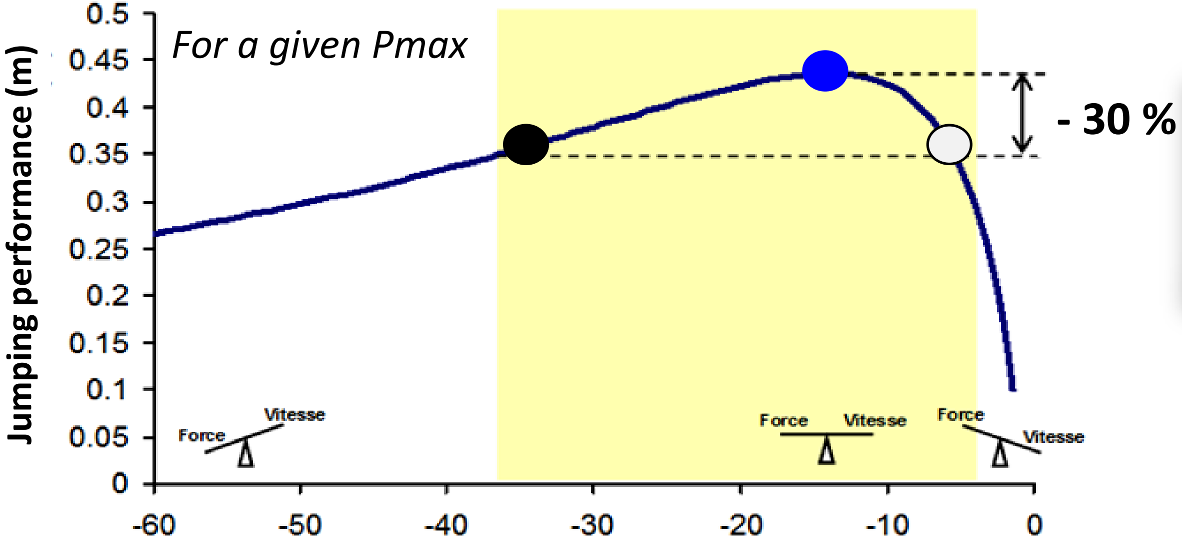
Best Performance | **Pmax**, **F-v Profile**, **Lower limb extension range**

✓ *Prediction errors : 4-6%*

Validity ??

Interest ??

Optimal Fv profile



← « force » profile | **FV Profile** | « velocity » profile →

Int J Sports Med 2014; 35: 505–510

Force-Velocity Profile: Imbalance Determination and Effect on Lower Limb Ballistic Performance

Authors: P. Samozino[1], P. Edouard[2,3], S. Sangnier[4,5], M. Brughelli[6], P. Gimenez[7], J.-B. Morin[3]

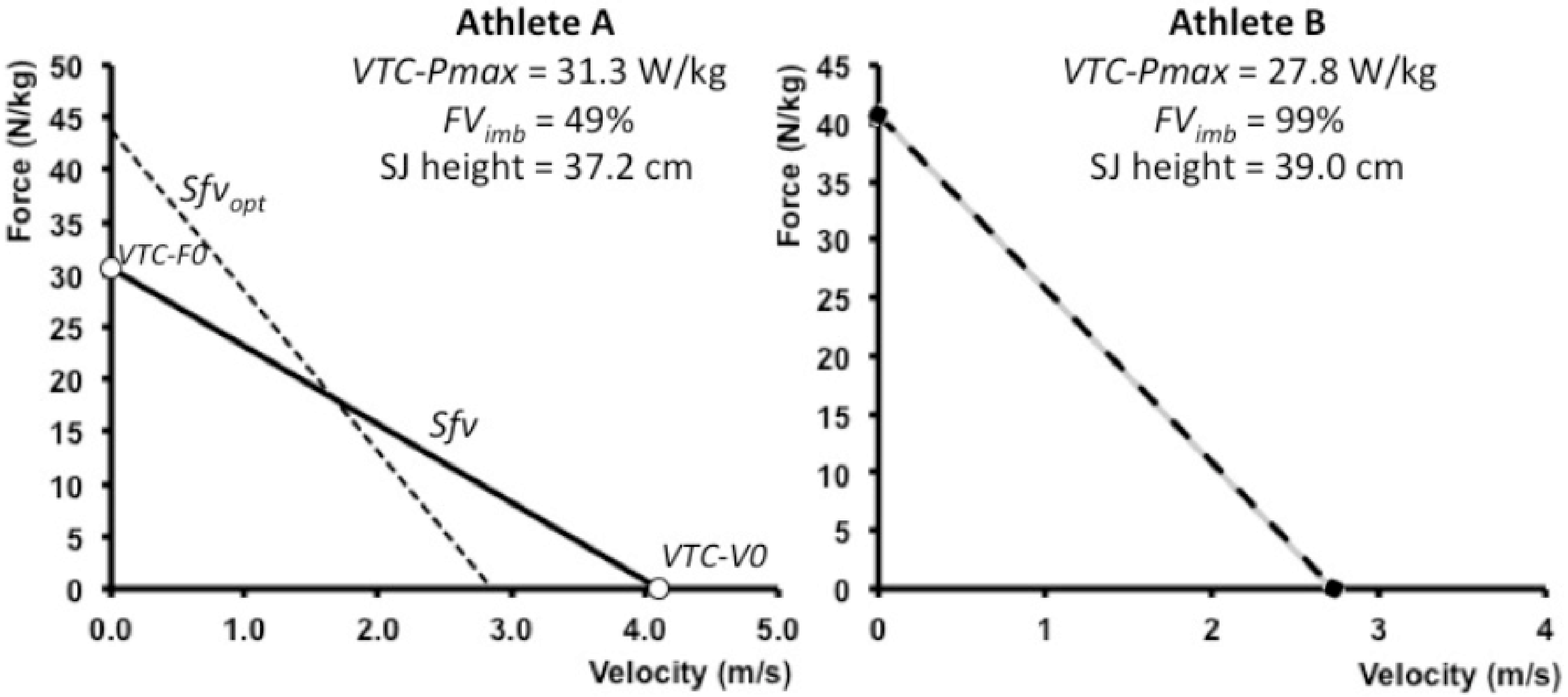
Improve performance with

- ✓ ↗ **Pmax**
- ✓ ↙ **FV imbalance**

Samozino et al, 2010, J Theor Biol

Samozino et al, 2014, IJSM

TYPICAL EXAMPLES



B is less powerful….but has better individual FV balance

→ better SJ performance

Date	01/05/15
Time	

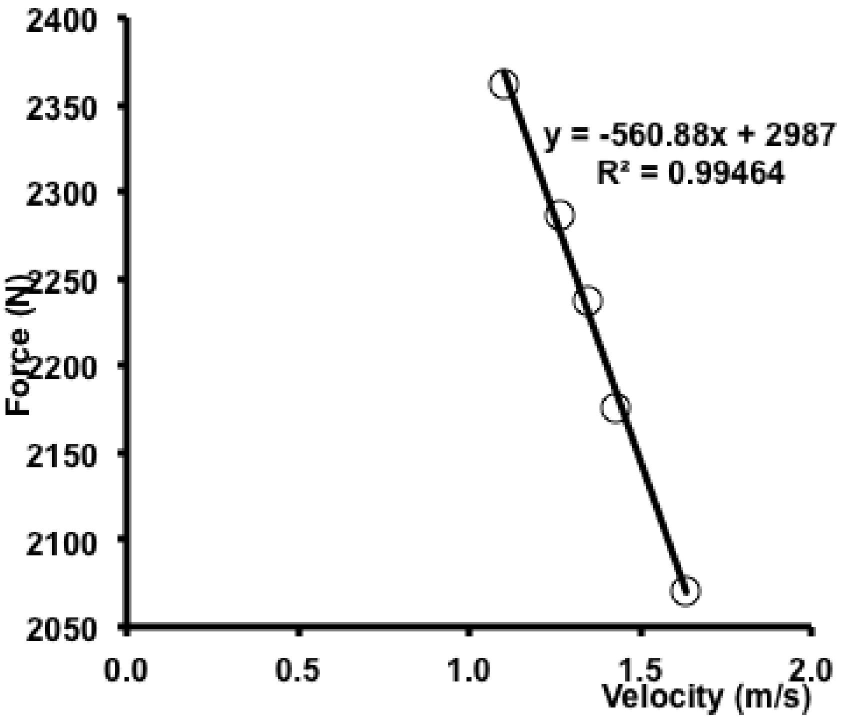
NAME	
Firstname	

Body Mass (kg) :	102
Lower limb length (m) :	1.34
Hi (m) :	0.83
Hpo (m) :	0.51

Condition (% BW)	Additional Mass (kg)	Total Mass (kg)	H1 (m)	H2 (m)	H3 (m)	Hmax (m)	F (N)	V (m.s-1)	P (W)
	0	102.0	0.545			0.545	2069.9	1.64	3384
	20	122.0	0.417			0.417	2175.4	1.43	3111
	30	132.0	0.371			0.371	2236.9	1.35	3018
	40	142.0	0.327			0.327	2286.2	1.27	2895
	50	152.0							
	60	162.0	0.248			0.248	2362.0	1.10	2605

r²	0.99
r	-1.00
Fo (N)	2987
Fo (N/kg)	29.3
Sfv (N.s/m)	-561
Sfv (N.s/m/kg)	-5.50
Vo	5.33
Pmax (W)	3977
Pmax (W/kg)	39.0
Sfv opt (N.s/m/kg)	-12.5

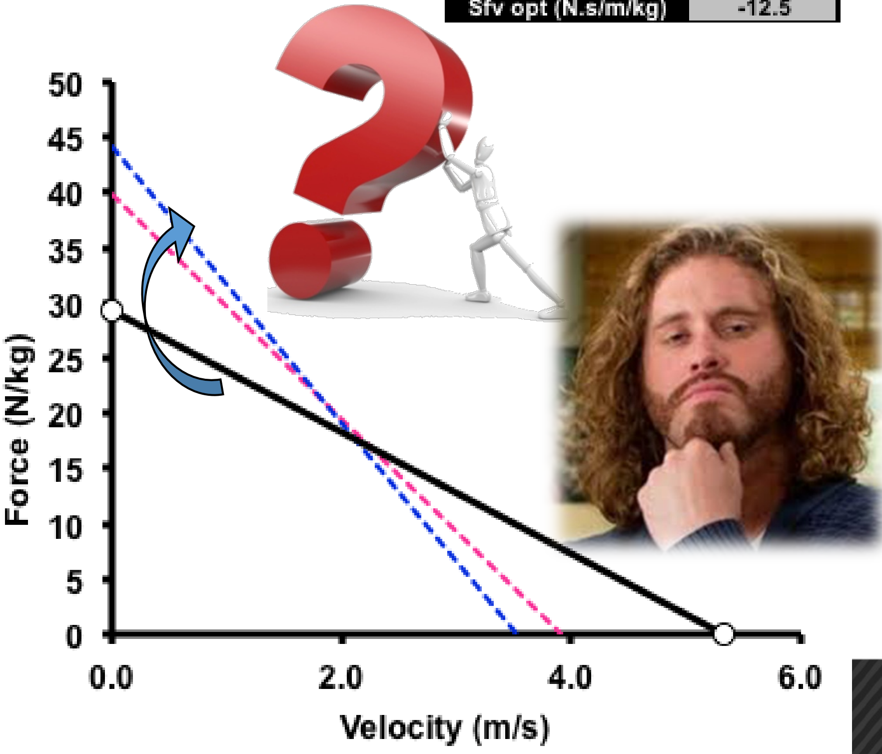
102



Fo (N/kg)	29.3
Vo	5.33
Pmax (W/kg)	39.0
Sfv (N.s/m/kg)	-5.50

F-v Profile =
54%
of the optimal
FORCE is to be developped

F-v Profile =
44%
of the optimal
FORCE is to be developped



« Optimized » Training

PILOT TRAINING STUDY

Pedro JIMENEZ-REYES
URJC, Madrid

→**9 weeks** (mistake #1)

→**OPTIMIZED (46) vs NON-OPTIMIZED (18)**

Experimental group:

22 force deficit
18 velocity deficit
6 well-balanced

frontiers in Physiology

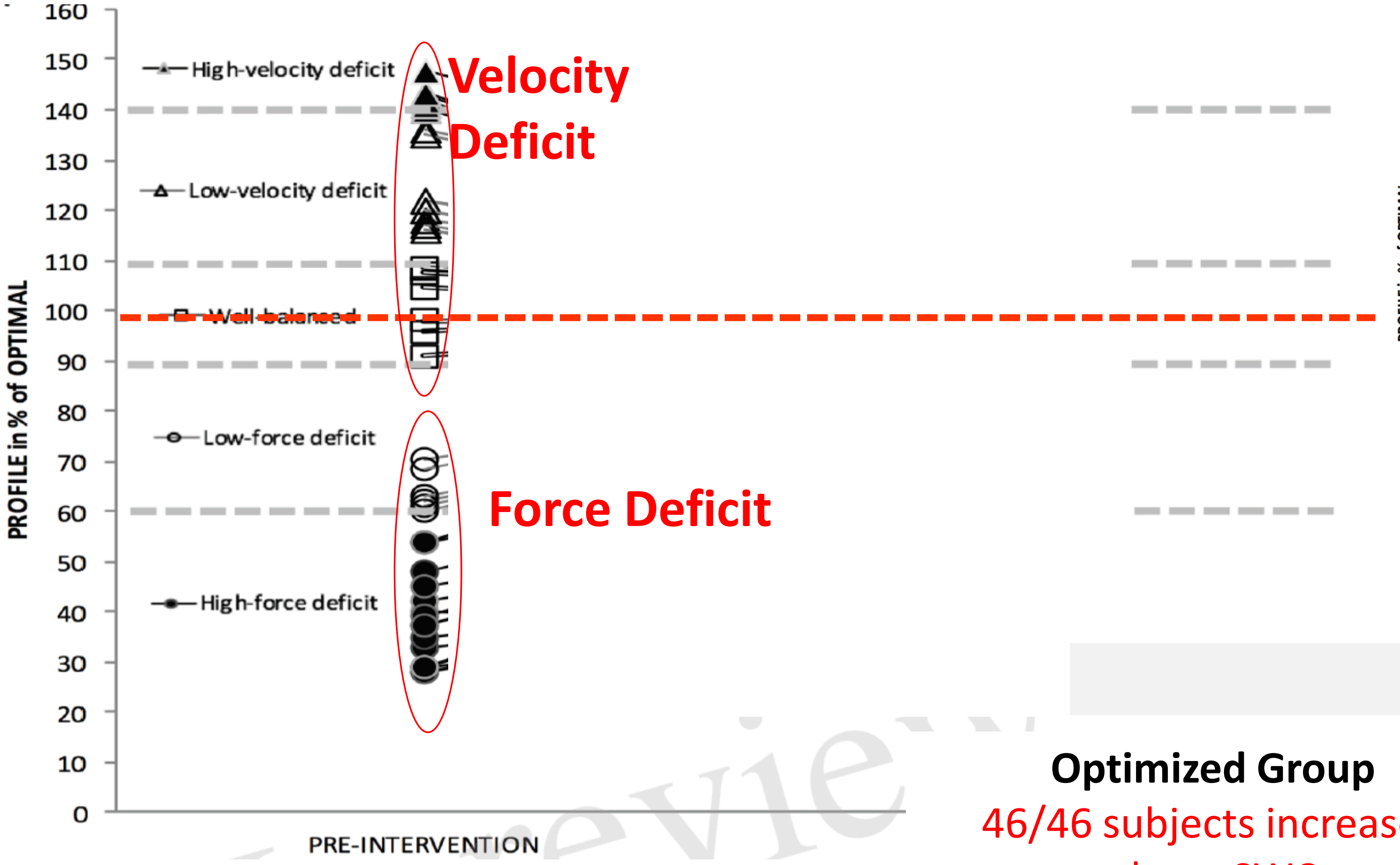
ORIGINAL RESEARCH
published: 09 January 2017
doi: 10.3389/fphys.2016.00677

Check for updates

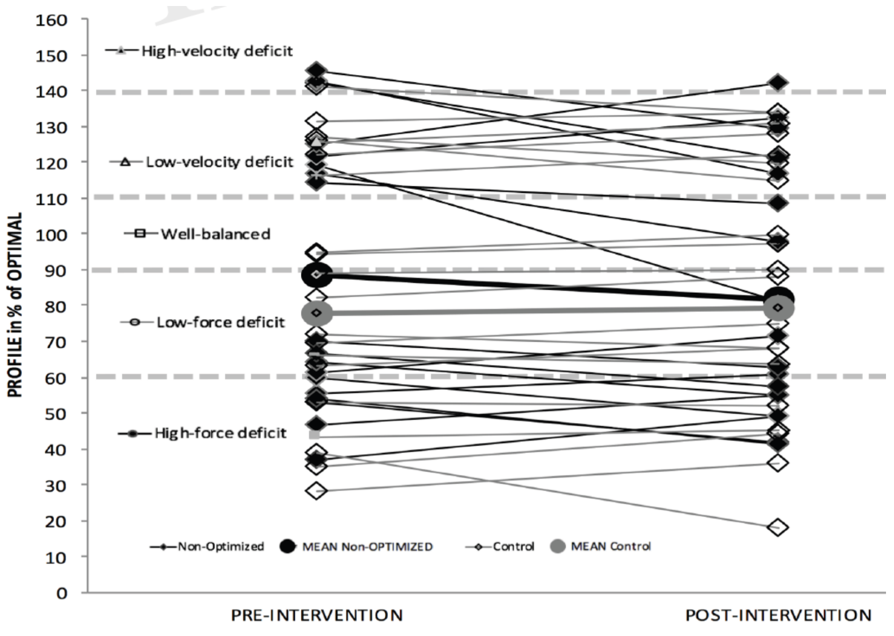
Effectiveness of an Individualized Training Based on Force-Velocity Profiling during Jumping

Pedro Jiménez-Reyes[1], Pierre Samozino[2], Matt Brughelli[3] and Jean-Benoît Morin[3,4]*

Optimized Training



NON-Optimized



JUMP HEIGHT

Optimized Group

46/46 subjects increased above SWC

12.7 ± 7.4 %

Non-Optimized Group

7/18 subjects increased above SWC

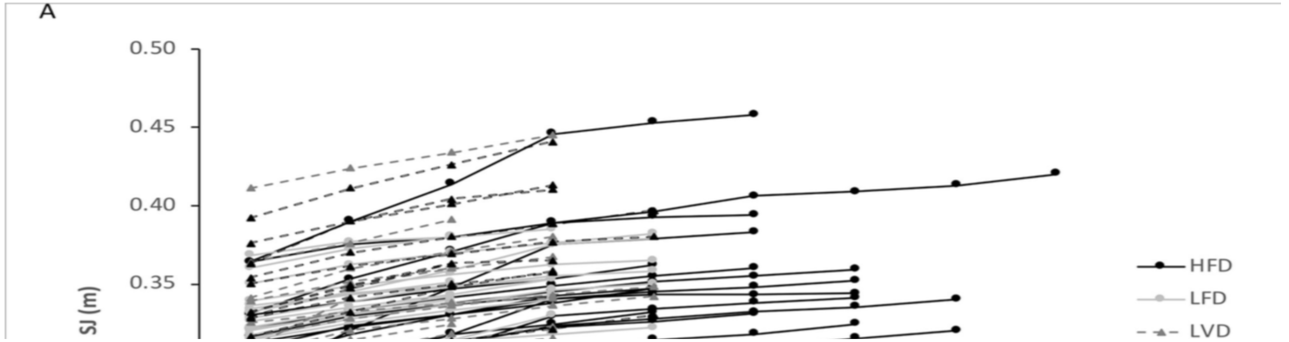
2.3 ± 4.7 %

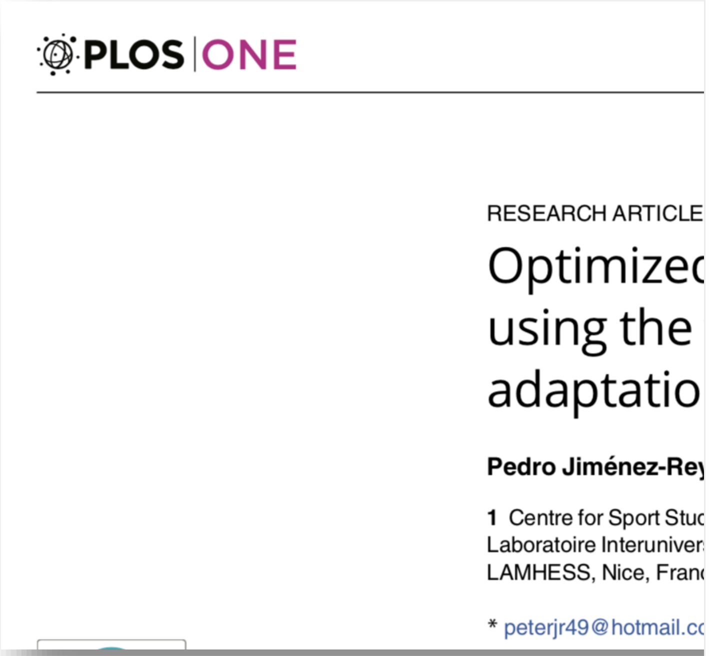
Replication - Improvement

REALLY individualized

Training and Detraining kinetics

HOT OFF THE PRESS




PLOS | ONE

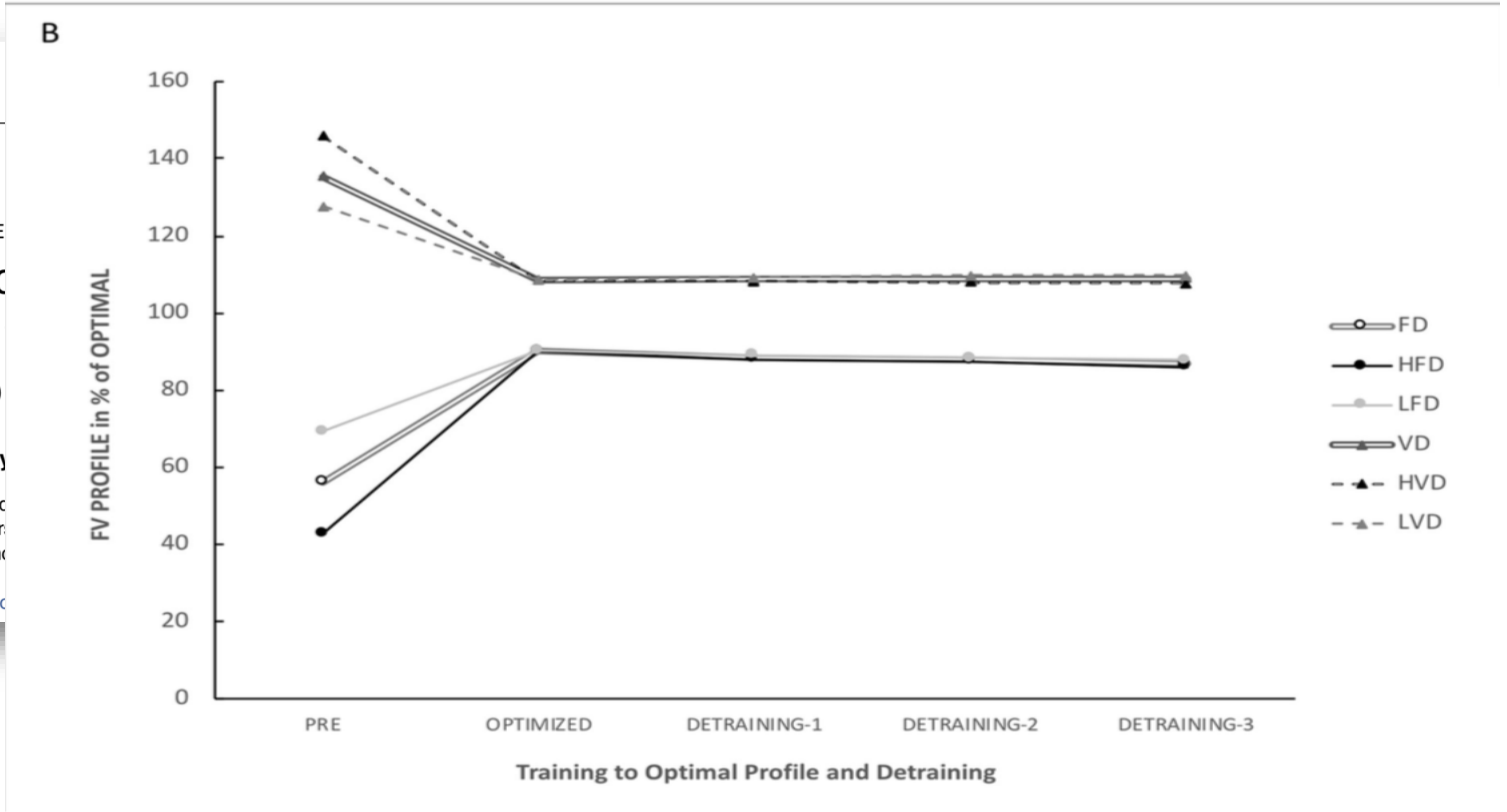
RESEARCH ARTICLE

Optimizec
using the
adaptatio

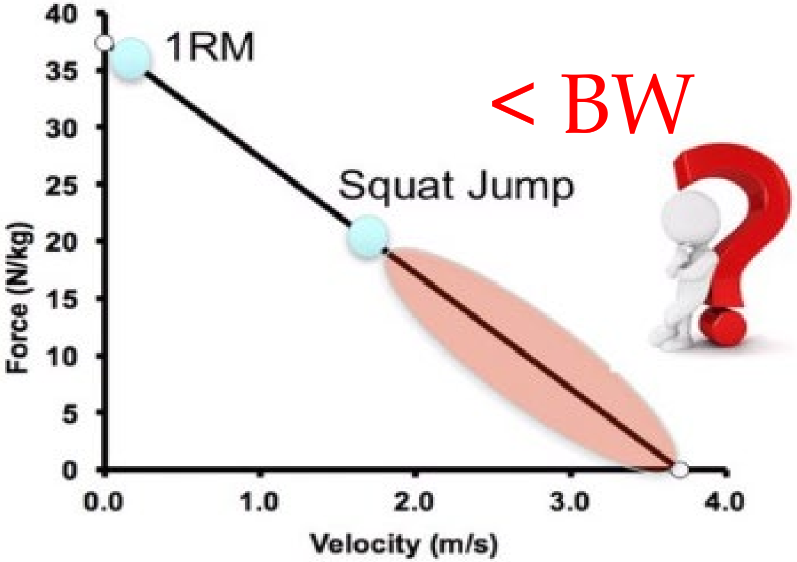
Pedro Jiménez-Rey

1 Centre for Sport Stud
Laboratoire Interunivers
LAMHESS, Nice, Franc

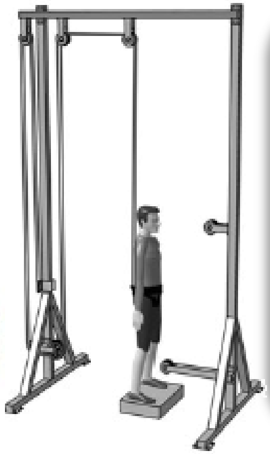
* peterjr49@hotmail.co

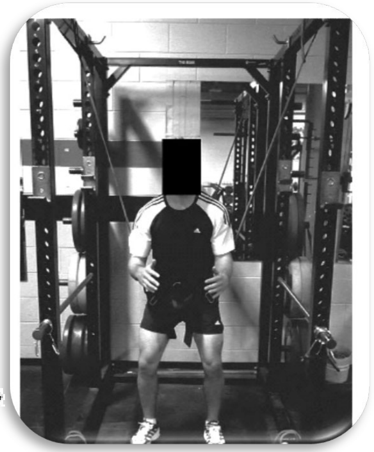


Deficit in force…ok…but how do you fix a velocity deficit?



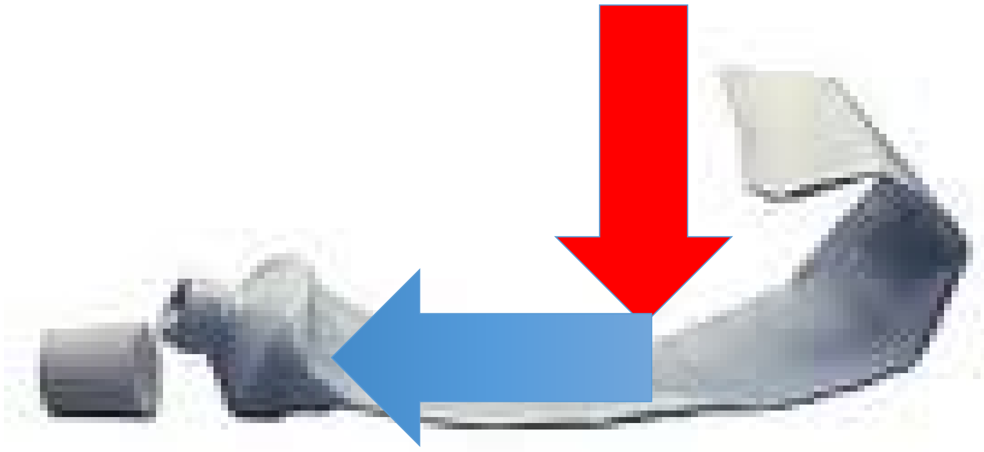
< BW





SUMMARY…

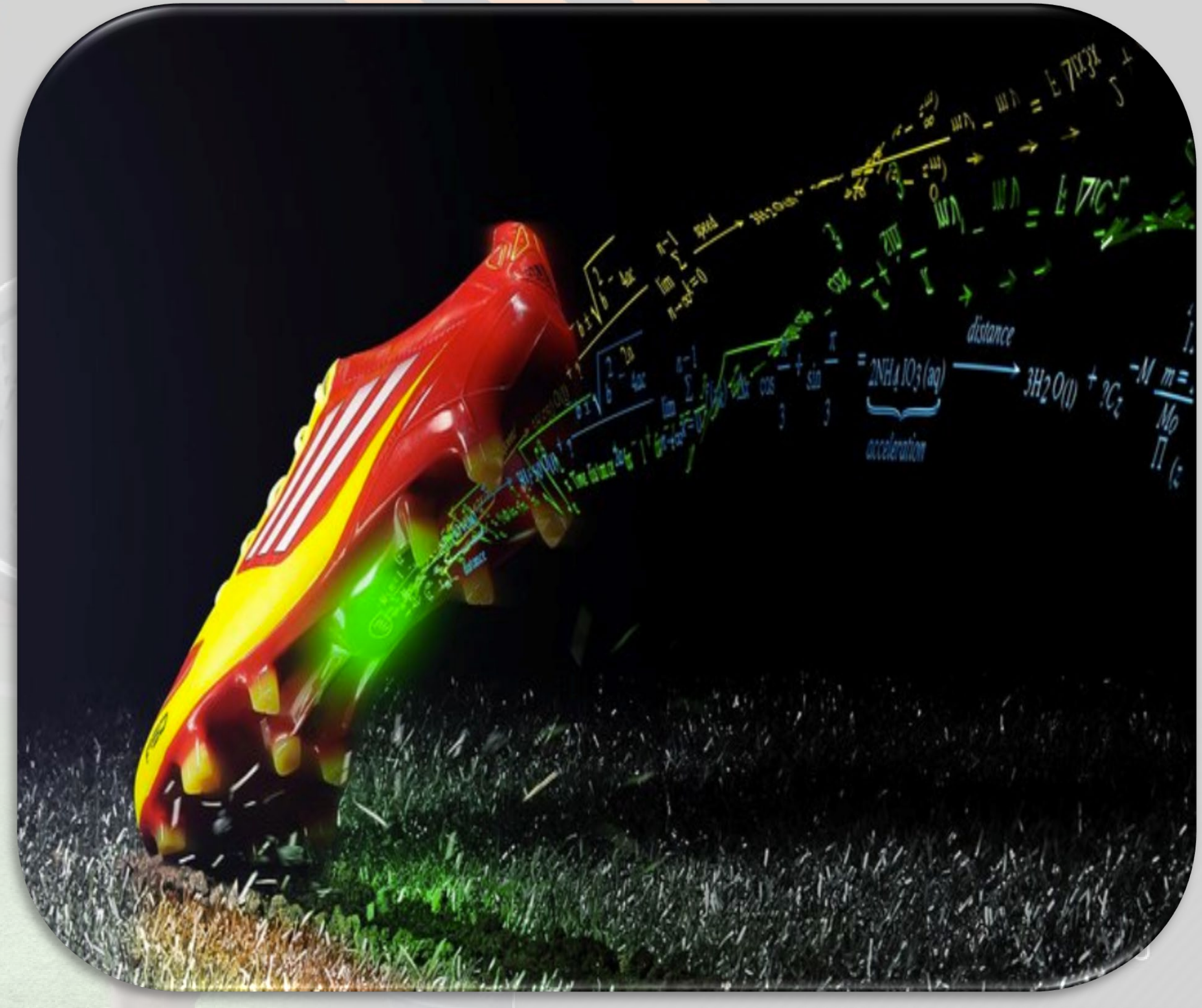
« Toothpaste Tube Theory »

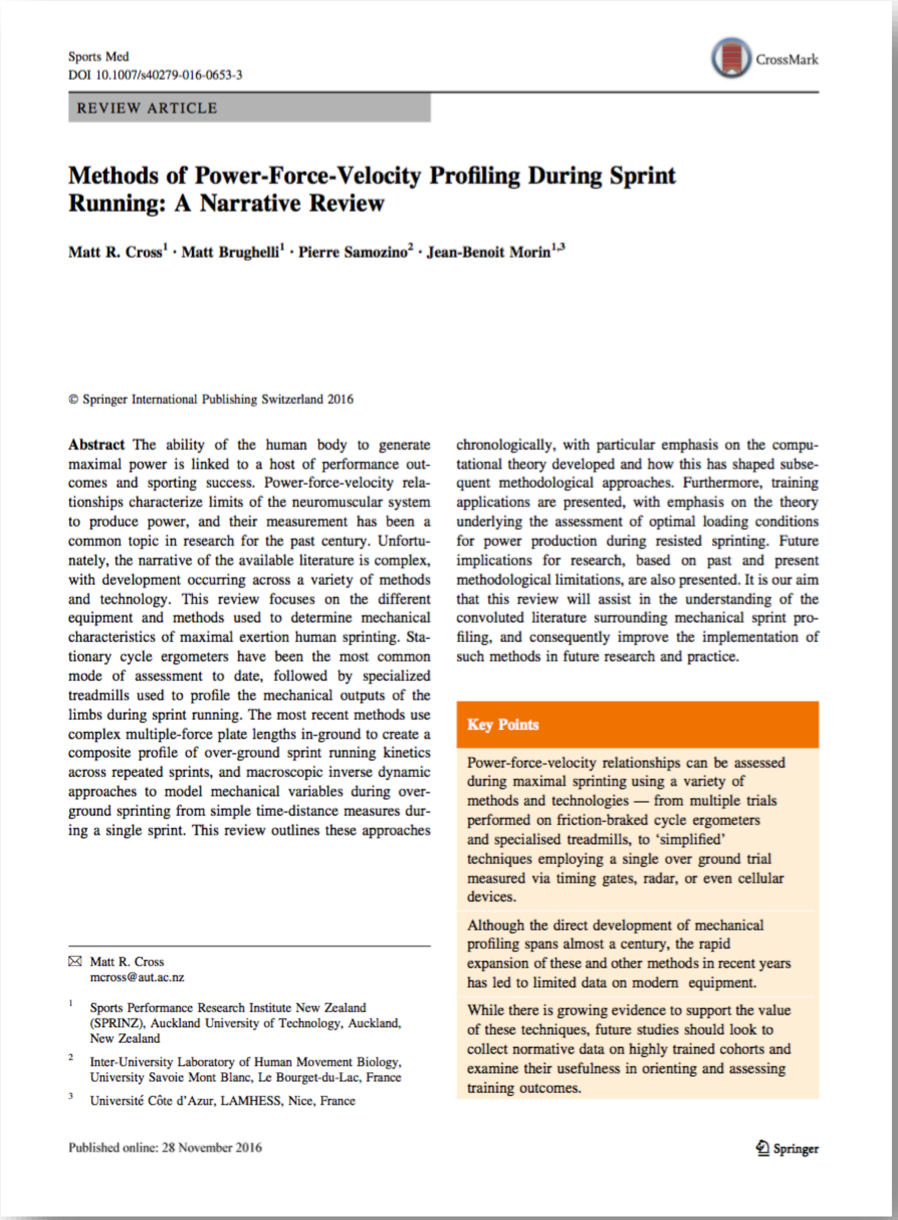


Don’t do the same better

Do something ELSE

« Horizontal » Profile





Sports Med
DOI 10.1007/s40279-016-0653-3

CrossMark

REVIEW ARTICLE

Methods of Power-Force-Velocity Profiling During Sprint Running: A Narrative Review

Matt R. Cross[1] · Matt Brughelli[1] · Pierre Samozino[2] · Jean-Benoit Morin[1,3]

© Springer International Publishing Switzerland 2016

Abstract The ability of the human body to generate maximal power is linked to a host of performance outcomes and sporting success. Power-force-velocity relationships characterize limits of the neuromuscular system to produce power, and their measurement has been a common topic in research for the past century. Unfortunately, the narrative of the available literature is complex, with development occurring across a variety of methods and technology. This review focuses on the different equipment and methods used to determine mechanical characteristics of maximal exertion human sprinting. Stationary cycle ergometers have been the most common mode of assessment to date, followed by specialized treadmills used to profile the mechanical outputs of the limbs during sprint running. The most recent methods use complex multiple-force plate lengths in-ground to create a composite profile of over-ground sprint running kinetics across repeated sprints, and macroscopic inverse dynamic approaches to model mechanical variables during over-ground sprinting from simple time-distance measures during a single sprint. This review outlines these approaches chronologically, with particular emphasis on the computational theory developed and how this has shaped subsequent methodological approaches. Furthermore, training applications are presented, with emphasis on the theory underlying the assessment of optimal loading conditions for power production during resisted sprinting. Future implications for research, based on past and present methodological limitations, are also presented. It is our aim that this review will assist in the understanding of the convoluted literature surrounding mechanical sprint profiling, and consequently improve the implementation of such methods in future research and practice.

Key Points

Power-force-velocity relationships can be assessed during maximal sprinting using a variety of methods and technologies — from multiple trials performed on friction-braked cycle ergometers and specialised treadmills, to 'simplified' techniques employing a single over ground trial measured via timing gates, radar, or even cellular devices.

Although the direct development of mechanical profiling spans almost a century, the rapid expansion of these and other methods in recent years has led to limited data on modern equipment.

While there is growing evidence to support the value of these techniques, future studies should look to collect normative data on highly trained cohorts and examine their usefulness in orienting and assessing training outcomes.

✉ Matt R. Cross
mcross@aut.ac.nz

1 Sports Performance Research Institute New Zealand (SPRINZ), Auckland University of Technology, Auckland, New Zealand

2 Inter-University Laboratory of Human Movement Biology, University Savoie Mont Blanc, Le Bourget-du-Lac, France

3 Université Côte d'Azur, LAMHESS, Nice, France

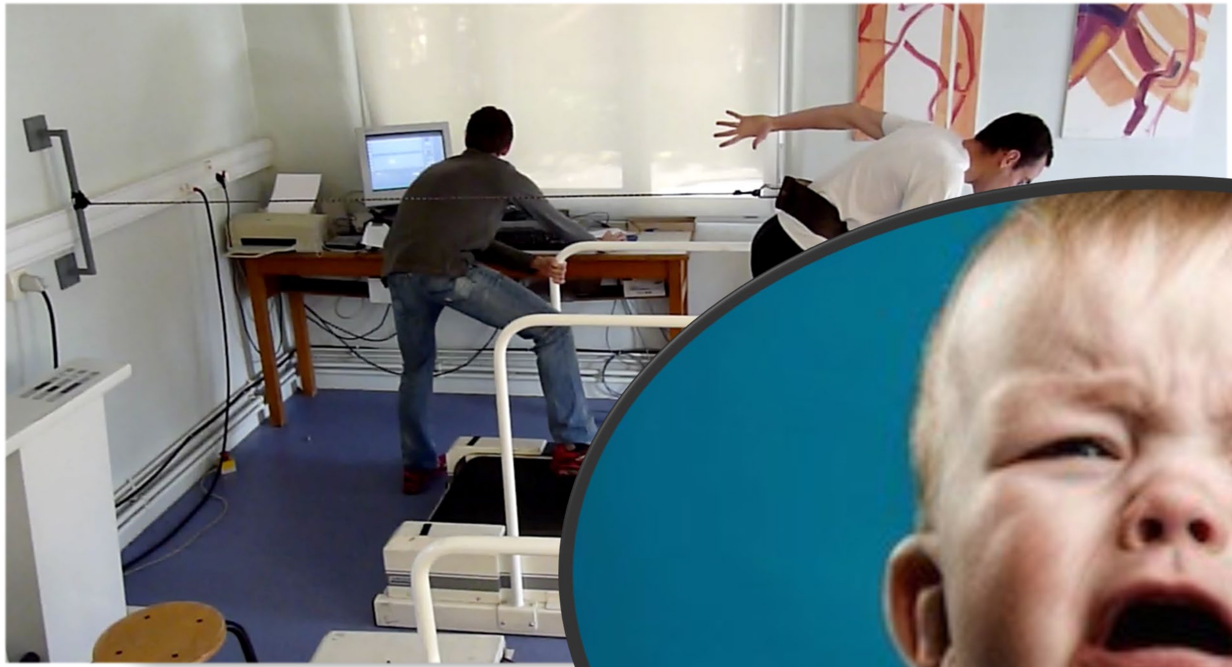
Published online: 28 November 2016

Springer

Matt Cross
(Univ Savoie & Nice
AUT, Auckland)
@MattCrossNZ

1 second....10 to 12-m

Two (im)possibilities



INSTRUMENTED SPRINT

St-Etienne, France

Doha, Qatar

FORCE PLATES

INSEP, Paris, France (7m)

Kanoya, Japan (50m+)

OK, How can we do with field devices??

2016: P. Samozino

Scand J Med Sci Sports 2015: ••: ••–••
doi: 10.1111/sms.12490

SCANDINAVIAN JOURNAL OF MEDICINE & SCIENCE IN SPORTS

A simple method for measuring power, force, velocity properties, and mechanical effectiveness in sprint running

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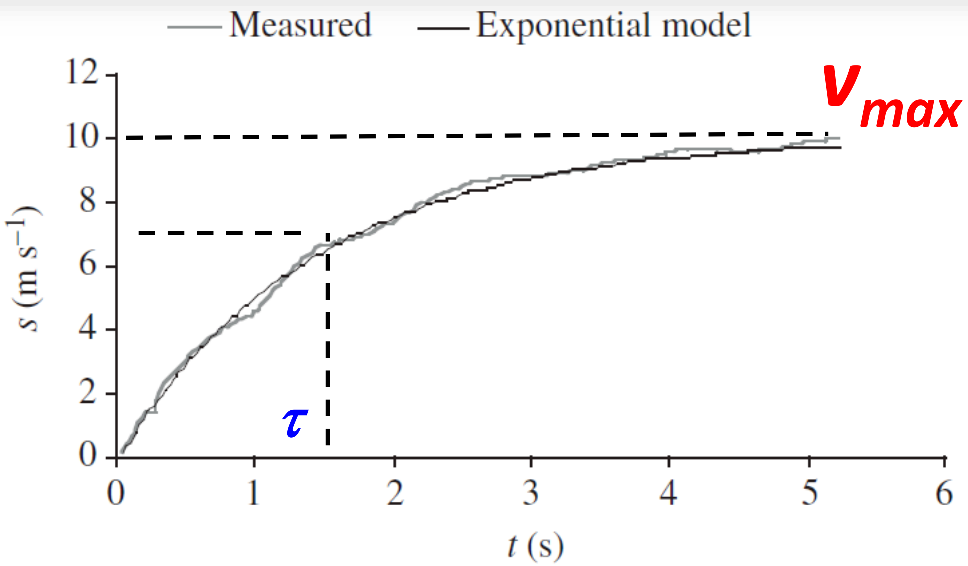
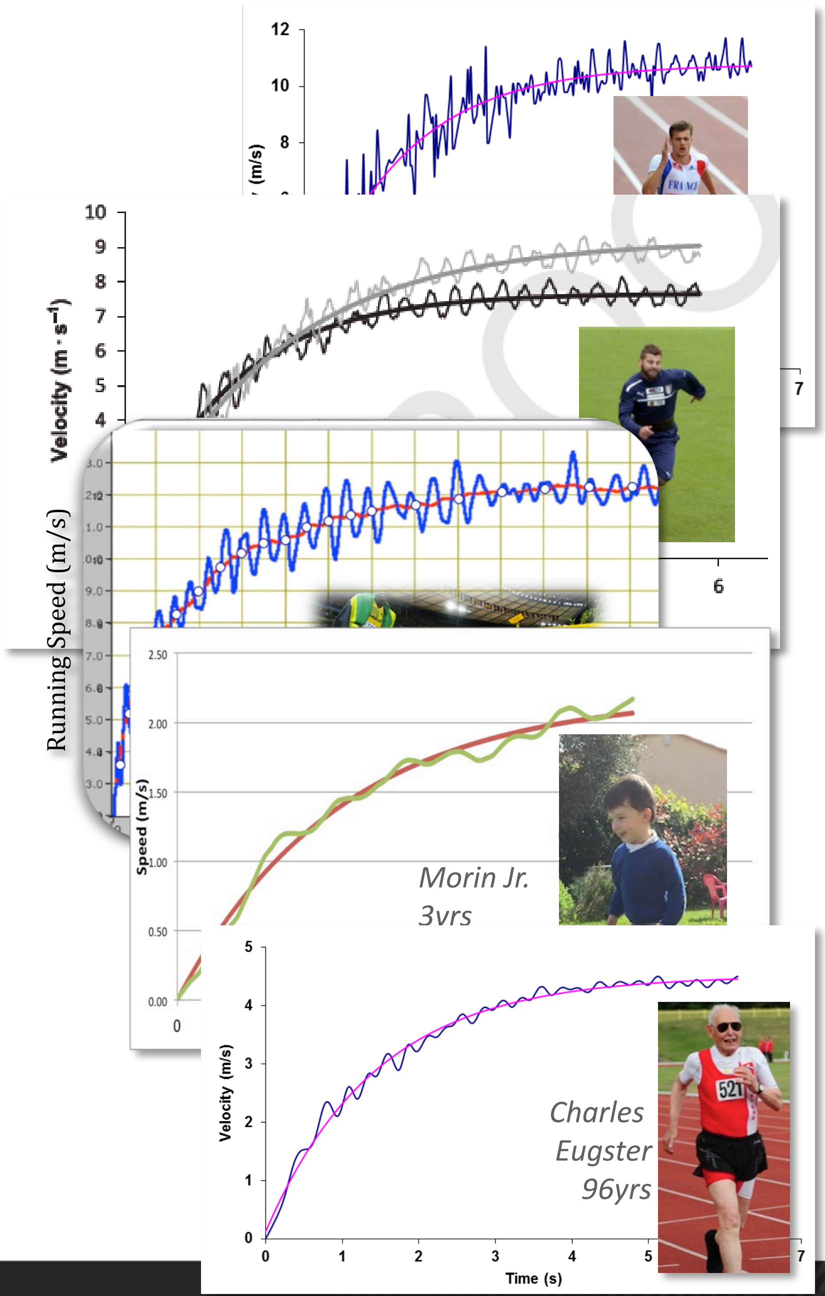


$$v(t) = v_{max}.(1-e^{(-t/\tau)})$$



2016 and 2019: Validation against force plates

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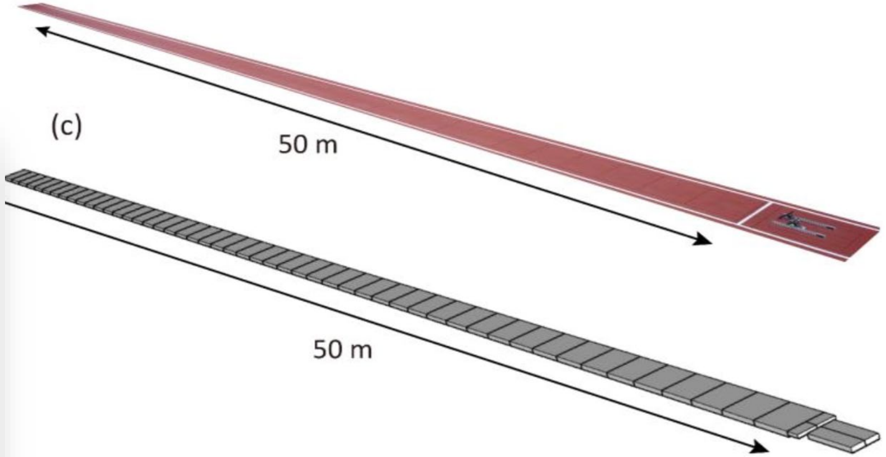
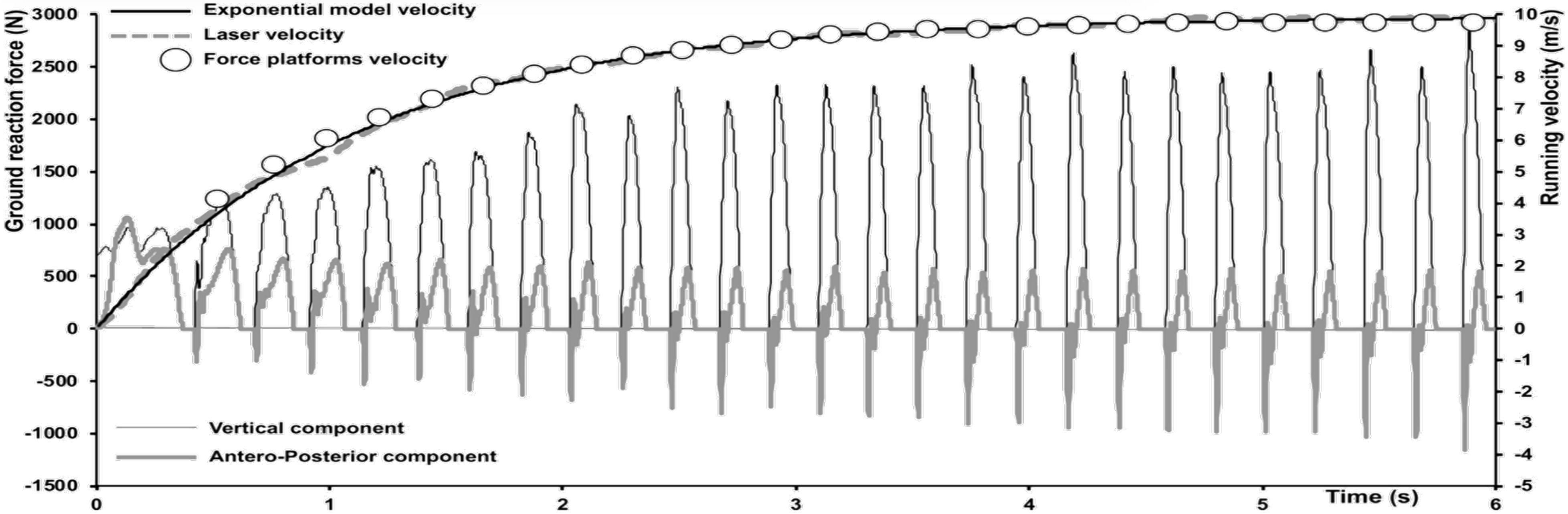
www.JBiomech.com

ELSEVIER

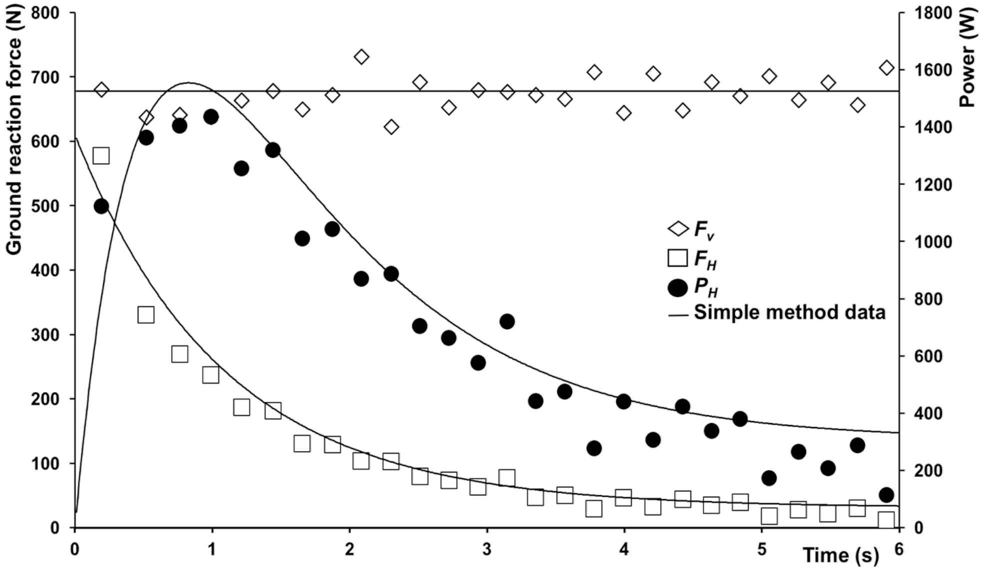
A simple method for computing sprint acceleration kinetics from running velocity data: Replication study with improved design

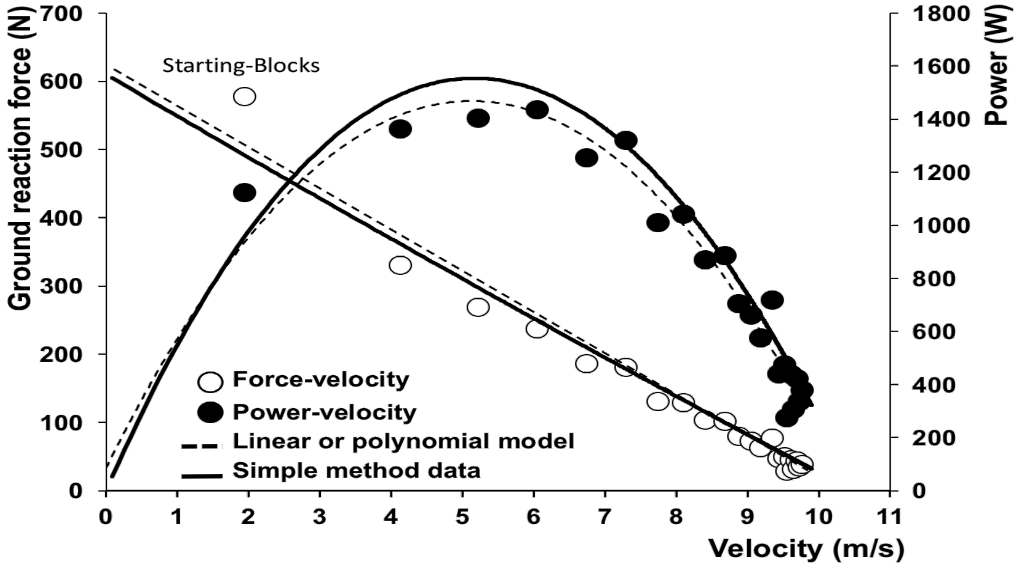
Jean-Benoit Morin [a,d,*], Pierre Samozino [b], Munenori Murata [c], Matt R Cross [b,d], Ryu Nagahara [c]





2016 and 2019: Validation against force plates





- Simple inputs (body mass, running velocity)
- High reliability
- In practice…1 acceleration up to Vmax

SIMPLER THAN SIMPLE…

2016: P. Jiménez-Reyes

Pedro JIMENEZ-REYES
URJC, Madrid

Iphone / i

240 fram

European Journal of Sport Scie
http://dx.doi.org/10.1080/174

ORIGINAL ARTICLE

Sprint performance
app: Comparison wi

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Catholic University of San Antonio, M
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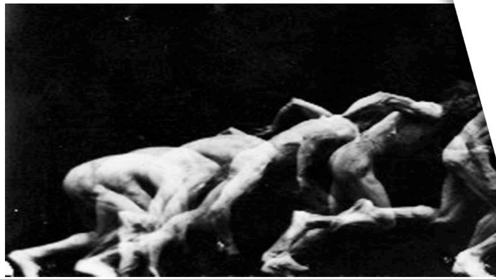
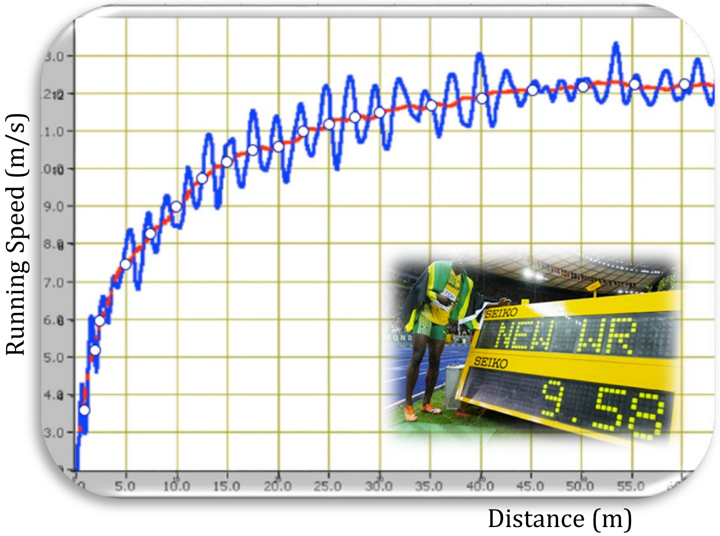
Madrid, Spain

EJ Marey, 1885, 2

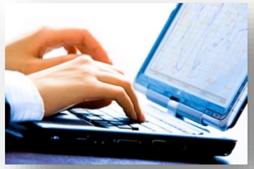


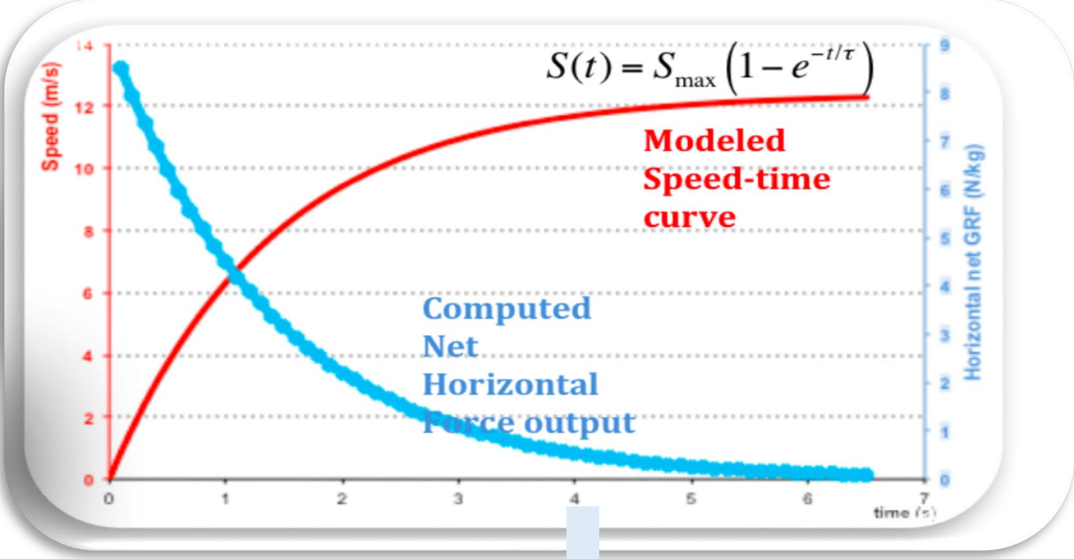
FORCE-VELOCITY-POWER outputs of Usain Bolt's World Record



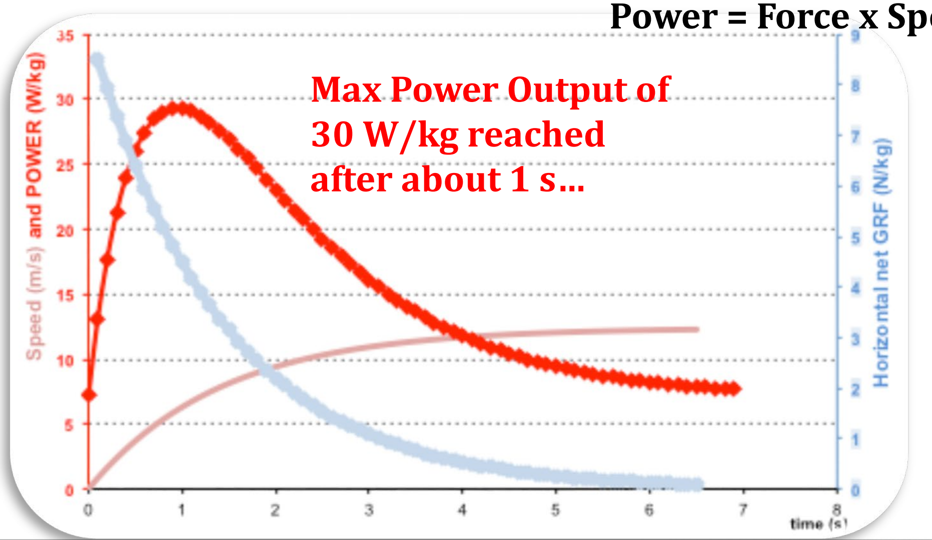
Field Measurements In competition conditions

Computing

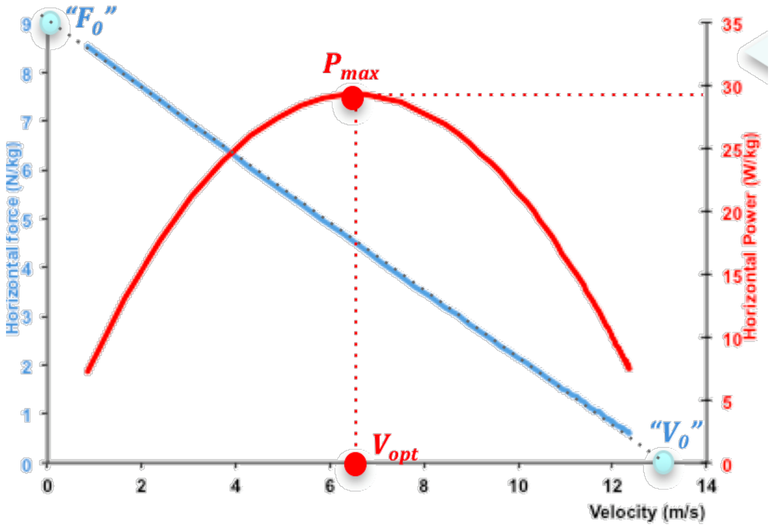




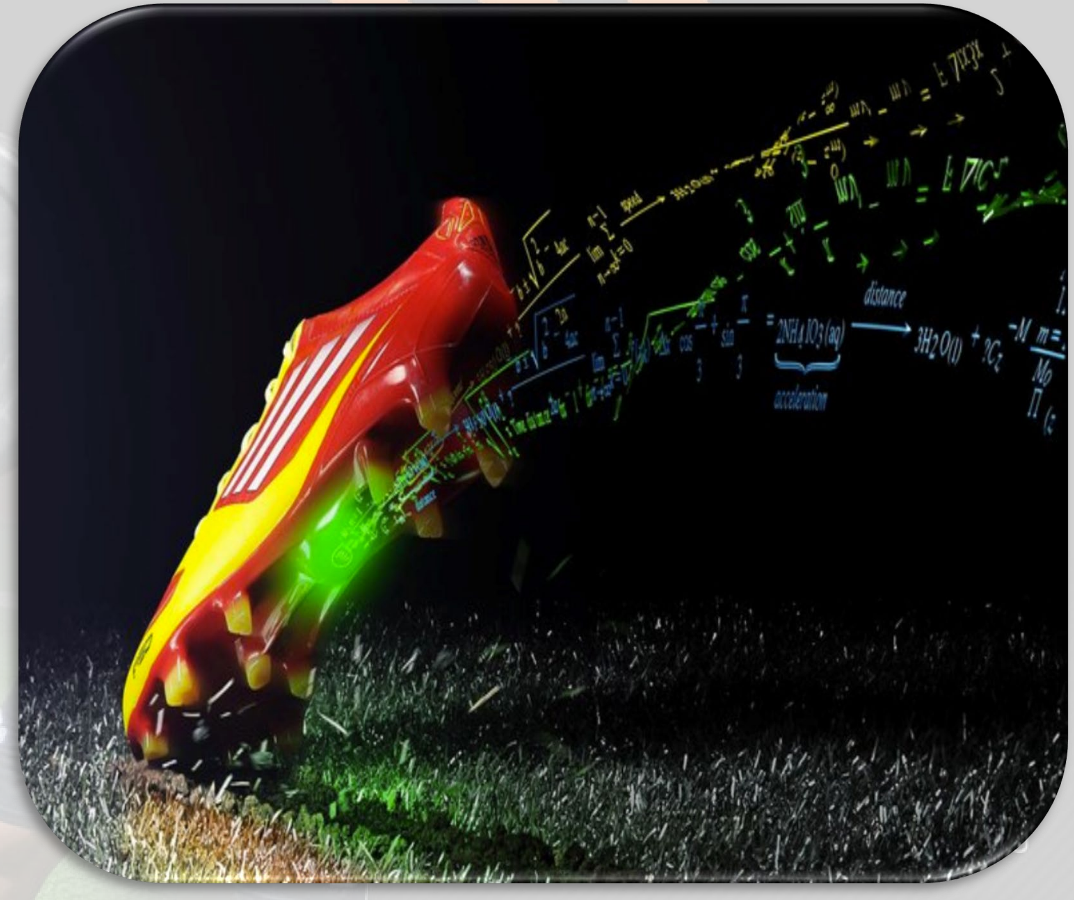
Power = Force x Speed…



<u>Specific, Field Sprint</u> Force-Velocity-Power profile



Applications: Training



TYPICAL EXAMPLE:
Player is « slow »……but has high velocity capabilities !

40-m test : **6.21** vs **6.37** s

FFF - CEPP Novembre 2012

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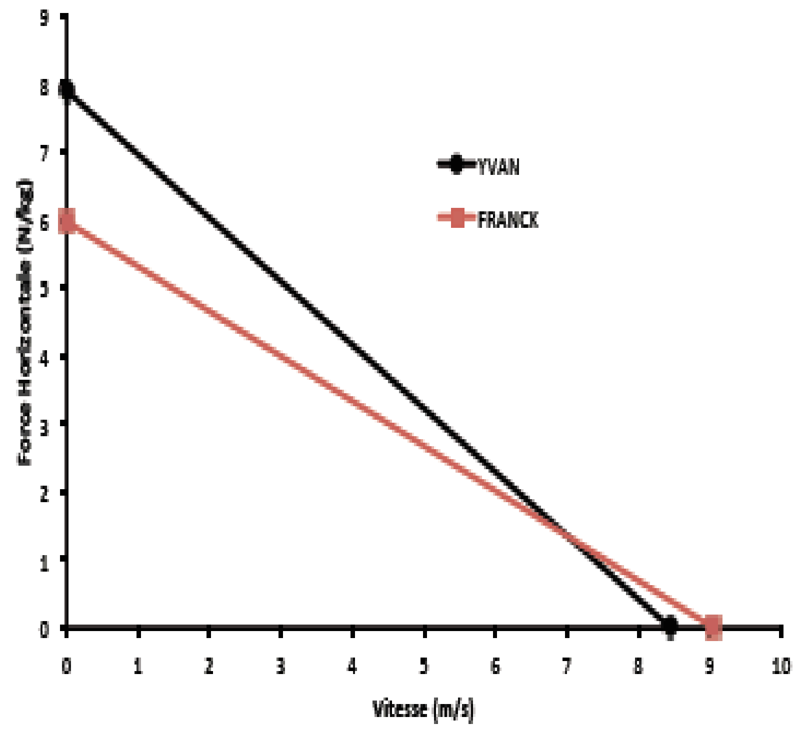
Qualités physiques évaluées lors du 60m sans charge

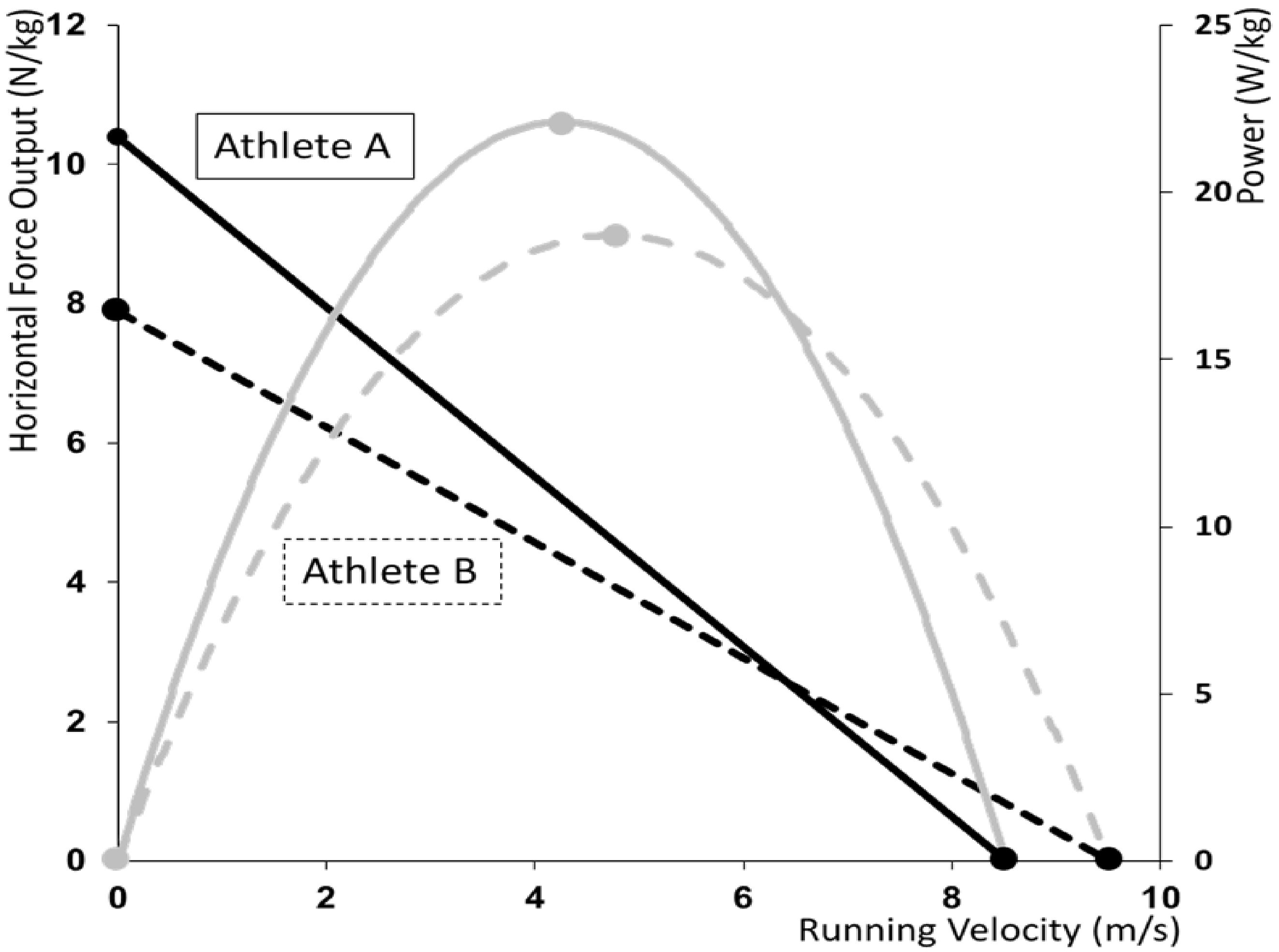
	Masse (kg)	Vmax théorique (m/s)	Fmax théorique (N)	Fmax théorique (N/kg)	Pmax (W)	Pmax (W/kg)	Profil F-v	Temps à 40 m (s)	Vmax mesurée (m/s)
YVAN	68	8.5	536	7.88	1125	16.5	-63.5	6.21	8.18
FRANCK	71	9.1	424	5.97	950	13.4	-46.9	6.37	8.64

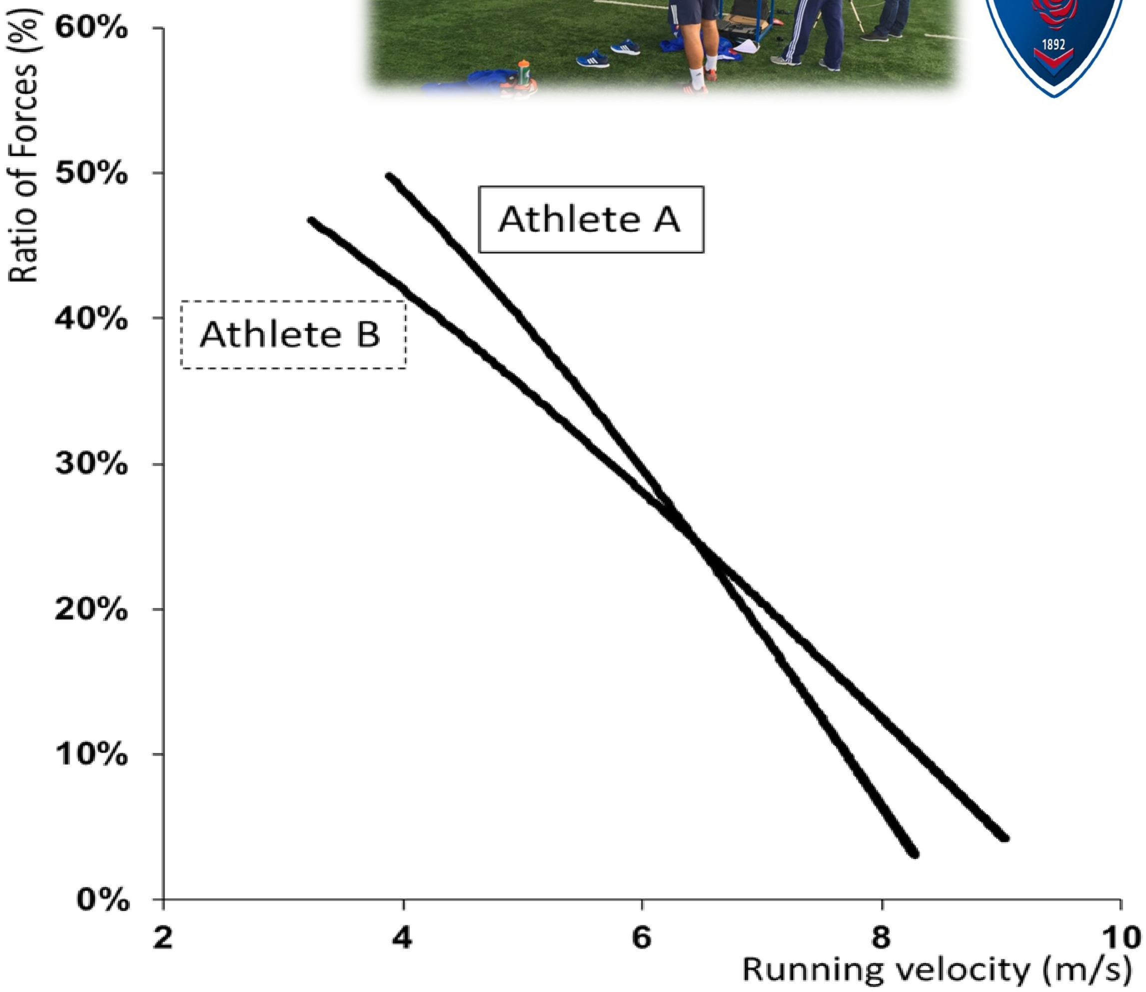
[redacted]



Example: Elite Rugby Union Team Follow-up

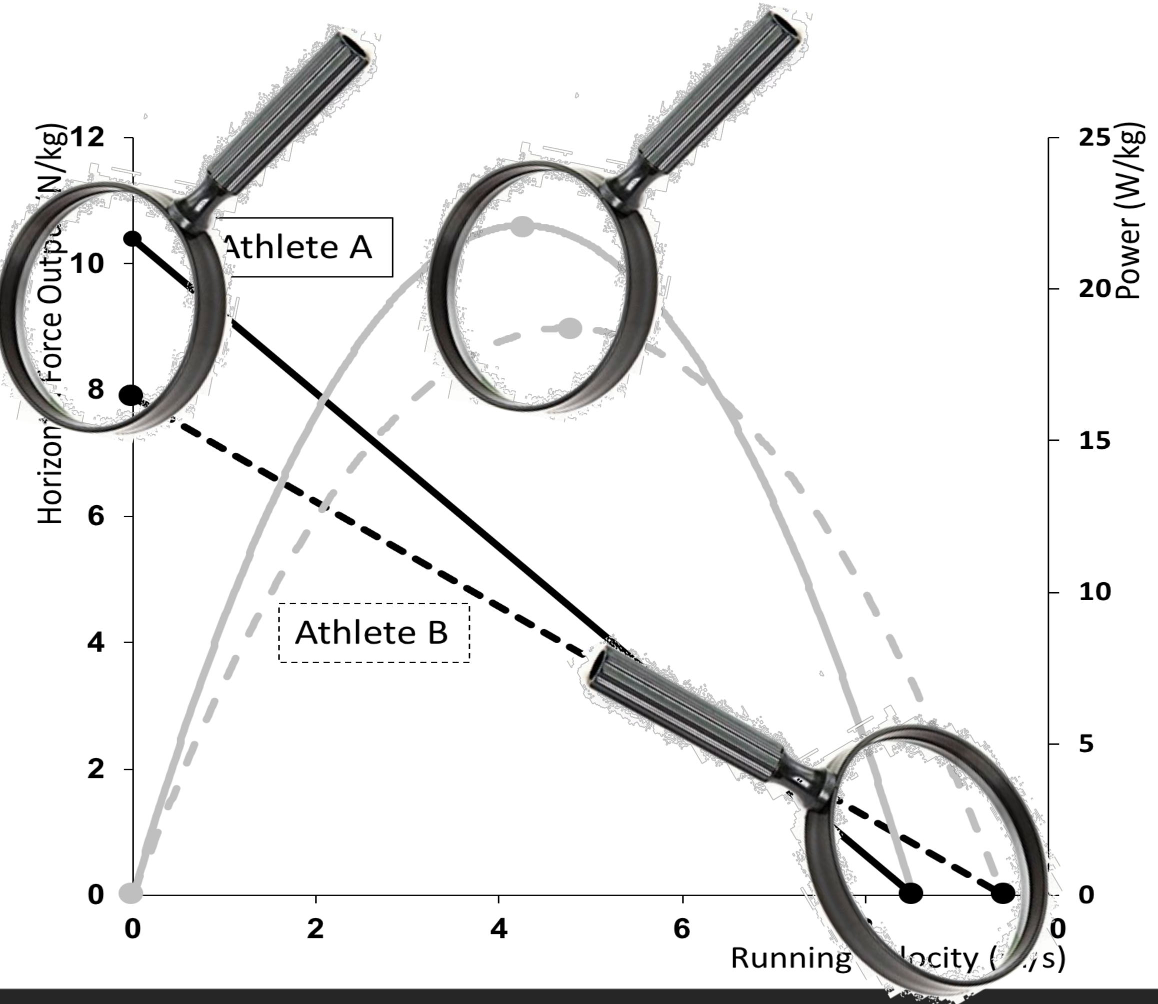
Same 30-m time, very different FVP profiles…

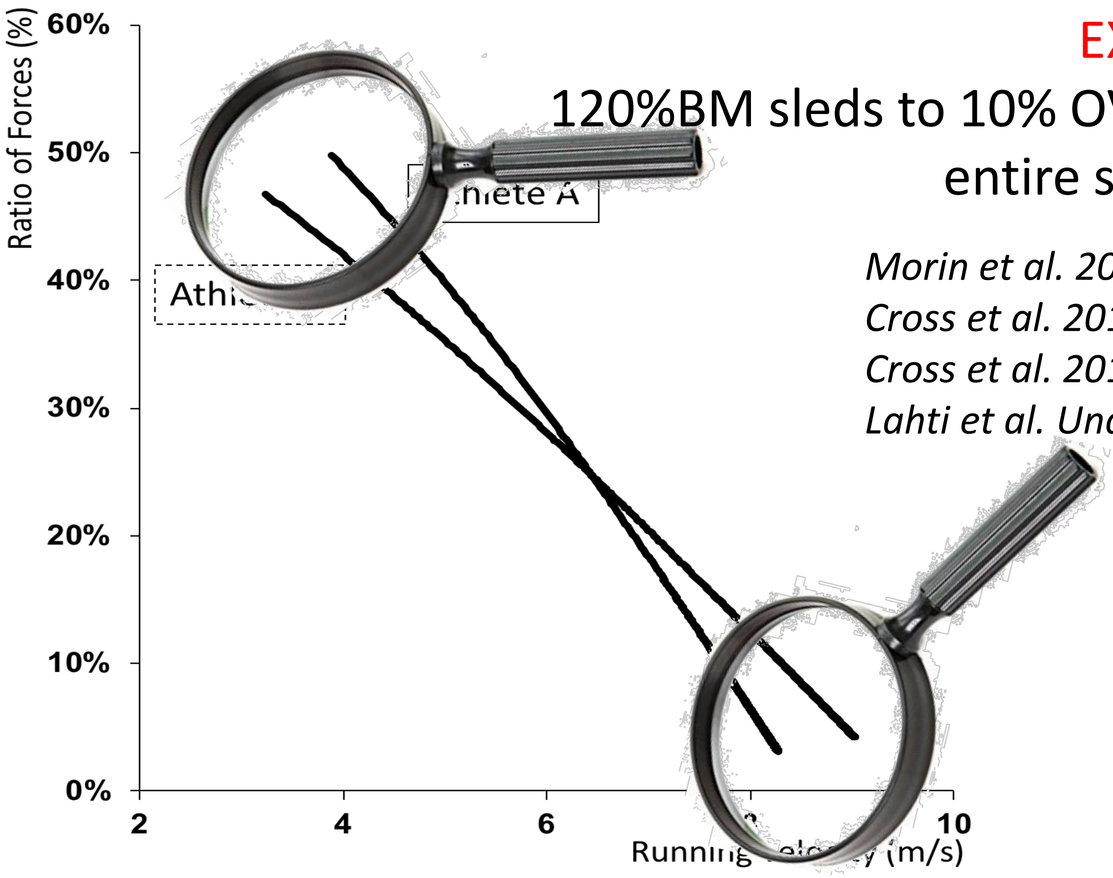




Towards Individualized Sprint Training…

What training input(s) for what component(s) of the FV spectrum?





EXPLORING

120%BM sleds to 10% OVERSPEED entire spectrum !

Morin et al. 2017 IJSPP
Cross et al. 2018 IJSPP
Cross et al. 2019 PLoS One
Lahti et al. Under review

Applications: Injury Management

PREPARE & REPAIR

Season follow-up…

Physical qualities evaluated during the acceleration						Mechanical effectiveness			Performa		
Vmax theoretical V0 (m/s)	Fmax theoretical F0 (N)	Fmax theoretical F0 (N/kg)	Pmax (W)	Max Horizontal Power Pmax (W/kg)	Force-Velocity profile	mean RF on 10m	RFpeak	DRF	Time @ 5 m (s)	Time @ 10 m (s)	Time @ 20 m (s)
9.38	673	6.68	1566	15.5	-71.8	29%	48%	-0.065	1.42	2.15	3.43
8.79	787	7.81	1717	17.0	-89.5	30%	54%	-0.079	1.34	2.07	3.35
9.42	731	6.44	1707	15.1	-77.6	29%	48%	-0.062	1.44	2.18	3.46
9.32	761	6.71	1762	15.5	-81.7	28%	48%	-0.065	1.41	2.18	3.42
8.86	645	7.17	1419	15.8	-72.9	28%	50%	-0.073	1.40	2.13	3.44
8.90	669	7.43	1478	16.4	-75.2	30%	53%	-0.074	1.35	2.12	3.40
8.04	790	6.38	1579	12.7	-98.3	25%	48%	-0.072	1.48	2.31	
9.34	733	7.65	1700	17.7	-78.5	30%	52%	-0.073	1.34	2.07	3.29
8.19	834	8.45	1697	17.2	-101.8	28%	54%	-0.092	1.31	2.08	3.39
8.30	517	5.47	1065	11.3	-62.3	22%	38%	-0.062	1.57	2.40	3.84
9.33	590	7.48	1365	17.3	-63.2	29%	49%	-0.073	1.37	2.07	3.32
9.46	568	7.20	1333	16.9	-60.1	29%	47%	-0.069	1.38	2.11	3.36
8.91	673	7.38	1488	16.3	-75.5	27%	47%	-0.076	1.37	2.11	3.39
8.70	694	7.80	1502	16.9	-79.8	27%	48%	-0.081	1.34	2.08	3.39
9.35	613	6.89	1425	16.0	-65.6	29%	49%	-0.066	1.40	2.14	
8.49	815	7.53	1720	15.9	-96.0	26%	47%	-0.081	1.36	2.13	3.44
8.69	785	8.63	1694	18.6	-90.3	29%	53%	-0.089	1.31	2.01	3.29
8.66	828	9.11	1782	19.6	-95.6	30%	58%	-0.092	1.26	1.99	3.24
9.10	778	7.56	1756	17.1	-85.5	30%	53%	-0.074	1.34	2.08	3.36
9.04	814	7.91	1828	17.8	-90.0	30%	53%	-0.078	1.33	2.07	3.31
8.69	758	8.43	1635	18.2	-87.2	28%	49%	-0.088	1.29	2.03	3.31
8.77	755	8.39	1642	18.3	-86.1	30%	56%	-0.085	1.31	2.05	3.30
9.14	567	5.81	1287	13.2	-62.1	25%	39%	-0.059	1.52	2.32	3.63
10.15	621	6.75	1562	17.0	-61.2	31%	50%	-0.060	1.39	2.12	3.34
8.60	585	6.44	1247	13.7	-68.0	27%	48%	-0.068	1.46	2.26	3.60
8.41	665	7.33	1390	15.3	-79.2	27%	51%	-0.079	1.40	2.17	3.48
9.18	650	6.64	1482	15.1	-70.8	29%	49%	-0.065	1.43	2.20	3.48
8.99	682	7.40	1522	16.5	-75.9	30%	53%	-0.074	1.36	2.13	3.37
9.14	714	7.75	1621	17.6	-78.2	30%	52%	-0.076	1.33	2.07	3.32
8.59	796	7.32	1699	15.6	-92.7	28%	50%	-0.077	1.40	2.14	3.45
8.81	718	6.60	1572	14.4	-81.5	27%	46%	-0.068	1.46	2.22	3.54
9.92	550	6.39	1352	15.7	-55.4	31%	50%	-0.058	1.44	2.18	3.43
9.14	586	6.17	1330	14.0	-64.1	27%	46%	-0.061	1.48	2.24	3.56
8.96	695	7.25	1543	16.1	-78.0	28%	49%	-0.073	1.39	2.14	3.42
0.46	91	0.84	181	1.8	12.4	2%	4%	0.01	0.07	0.09	0.12
5%	13%	12%	12%	11%	16%	6%	8%	13%	5%	4%	4%
8.04	517	5.47	1065	11.3	-101.8	22%	38%	-0.09	1.26	1.99	3.24
10.15	834	9.11	1828	19.6	-55.4	31%	58%	-0.06	1.57	2.40	3.84

Primary prevention & Training Content Management

Review

Sports-related workload and injury risk: simply knowing the risks will not prevent injuries

Michael K Drew,[1,2] Jill Cook,[2,3] Caroline F Finch[2]

ABSTRACT
Training loads contribute to sports injury risk but their mitigation has rarely been considered in a sports injury prevention framework. A key concept behind monitoring

prevention framework. A key concept behind monitoring training loads for injury prevention is to screen for those at increased risk of injury so that workloads can be adjusted to minimise these risks. This review describes

rehabilitation practices that include a graded return to training programme to reduce the risk of sustaining a subsequent injury. The association of training loads with injury incidence is now established. Prevention measures such as rule changes that affect the workload of an athlete are universal whereas those that address risk factors of an asymptomatic subgroup are more selective. Prevention measures, when implemented for asymptomatic individuals exhibiting possible injury risk factors, are indicated for an athlete at risk of developing a sports injury. Seven key indicated risks and associated prevention measures are proposed.

history of previous injuries sustained. Preseason hamstring strength testing with the Nordic hamstring test[4] followed by an eccentric strengthening programme for athletes with lower strength is one

start of the training programme. An increase from two to three sessions a week to daily or twice daily (as is common in these training programmes and club situations) poses a large risk of injury to the athlete. However, simple measures to control this risk are feasible.

High performance training camps also pose significant risks of injury. In judo, camp injury rates have been as high as 83%,[6] and it has been suggested that these may be due to factors such as new techniques, higher intensity and scrutiny of coaching, or (micro) trauma from training. In this judo example, the average week-to-week increase in time

Return to sport …or return to (sprint) Performance

TABLE 2. Rehabilitation and RTS algorithm program for hamstring injury.

	REGENERATION PHASE	FUNCTIONAL PHASE	
Manual Therapy	Manual therapy: - Plantar fascia, gastrocnemius and hamstring (avoiding injury site) massage - Lumbar Z-joint mobilization - Sliding Neural Mobilization (3 x 12 reps) NMES	Manual therapy: - Plantar fascia, gastrocnemius and hamstring (injury site included) massage - Lumbar Z-joint mobilization	1. 2. 3
Flexibility	Psoas static flexibility with pelvic retroversion (4 x 15 sec) Quadriceps dynamic mobility (2 x 8 reps) Hamstring dynamic mobility with fitball (2 x 8 reps) Hamstring dynamic mobility supine (2 patterns) (2 x 8 reps)	Hamstring dynamic mobility + contralateral psoas flexibility (2 x 5 reps) Hamstring wall flexibility (Push/Pull) (3 x 3 reps)	2. 3
Gluteus	**Gluteus Maximus** (Choose an option daily as pain tolerated): **Option A** Prone hip extension (2 x 10 reps x 3 sec) Single leg bridge + contralateral kick (as tolerated) (2 x 5 reps x 3 sec) Double leg bridge (50% BW; 3 x 6 reps x 3 sec) **Option B** Hip thrust (40% BW; 3 x 6 reps x 3 sec) Single leg bridge + contralateral kick (as tolerated) (10% BW; 2 x 4 reps x 3 sec) Single leg hip thrust + contralateral kick (as tolerated) (3 x 6 reps x 3 sec) **Gluteus Medius:** Clamshell with band (3 x 6 reps x 3 sec) Side lying hip abduction with band (3 x 6 reps x 3 sec)	**Gluteus Maximus** (Choose an option): **Option A** Single leg hip thrust (10% BW; 3 x 4 reps x 3 sec) Double leg hip thrust (60% BW; 3 x 8 reps x 3 sec) Walking sled push (75% BW; 15 m x 2 reps) **Option B** Single-leg foot and shoulder elevated hip thrust + contralateral kick (2 x 4 reps x 3 sec) Single leg back extension + perturbations (2 x 4 reps) Swing leg hip extension + contralateral hip flexion (2 x 3 changes) **Gluteus Medius:** Side step running with band (5 m x 5 go and back) Monster running with band (5 m x 5 go and back)	2
Hamstring strength	Prone isometrics (mid and long length) (2 x 5 reps x 5 sec) Standing long length isometrics (2 x 5 reps x 5 sec) Supine isometrics (tolerated degrees) (2 x 5 reps x 3 sec) Submaximal eccentric manual resistance in prone (intensity as tolerated) (2 x 8 reps)	(4 Hamstring strength exercises per session selecting 2 hip dominant and 2 knee dominant) **HIP dominant** Double leg deadlift with 4 kg medicine Ball (2 x 8 reps) Lunge (15% BW; 2 x 6 reps) Single leg deadlift with 15kg + step up (2 x 6 reps) **KNEE dominant** Double leg slide curl (2 x 6 reps) Nordic hamstring (2 x 4 reps) Sprinter eccentric leg curl (2 x 6 reps)	2
Plyometrics		Double leg hurdle hop with trunk flexion (2 x 4 reps) Double broad jump with 5 kg (2 x 4 reps) 2 consecutive explosive scissor jumps (3 times) Single leg horizontal jump (2 x 3 reps)	2
Ankle stabilizers	Double leg hamstring / gastrocnemius disassociation drill (3 x 6 reps) Single leg hamstring / gastrocnemius disassociation drill (2 x 6 reps) Step bounding side to side (25% BW; 2 x 10 reps)	Ankle drill 1 (20% BW; 10 m x 4 reps) Ankle drill 2 (20% BW; 10 m x 4 reps)	2
Lumbopelvic control	Side bridge feet in bench + perturbation (2 x 5 reps x 5 sec) Birdog (2 x 5 reps x 5 sec) Long lever posterior pelvic plank (2 x 4 reps x 5 sec) Leg scissors arms on the floor (2 x 5 reps x 5 sec)	Stir the pot with fitball (3 x 2 reps) Leg Scissors arms on the chest (2 x 5 reps x 5 sec) Single-leg stand rotating reaches 4 kg (2 x 6 reps) TRX helicopter (2 x 4 reps) Sprinter push/pull with pulleys (2 x 6 reps)	2. 3
Running technique	**Frontal plane** running drills Low- to moderate-intensity sidestepping (10 m x 5 reps) Low- to moderate-intensity grapevine stepping (10 m x 5 reps) Low- to moderate-intensity steps forward and backward over a tape line while moving sideways (10 m x 5 reps) **Sagittal plane** running drills (vertical emphasized execution specially first days or painful subjects) - 8 running exercise drills (statics in place dynamics over 8m) Running 5 m + 5 m deceleration (4 reps) Running 10 m + 5 m deceleration (3 reps) Running 15 m + 5 m deceleration (2 reps)	**Warm Up:** Hamstring Ballistic stretching (2 x 6 reps) Static "B" drill with resisted band (2 x 5 reps) Hurdle drills (1 set walking lower intensity, 1 set bounding higher intensity) Hurdle drill 1 (2 reps) Hurdle drill 2 (2 reps) Hurdle drill 3 (2 reps) Hurdle drill 4 (2 reps) Military march (15 m x 2 reps) Lunge + deadlift (4 reps for each leg) Lunge + "B" drill (4 reps for each leg) From Skipping to running (20 m x 4 reps) Sprint bounding (15 m x 3 reps) Running with hurdle jumps (15 m x 1 rep) Sprinting 5 m (3 reps), 10 m (3 reps), 15 m (4 reps), 20 m (3 reps), 30 m (2 reps) and 40 m (1 rep) (15 sec of rest per each 1 sec sprinting) Sled push resisted accelerations (30% BW) 5 m (3 reps) and 10 m (2 reps)	1

1, contents corresponding to the training day 1; 2, contents corresponding to the training day 2; 3, contents corresponding to the training day 3. Minimum of three blocks 1-2-3 in the functional phase before RTS.
Reps, repetitions; BW, body weight; NMES, neuromuscular electrical stimulation.

APPLIED SCIENCES

A Multifactorial, Criteria-based Progressive Algorithm for Hamstring Injury Treatment

JURDAN MENDIGUCHIA[1], ENRIQUE MARTINEZ-RUIZ[2], PASCAL EDOUARD[3,4,5], JEAN-BENOÎT MORIN[6], FRANCISCO MARTINEZ-MARTINEZ[7], FERNANDO IDOATE[8], and ALBERTO MENDEZ-VILLANUEVA[9]

Jurdan Mendiguchia
Zentrum Center
Baranain, Spain

REHABILITAITON
TARGET REFERENCE
PROFILE (PRE-INJURY)

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Return to sport …or return to (sprint) Performance

FV SPRINT PROFILE FOR AN INJURED PLAYER: 3 TESTS

1 & 2 = PRE-INJURY

Test	Date	Height (m)	Mass (kg)	30-m Time (s)	V Max (m/s)	F0 (N/Kg)	V0 (m/s)	P Max (W)	P Max (W/Kg)	DRF	FV slope	RF_10m	RF Peak
1	21/09/2017	1,87	95	4,58	8,88	6,98	9,20	1524	16,1	-7%	-72,1	32%	50%
2	22/11/2017	1,87	95	4,62	8,39	7,63	8,65	1567	16,5	-8%	-83,9	32%	52%
3	09/02/2018	1,87	95	4,48	8,55	8,40	8,80	1755	18,5	-9%	-90,7	32%	55%

TEST 3: AFTER return-to-sport, to validate the « return to performance »

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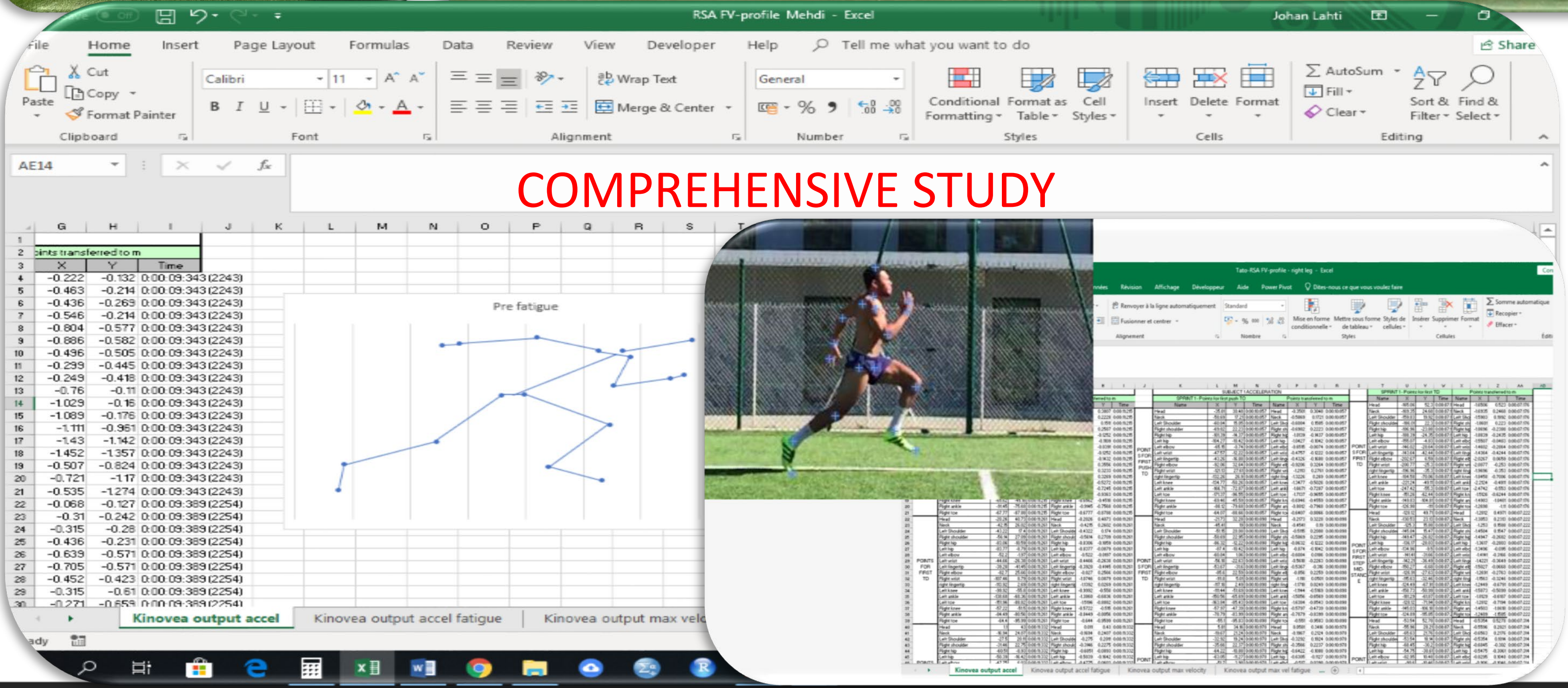
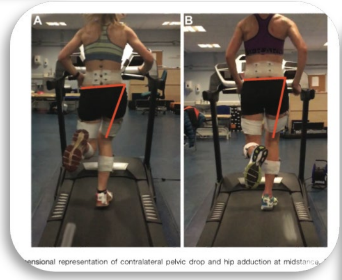
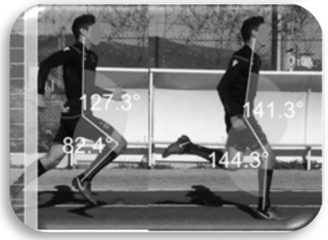
Use in prevention ??
Sprint mechanics as a « risk » factor

Use in Prevention?







Sprint « pattern » and pelvic control as additional pieces of the puzzle

Merci !

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