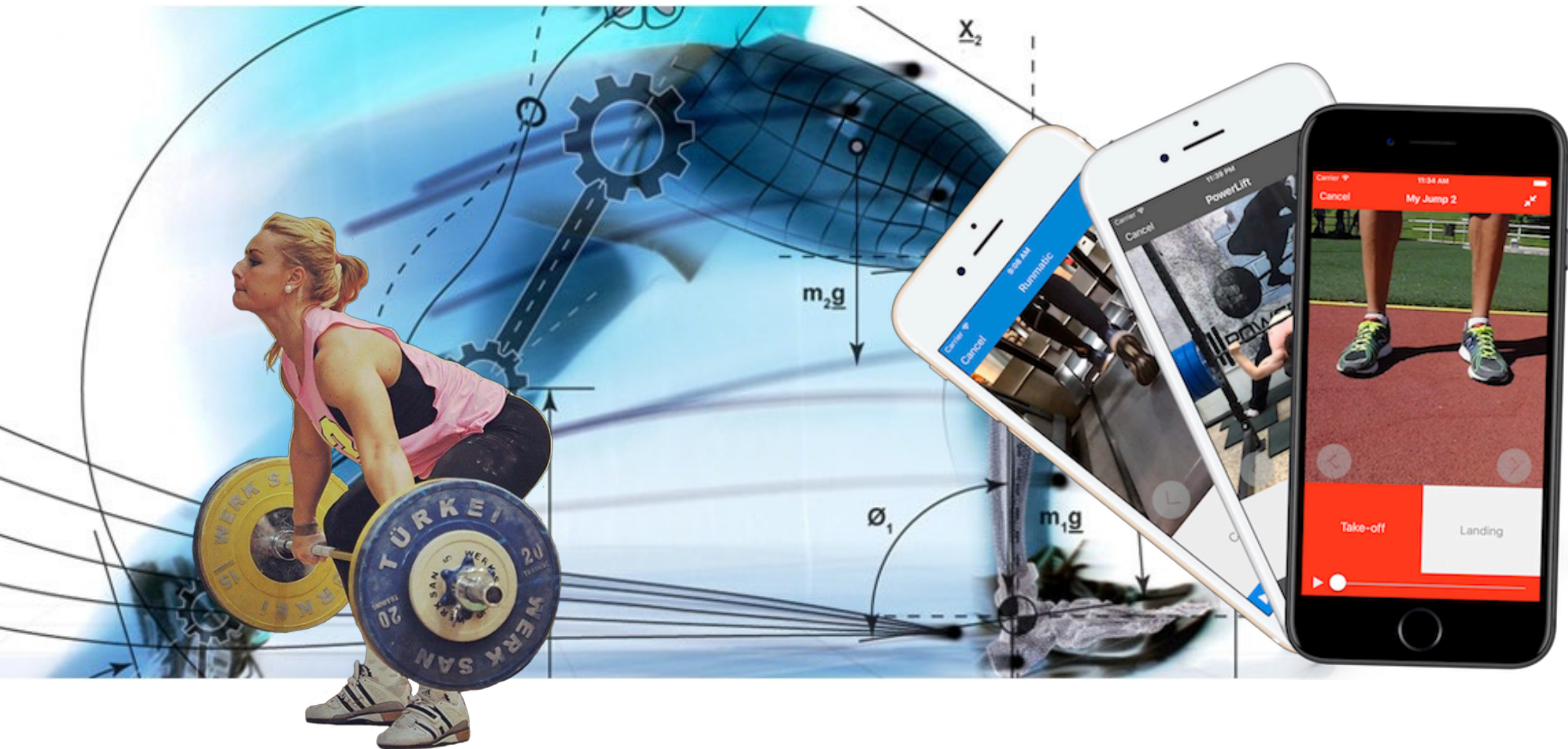


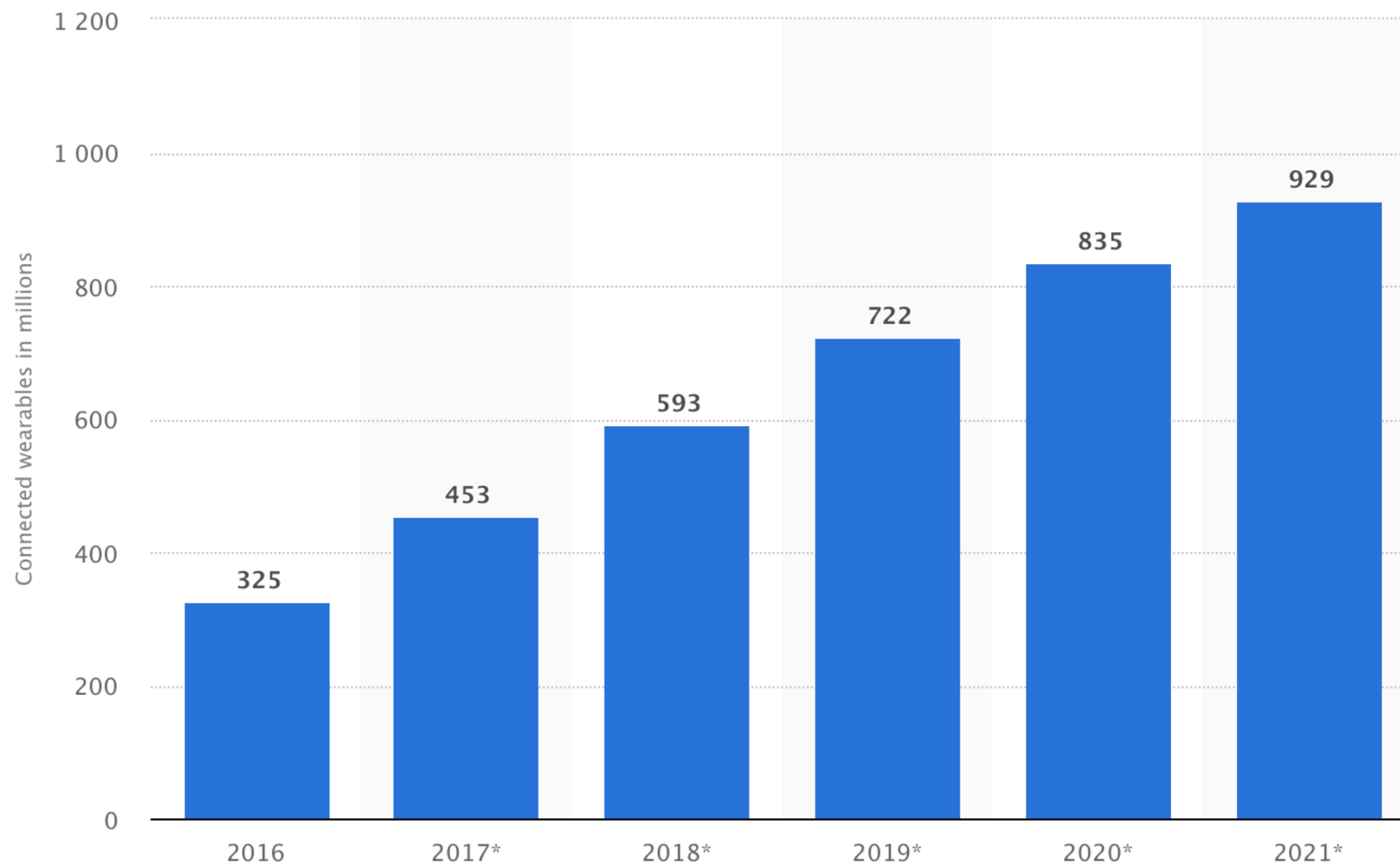
MONITORING ATHLETES USING SIMPLE METHODOLOGIES



THE ERA OF TRACKING



Activity trackers WORLDWIDE



1 EXA = 1.000.000 TERA!!!

2005 – 130 EXABYTES

2010 – 1,200 EXABYTES

2015 – 7,900 EXABYTES

2020 – 40,900 EXABYTES

DATA SCIENCE



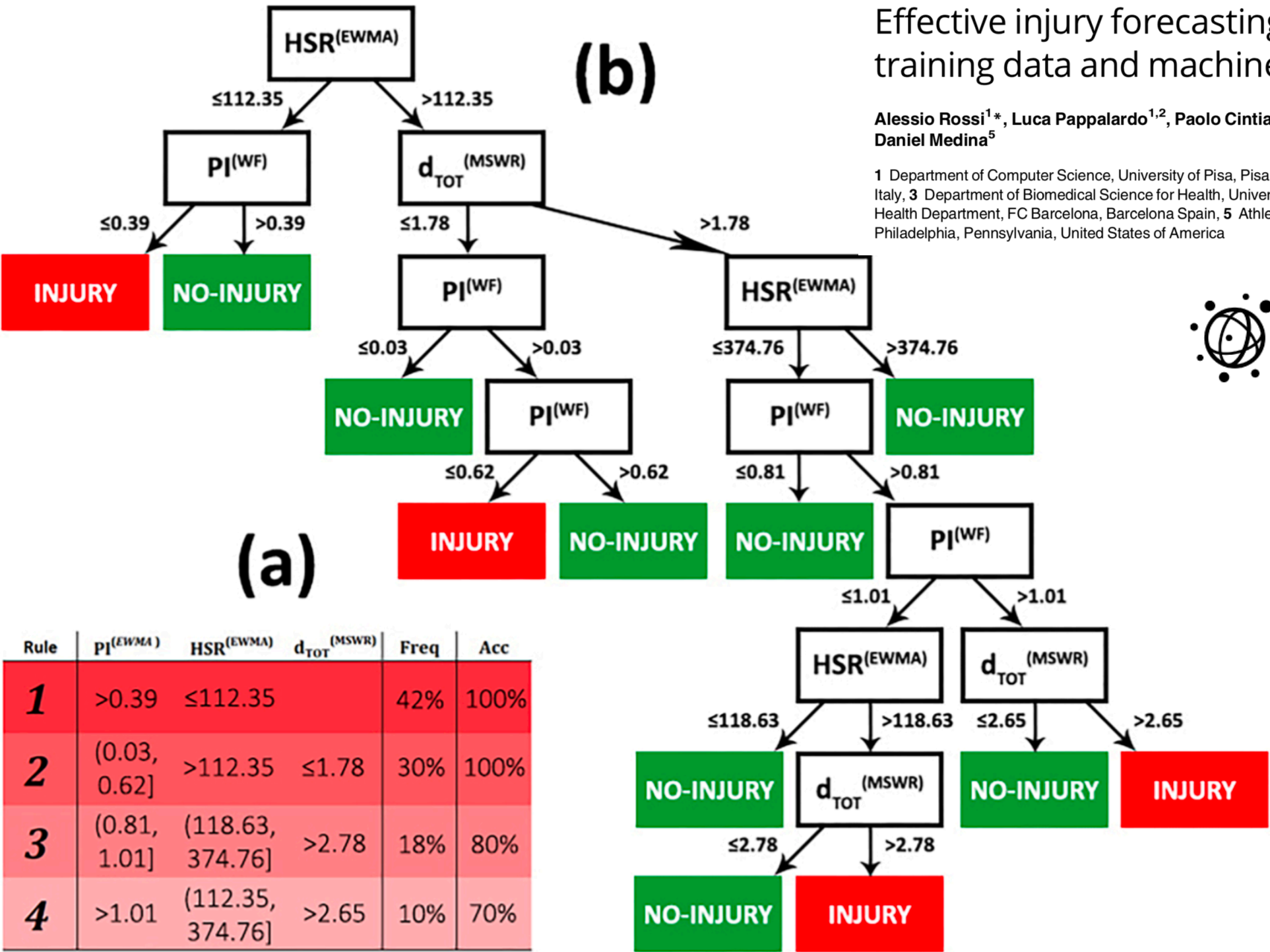
DATA SCIENCE

RESEARCH ARTICLE

Effective injury forecasting in soccer with GPS training data and machine learning

Alessio Rossi^{1*}, Luca Pappalardo^{1,2}, Paolo Cintia², F. Marcello Iaia³, Javier Fernàndez⁴, Daniel Medina⁵

¹ Department of Computer Science, University of Pisa, Pisa, Italy, ² ISTI, National Research Council, Pisa, Italy, ³ Department of Biomedical Science for Health, University of Milan, Milan, Italy, ⁴ Sports Science and Health Department, FC Barcelona, Barcelona Spain, ⁵ Athletic Care Department, Philadelphia 76ers, Philadelphia, Pennsylvania, United States of America



COACH



EXPERT IN COACHING
NOVICE IN DATA ANALYSIS

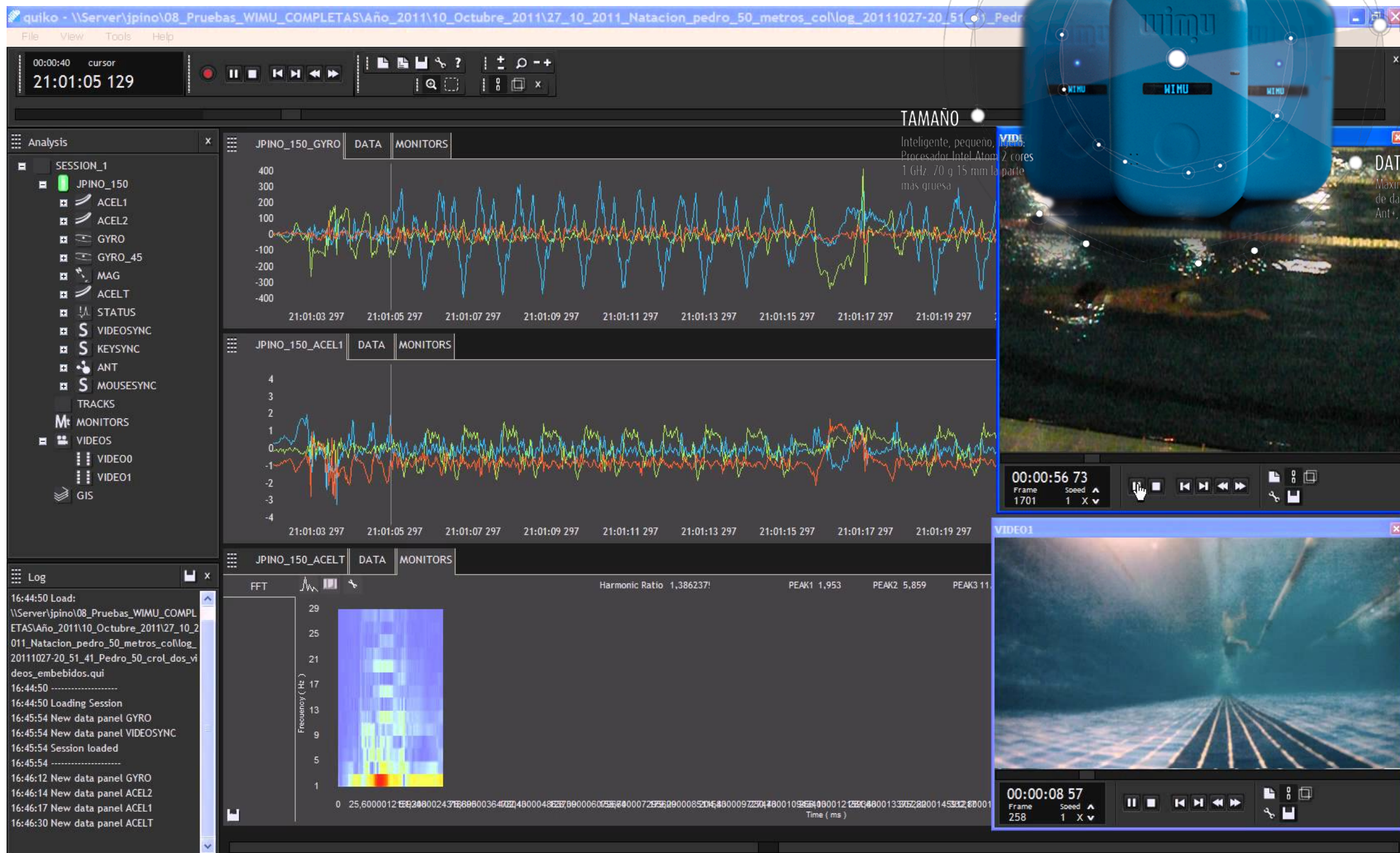
VS

DATA ANALYST

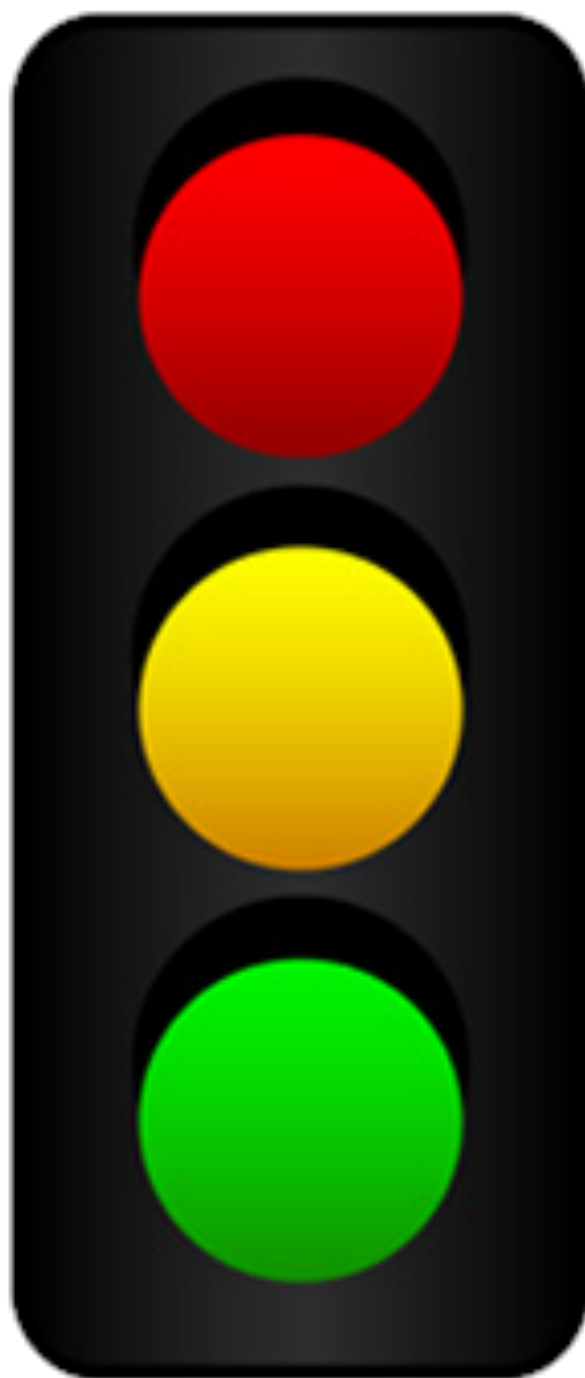


EXPERT IN DATA ANALYSIS
NOVICE IN COACHING

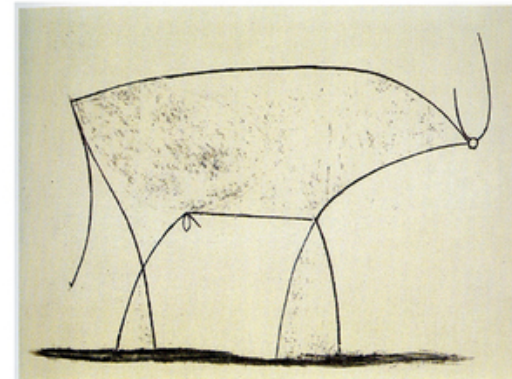
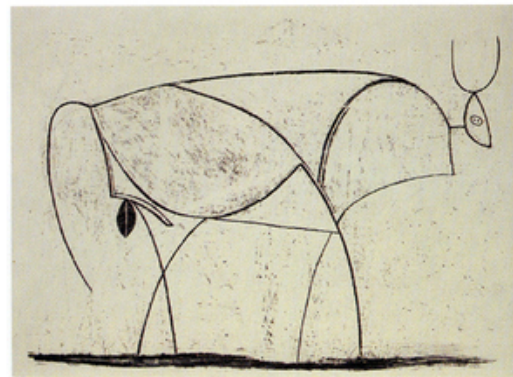
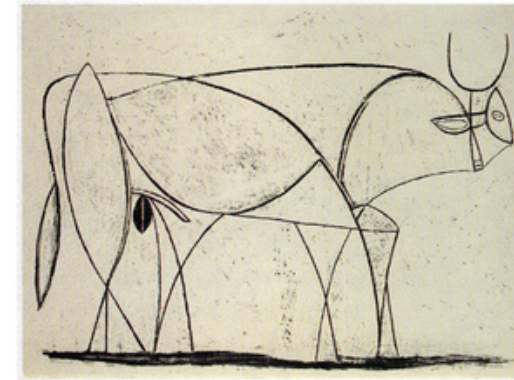
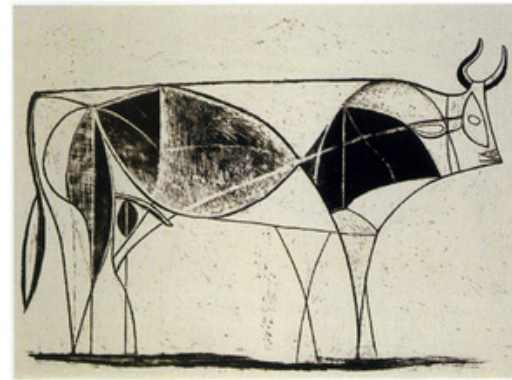
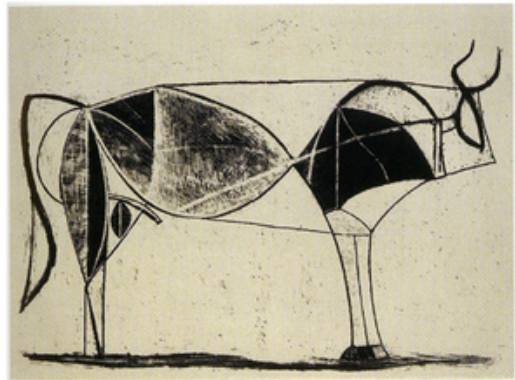
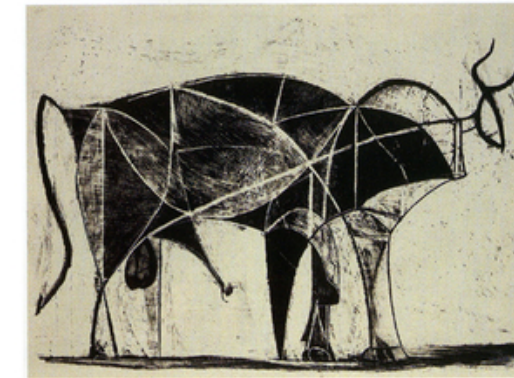
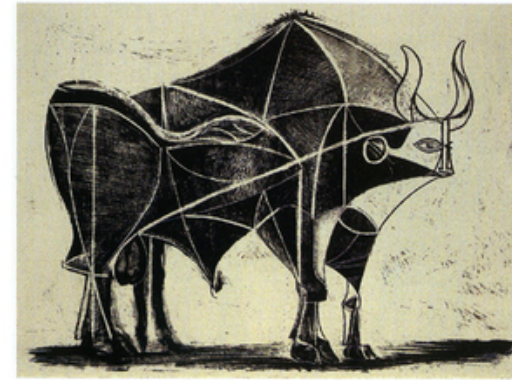
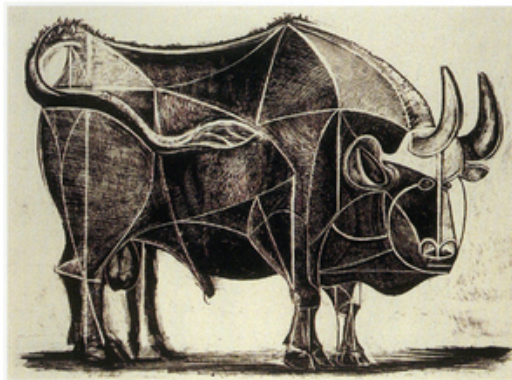
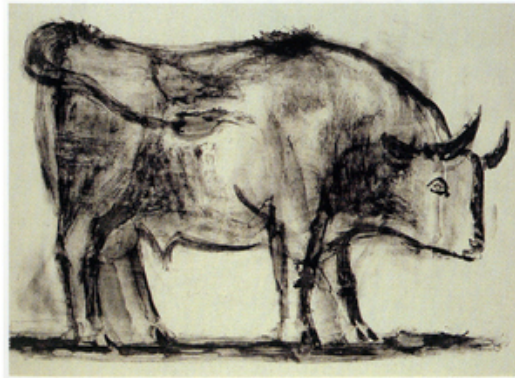
WHAT DATA ANALYST SEES



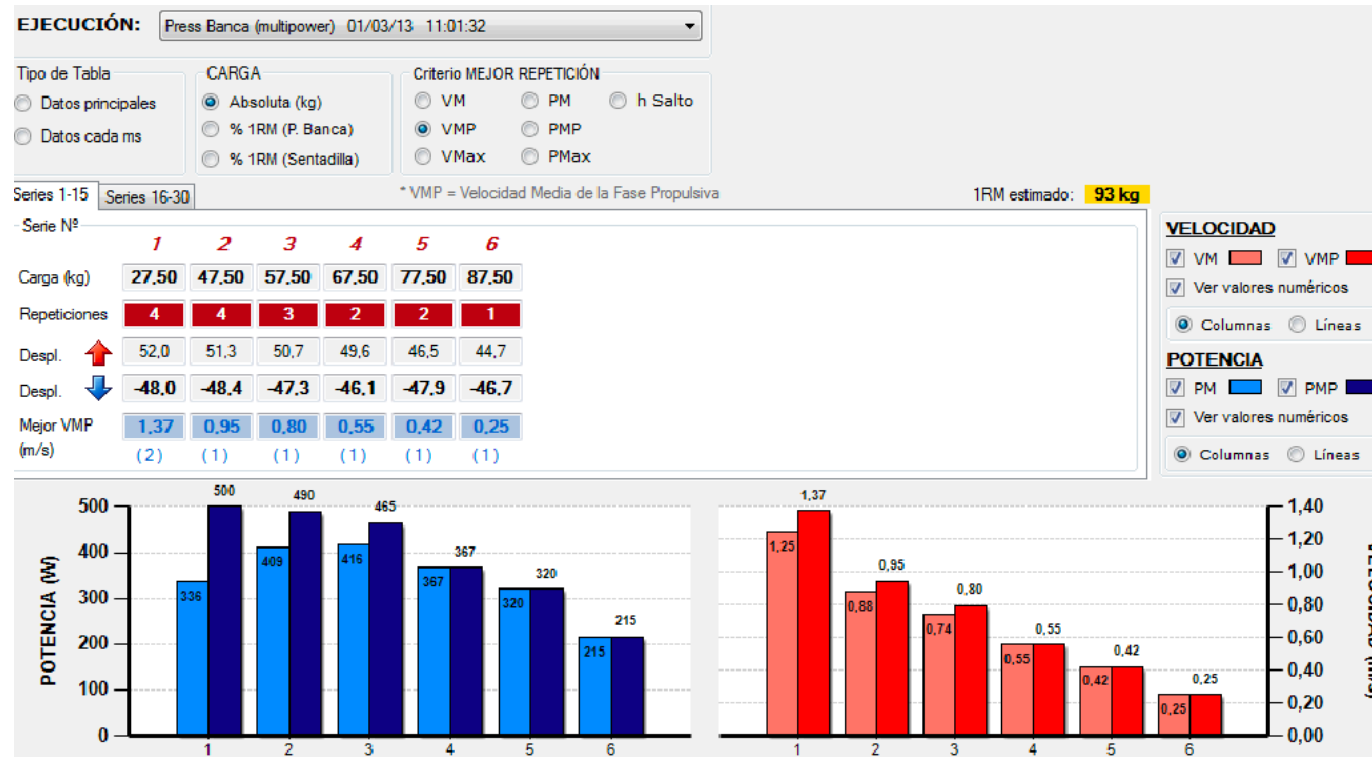
WHAT COACHES WANT



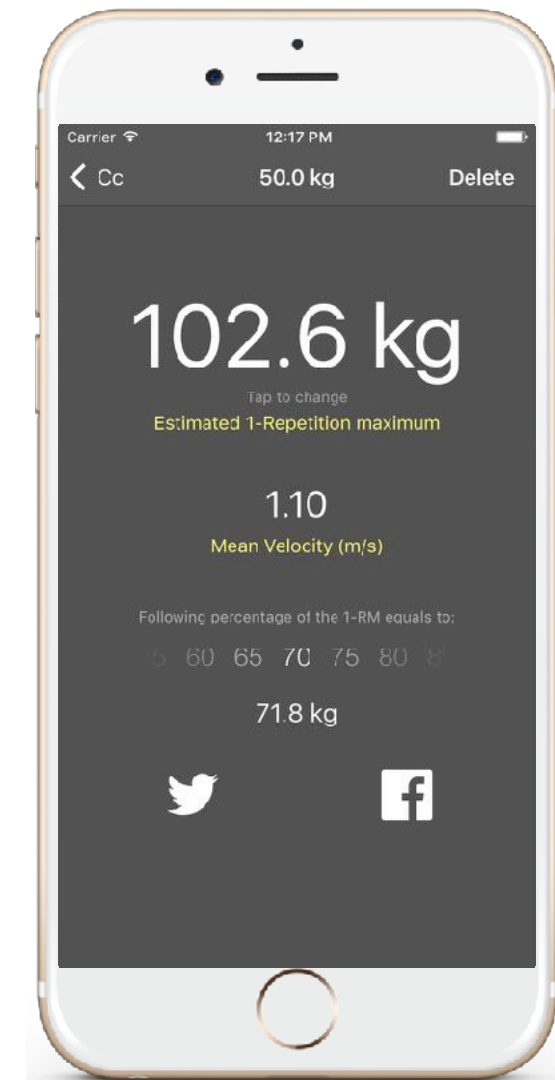
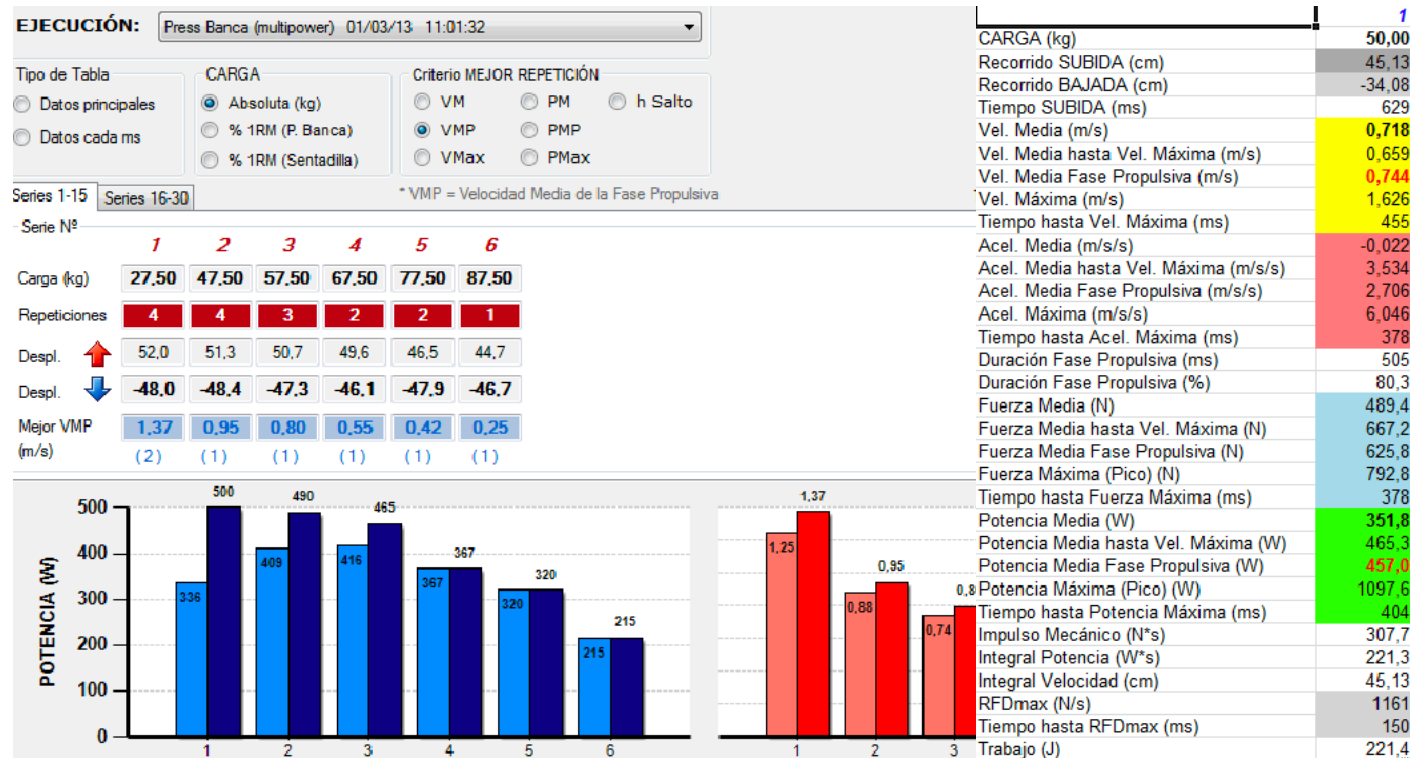
PHILOSOPHY



Picasso



	1
CARGA (kg)	50,00
Recorrido SUBIDA (cm)	45,13
Recorrido BAJADA (cm)	-34,08
Tiempo SUBIDA (ms)	629
Vel. Media (m/s)	0,718
Vel. Media hasta Vel. Máxima (m/s)	0,659
Vel. Media Fase Propulsiva (m/s)	0,744
Vel. Máxima (m/s)	1,626
Tiempo hasta Vel. Máxima (ms)	455
Acel. Media (m/s/s)	-0,022
Acel. Media hasta Vel. Máxima (m/s/s)	3,534
Acel. Media Fase Propulsiva (m/s/s)	2,706
Acel. Máxima (m/s/s)	6,046
Tiempo hasta Acel. Máxima (ms)	378
Duración Fase Propulsiva (ms)	505
Duración Fase Propulsiva (%)	80,3
Fuerza Media (N)	489,4
Fuerza Media hasta Vel. Máxima (N)	667,2
Fuerza Media Fase Propulsiva (N)	625,8
Fuerza Máxima (Pico) (N)	792,8
Tiempo hasta Fuerza Máxima (ms)	378
Potencia Media (W)	351,8
Potencia Media hasta Vel. Máxima (W)	465,3
Potencia Media Fase Propulsiva (W)	457,0
Potencia Máxima (Pico) (W)	1097,6
Tiempo hasta Potencia Máxima (ms)	404
Impulso Mecánico (N*s)	307,7
Integral Potencia (W*s)	221,3
Integral Velocidad (cm)	45,13
RFDmax (N/s)	1161
Tiempo hasta RFDmax (ms)	150
Trabajo (J)	221,4



It's not what I have, but what can I do with it!

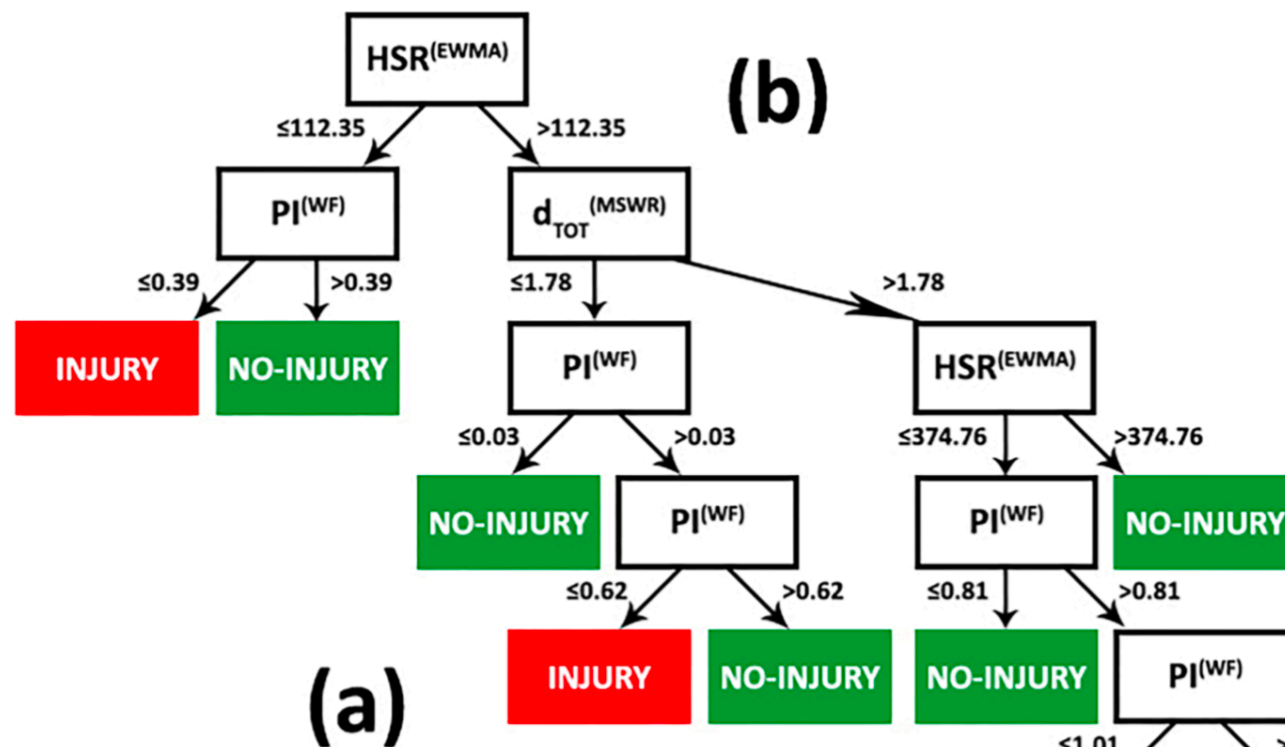
SIMPLICITY IS A SUPERPOWER!



It doesn't matter how many resources you have.



If you don't know how to use them,
it will never be enough.



(a)

Rule	$PI^{(EWMA)}$	$HSR^{(EWMA)}$	$d_{TOT}^{(MSWR)}$	Freq	Acc
1	>0.39	≤ 112.35		42%	100%
2	$(0.03, 0.62]$	>112.35	≤ 1.78	30%	100%
3	$(0.81, 1.01]$	$(118.63, 374.76]$	>2.78	18%	80%
4	>1.01	$(112.35, 374.76]$	>2.65	10%	70%

INFORMACIÓN
 Potente procesamiento información: RAW DATA, Wimu Cloud

TAMAÑO
 Inteligente, pequeño, ligero: Procesador Intel Atom 2 cores 1 GHz. 70 g 15 mm la parte más gruesa

PRECISIÓN
 Precisión líder: Avanzado Hybrid System: GPS/GNSS + UWB 10cm precisión

DATOS
 Máxima calidad transferencia de datos: WIFI, Bluetooth, Ant+, HUB de Sensores

GPS-Accelerometer data
1GB player/day!!



Lorena Torres
@lorenatorres07

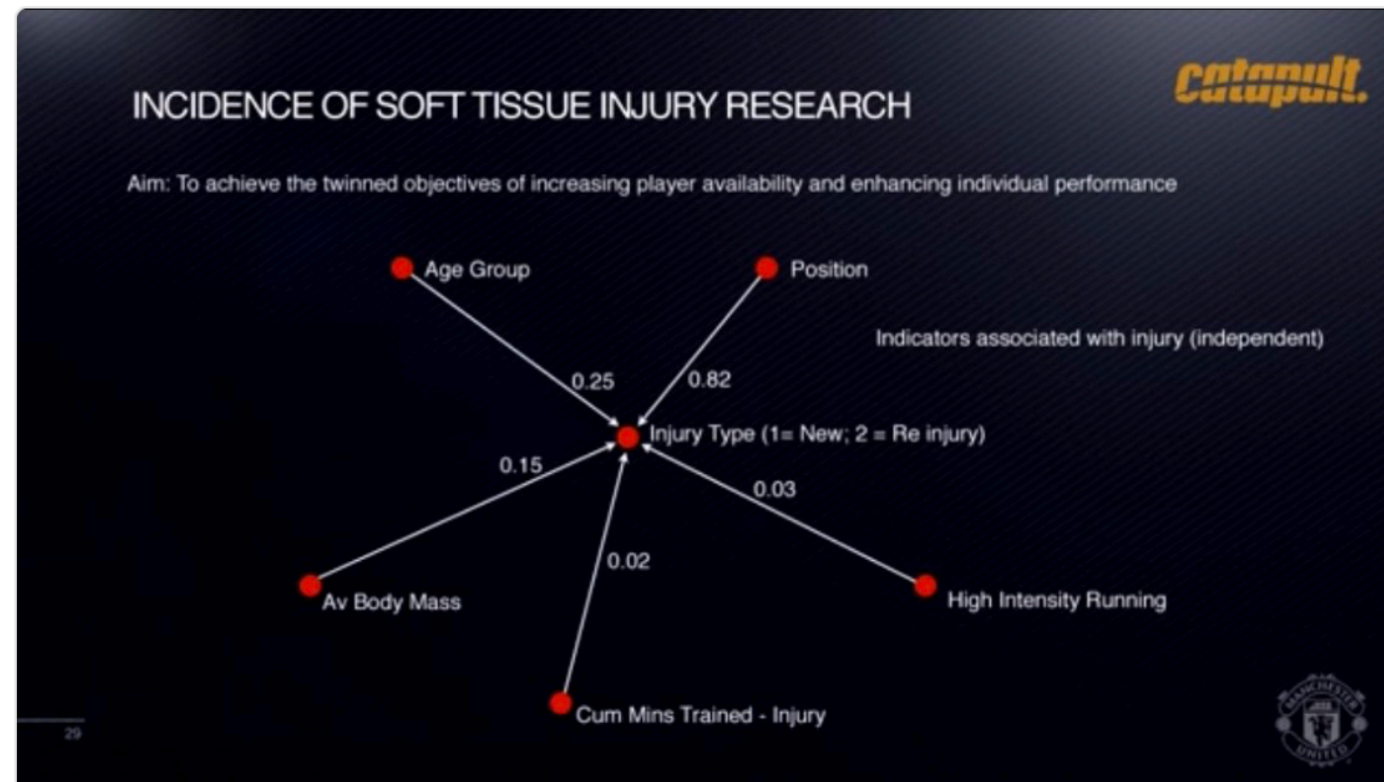
Siguiendo



Injury prediction:"is a waste of time; we've been there, done it & failed. We spent 2y & lot of money trying to work this injury prediction model. It's too complex, so many different parameters are involved when a player breaks down.

It's about risk managment" T.Strudwick
@ManUtd

Traducir Tweet





Article

Association between Subjective Indicators of Recovery Status and Heart Rate Variability among Divison-1 Sprint-Swimmers

Andrew A. Flatt ^{1,*} , Michael R. Esco ² and Fabio Y. Nakamura ^{3,4}

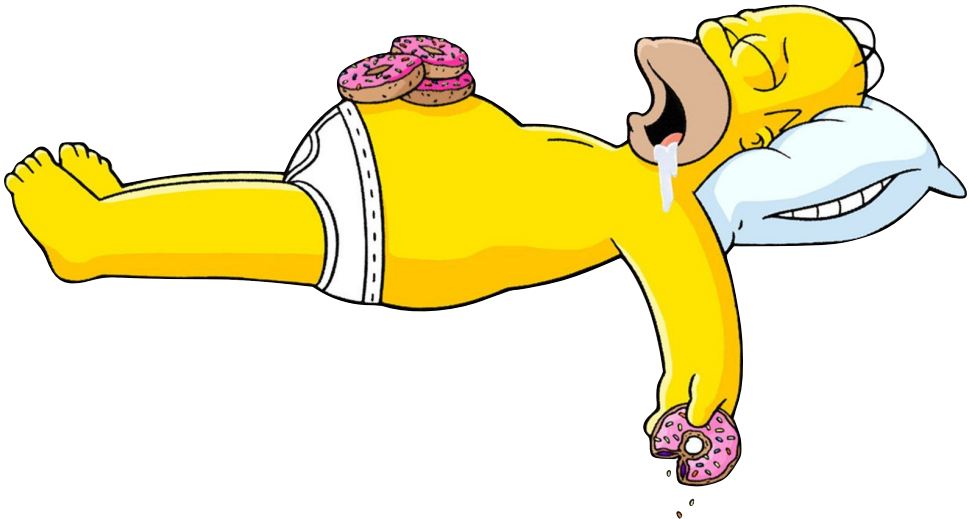


Table 1. Model-adjusted mean ± standard deviation for resting heart rate parameters.

Parameter	Better	Average	Worse
RHR (b·min ^{−1})			
Sleep	62.0 ± 7.7 *	63.9 ± 7.7	65.6 ± 7.8
Fatigue	63.0 ± 7.7	63.6 ± 7.8	64.2 ± 7.8
Soreness	63.2 ± 7.8	63.5 ± 7.7	63.8 ± 7.7
Stress	62.3 ± 7.7 *	63.9 ± 7.8	64.5 ± 7.7
Mood	61.8 ± 7.7 *¥	64.7 ± 7.8	64.3 ± 7.6
LnRMSSD			
Sleep	86.6 ± 7.5 *¥	84.1 ± 7.5 *	81.3 ± 7.6
Fatigue	85.9 ± 7.9 *	84.1 ± 7.9	82.7 ± 7.9
Soreness	84.8 ± 7.8	84.2 ± 7.7	84.2 ± 7.8
Stress	85.7 ± 7.8 *	84.3 ± 7.9	83.0 ± 7.8
Mood	86.6 ± 7.7 *¥	83.7 ± 7.8	82.7 ± 7.7

“Perceived sleep quality showed the strongest relationship with HRV”

MODELSTORNG!

Monitoring: why?

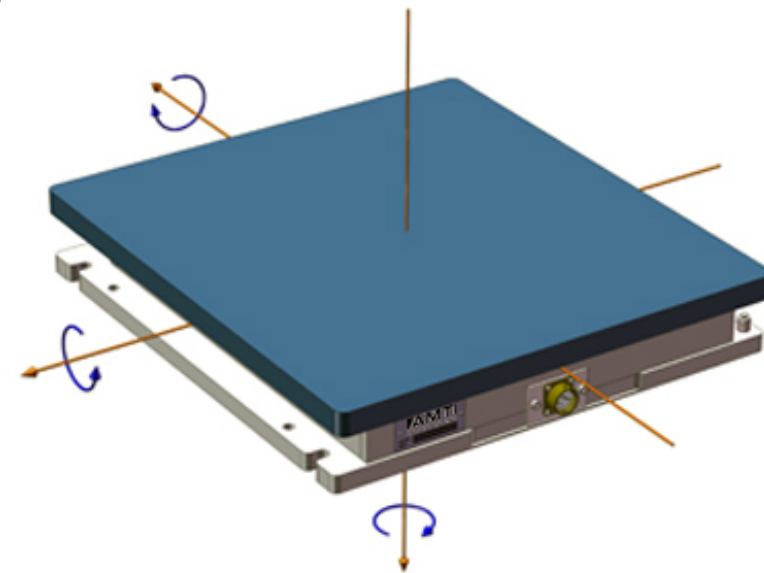
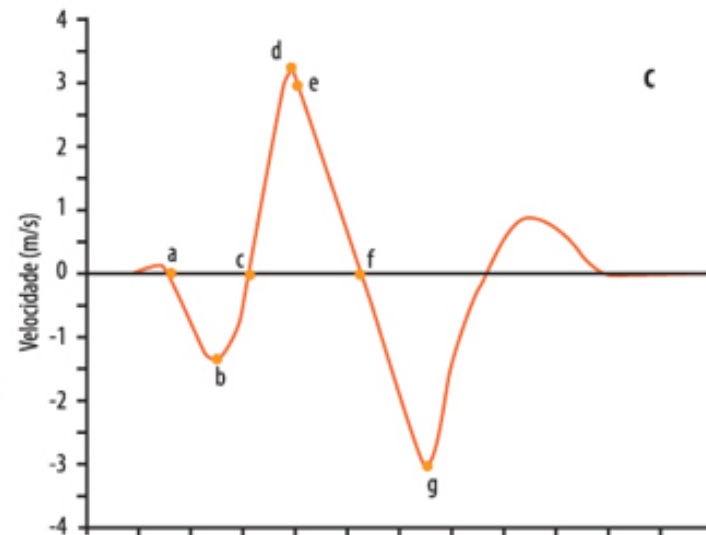
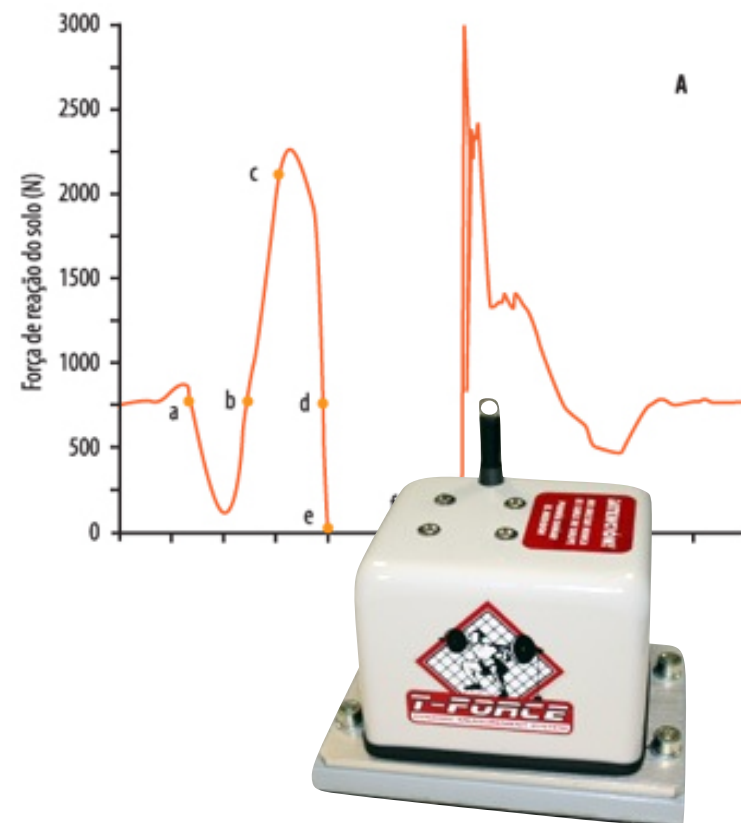


Check if athlete **improves/**
recover properly



Check if athlete returns to
pre-injury scores

Monitoring: how?



Vertical jumping

HRV

FV profile

Sprint performance

Barbell velocity

GPS

Running mechanics

Daily steps

ROM

Stiffness



Barbell velocity

Jump FV profile



Running/sprinting

ROM

Barbell velocity

Jump FV profile



Running/sprinting

ROM

Force-velocity profile: why?

1

Know your athlete's maximal force-velocity-power capabilities

2

Understand which capability has a stronger deficit (detect weaknesses)

3

INDIVIDUALIZE & OPTIMIZE training

Force-velocity profiling in jumping: what?



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

PIERRE SAMOZINO¹, ENRICO REJC², PIETRO ENRICO DI PRAMPERO², ALAIN BELLI³, and JEAN-BENOIT MORIN³

¹Laboratory of Exercise Physiology (EA4338), University of Savoy, Le Bourget du Lac, FRANCE.

²Department of Biomedical Sciences and Technologies, University of Udine, Udine, ITALY; and

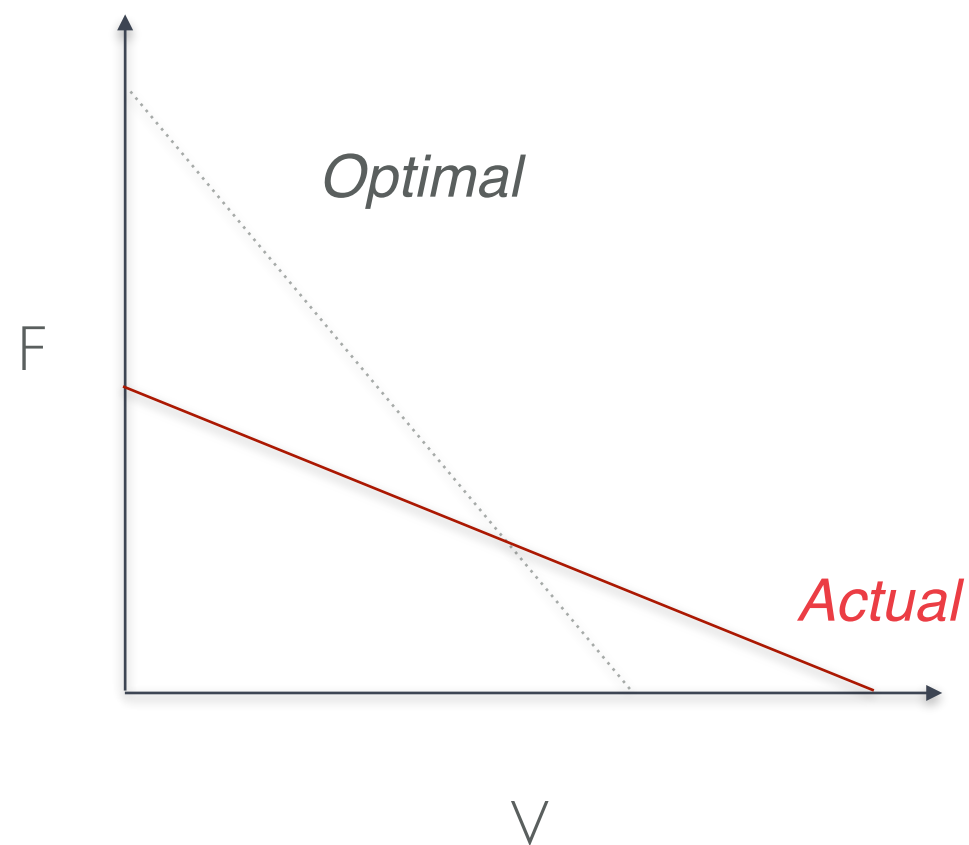
³Laboratory of Exercise Physiology (EA4338), University of Lyon, Saint Etienne, FRANCE

- Simple method to measure force, power and velocity of the lower limbs during jumping
- Validated with a force platform

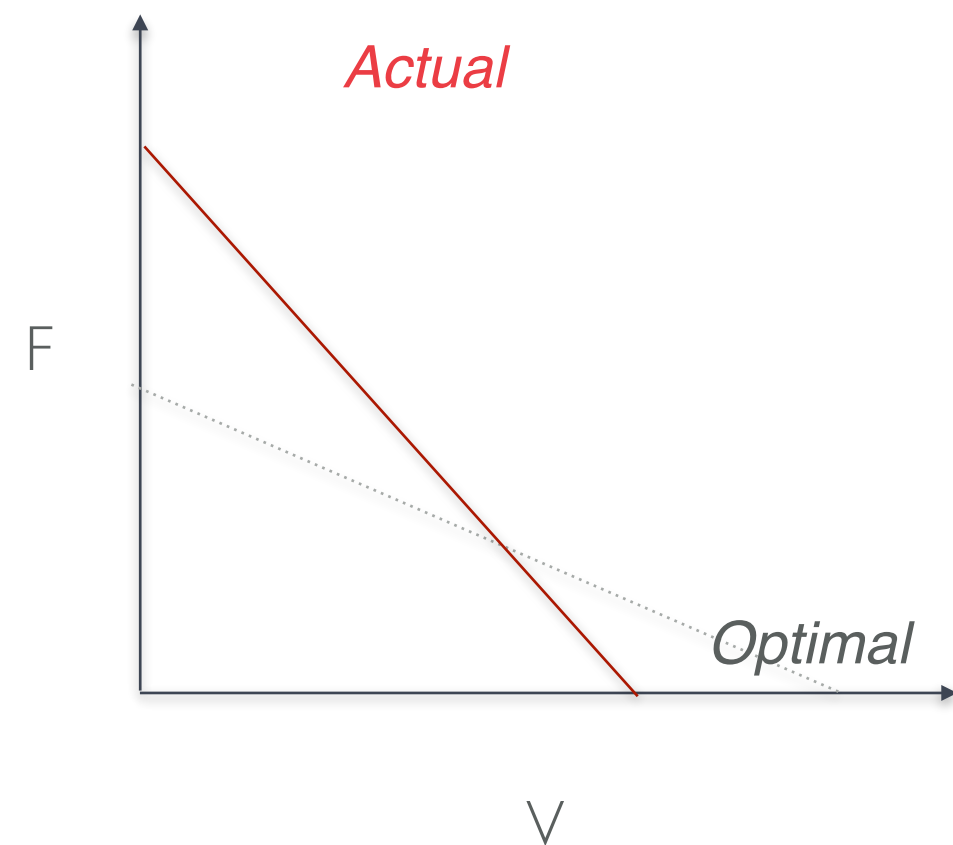
	Force plate method	Computation method	Absolute bias (%)	Pearson correlation coefficient (r)
$\bar{F}$ (N)	1294 ± 132	1282 ± 133	1.74 ± 1.17	0.98***
$\bar{v}$ (m s ⁻¹)	1.08 ± 0.12	1.10 ± 0.12	2.88 ± 2.00	0.96***
$\bar{P}$ (W)	1412 ± 221	1411 ± 224	2.29 ± 1.95	0.98***

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

There is an optimal FV combination that optimizes performance



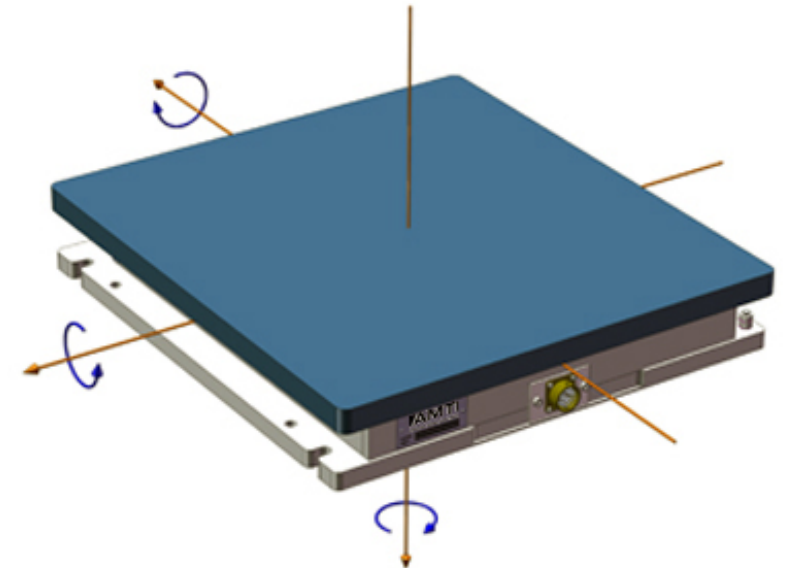
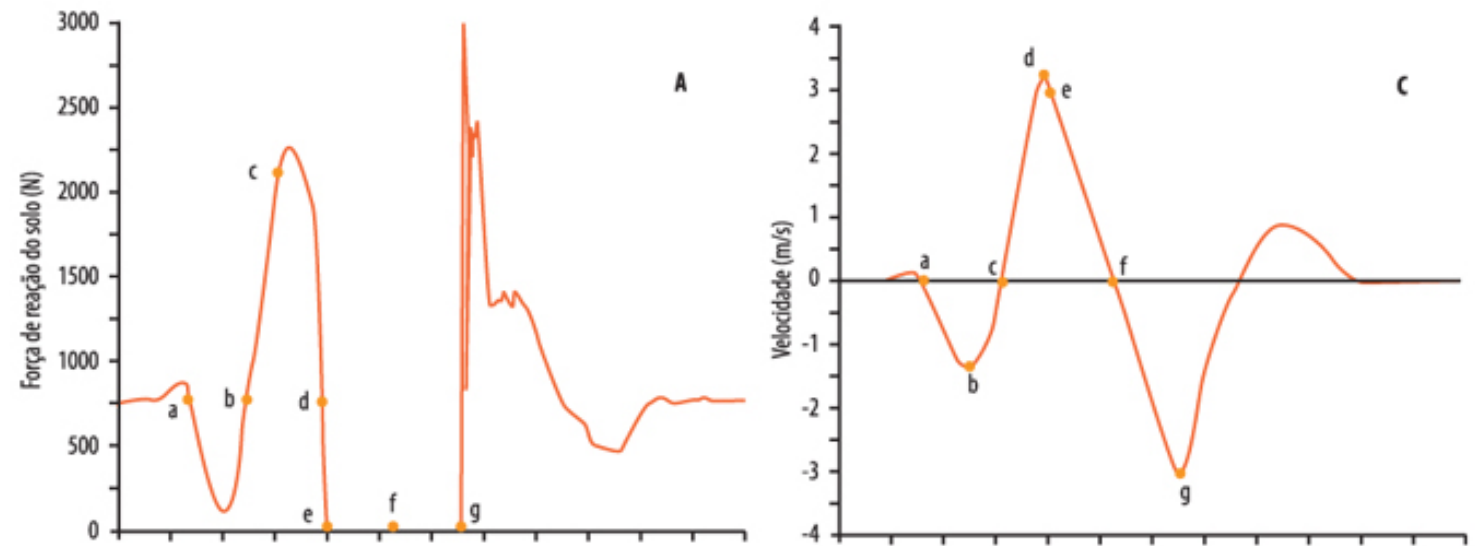
Force deficit



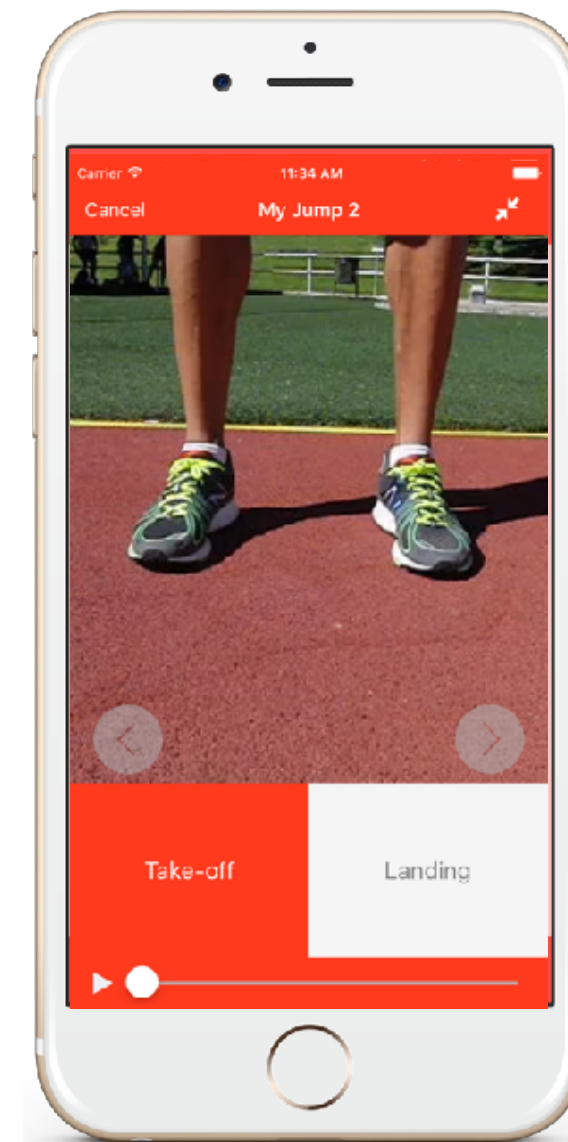
Velocity deficit

Force-velocity profiling in jumping: how?

- Two ways:
 - Take-off velocity (TOV)
 - $h = v^2/2g$
 - Time in the air (TIA)
 - $h = gt^2/8$
- Force plates, infrared platforms, contact platforms, accelerometers etc.
- DRAWBACKS platforms
 - Price: good ones 3000€
 - Transportability
 - Usefulness



My Jump 2



Measures jump height by measuring flight time thanks to the high-speed camera on the iOS devices

My Jump 2

- 100 different jumps were recorded with My Jump
- Simultaneously measured with a Kistler FP
- Results were compared
- Very high validity and reliability ($r=0.995$)
- Mean Diff 1.2cm (iPhone 5s)
- higher accuracy on iPhone 6 or newer (240fps)



Journal of Sports Sciences

Publication details, including instructions for authors and subscription information:
<http://www.tandfonline.com/loi/rjsp20>

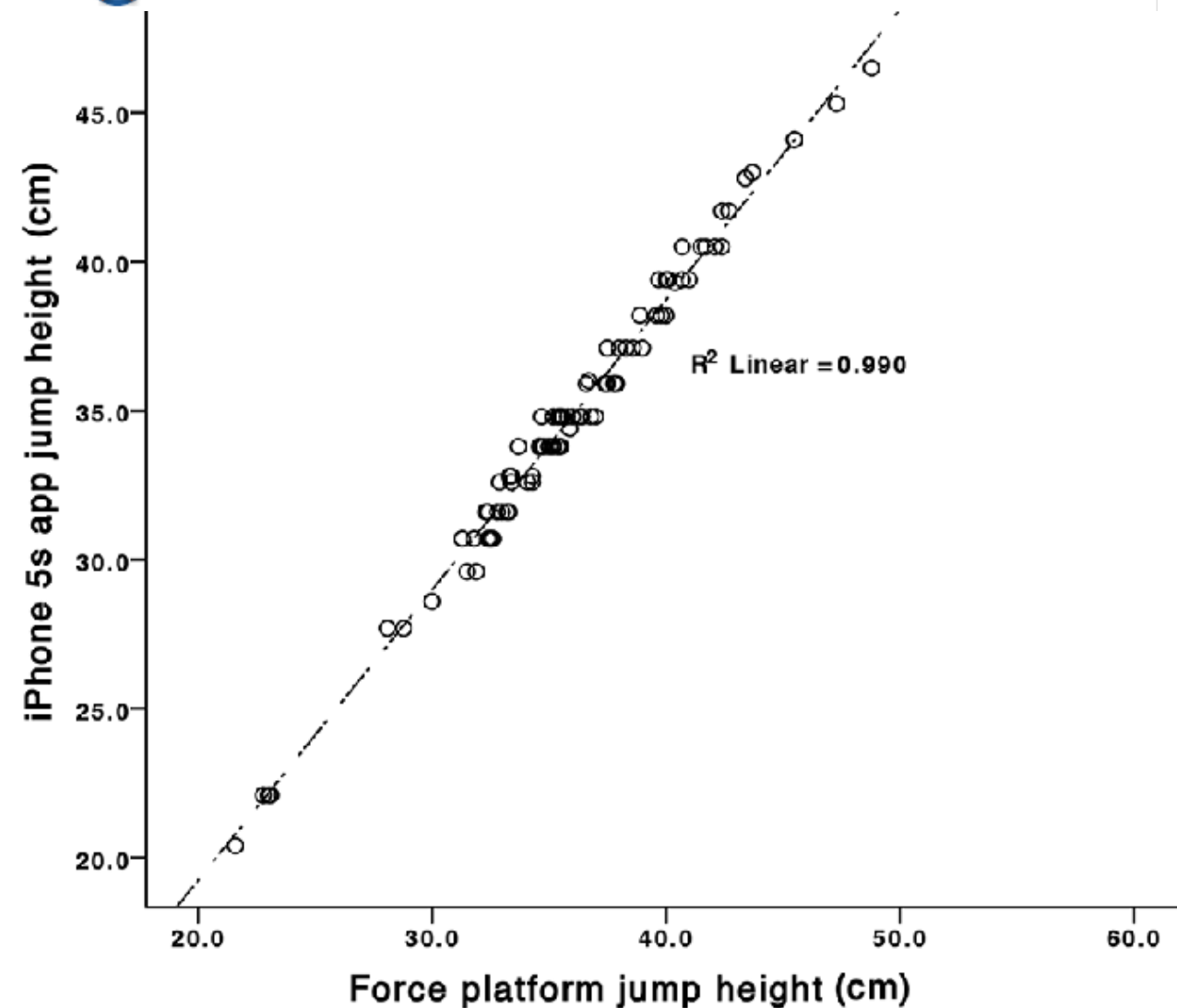
The validity and reliability of an iPhone app for measuring vertical jump performance

Carlos Balsalobre-Fernández^a, Mark Glaister^b & Richard Anthony Lockett^b

^a Department of Physical Education, Sport and Human Movement, Autonomous University of Madrid, Madrid, Spain

^b School of Sport, Health and Applied Science, St Mary's University, Twickenham, United Kingdom

Published online: 02 Jan 2015.



Balsalobre-Fernández, C, Glaister, M, and Lockett, RA. The validity and reliability of an iPhone app for measuring vertical jump performance. J Sports Sci, 2015.

Barbell velocity

Jump FV profile



Running/sprinting

ROM

HOW TO PRESCRIBE LOADS?

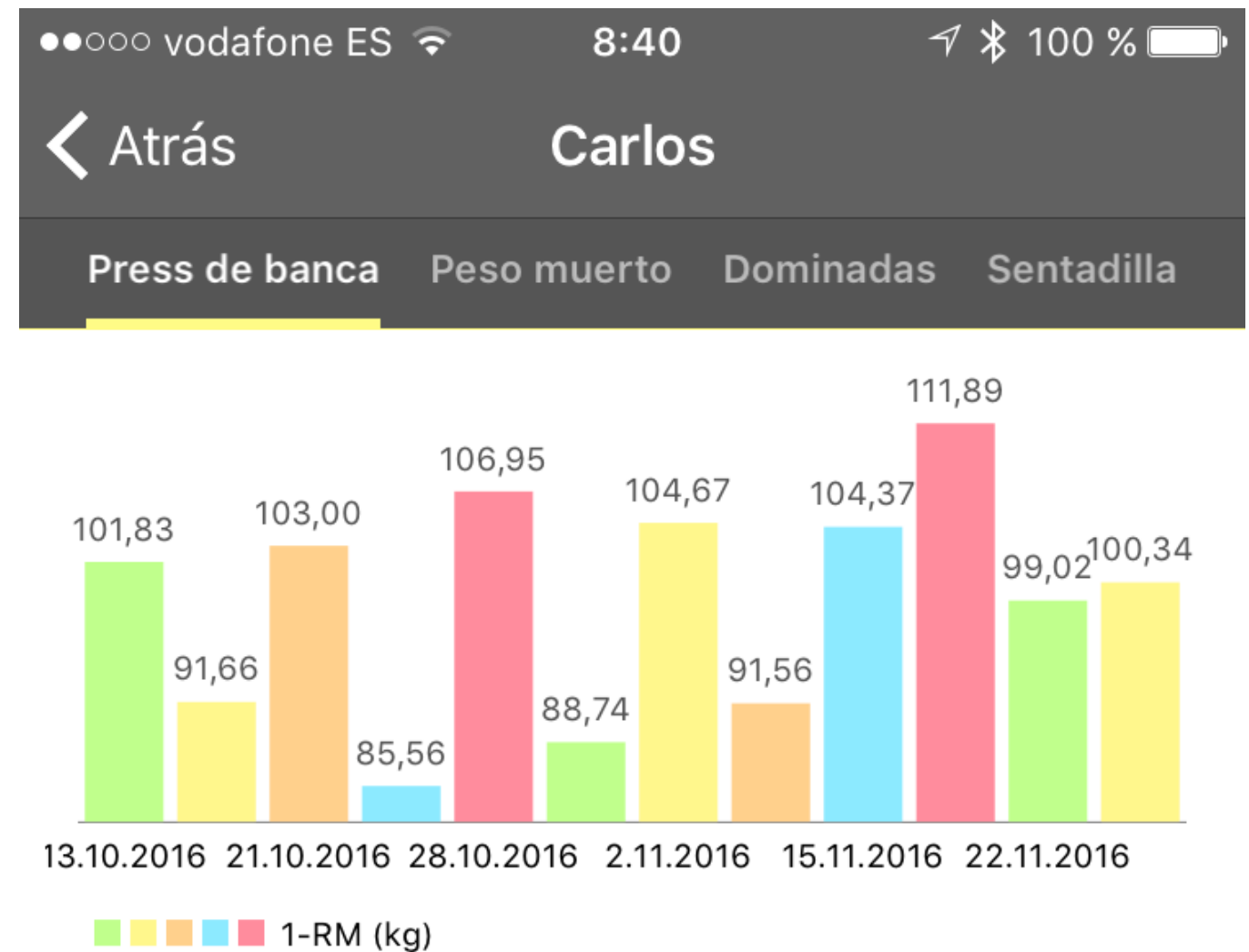
DIRECT MEASUREMENT OF 1-RM



Problems...??

Programming issues

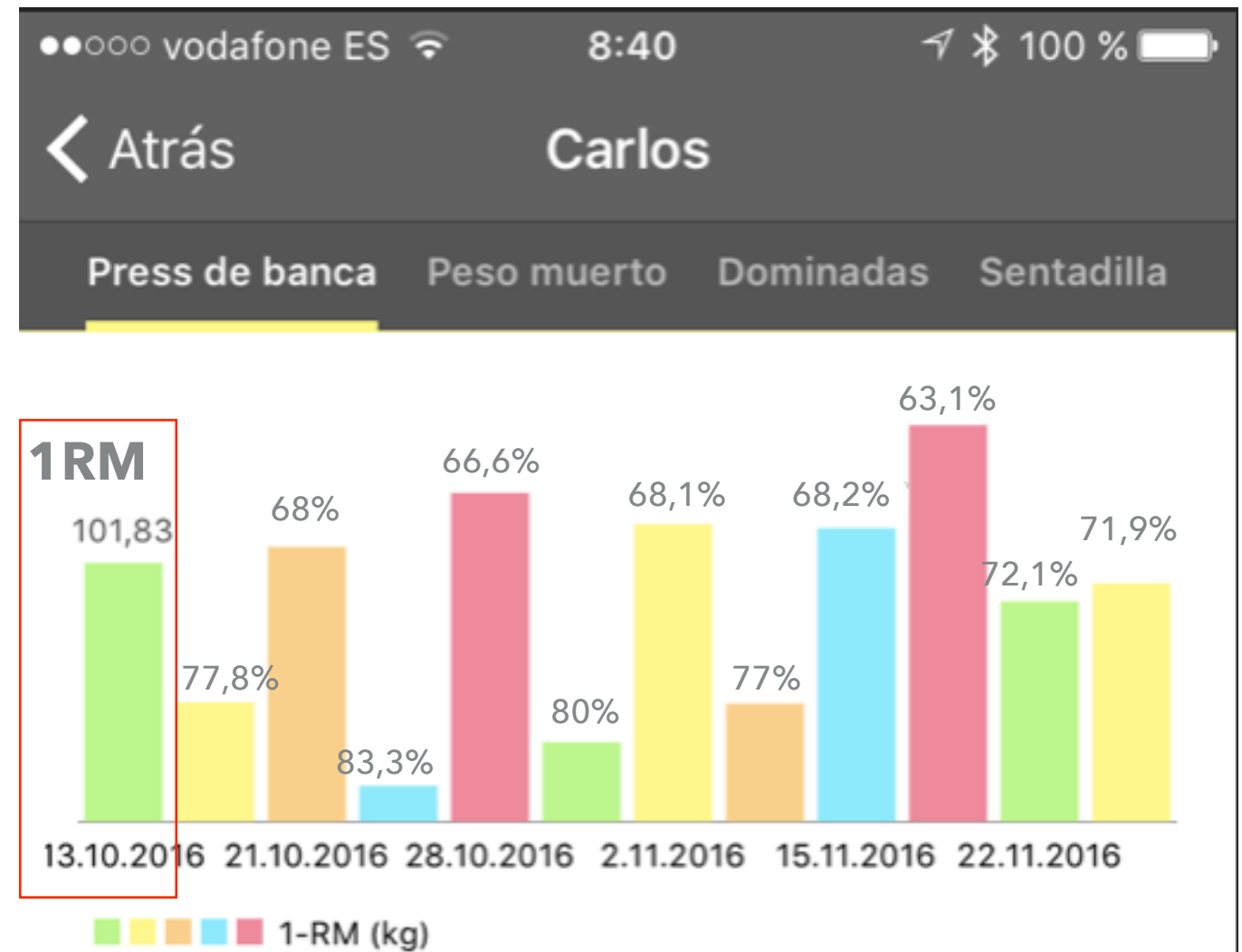
- Even if the athlete is ready to lift a 1-RM, it can vary greatly even on a day-to-day basis
- In order to adjust training programs, 1-RM should be measured very often
- This could interfere with training
- Overtraining/overreaching?
- Is the athlete really training with the programmed load?



EXAMPLE: 4weeks @70%1-RM = 71,3 kg

Programming issues

- Even if the athlete is ready to lift a 1-RM, it can vary greatly even on a day-to-day basis
- In order to adjust training programs, 1-RM should be measured very often
- This could interfere with training
- Overtraining/overreaching?
- Is the athlete really training with the programmed load?

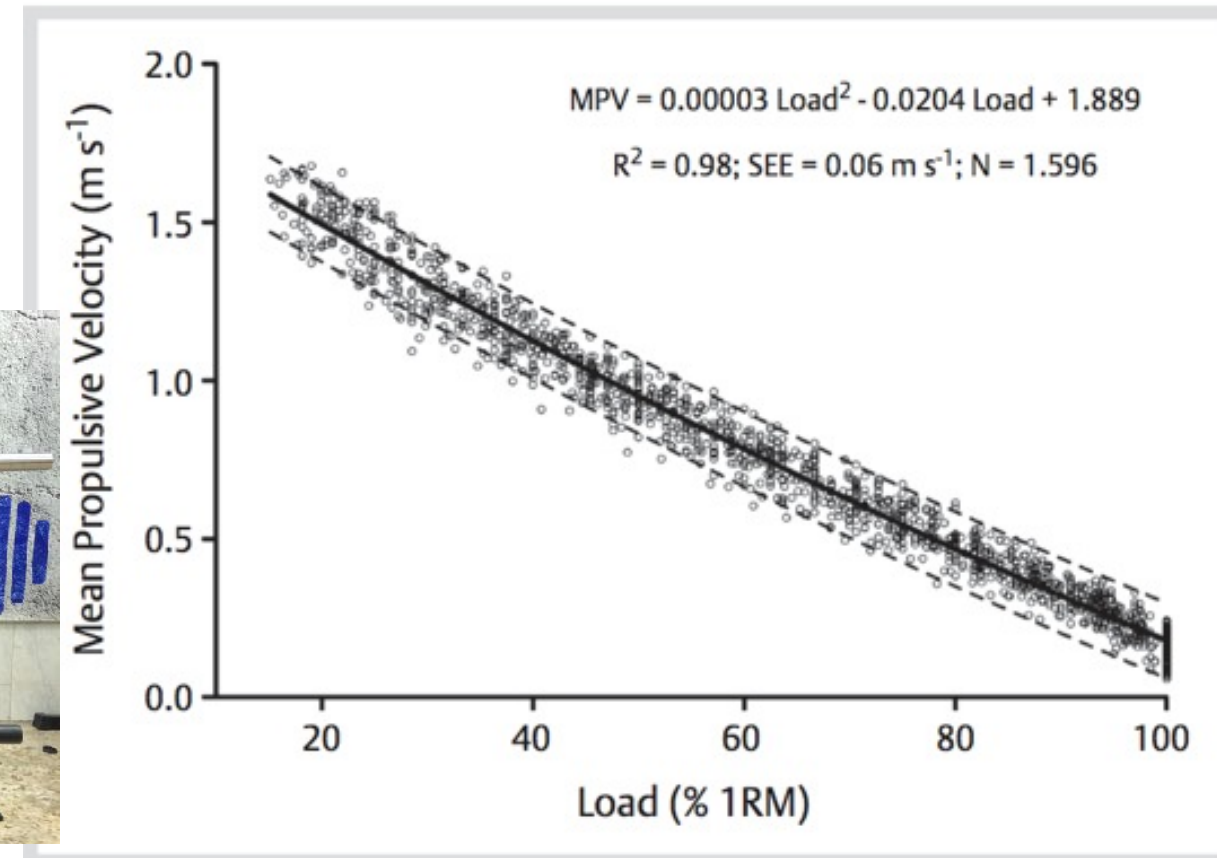


EXAMPLE: 4weeks @70%1-RM = 71,3 kg

NOT A SINGLE DAY IS WHAT WE PROGRAMMED!

ALTERNATIVES?

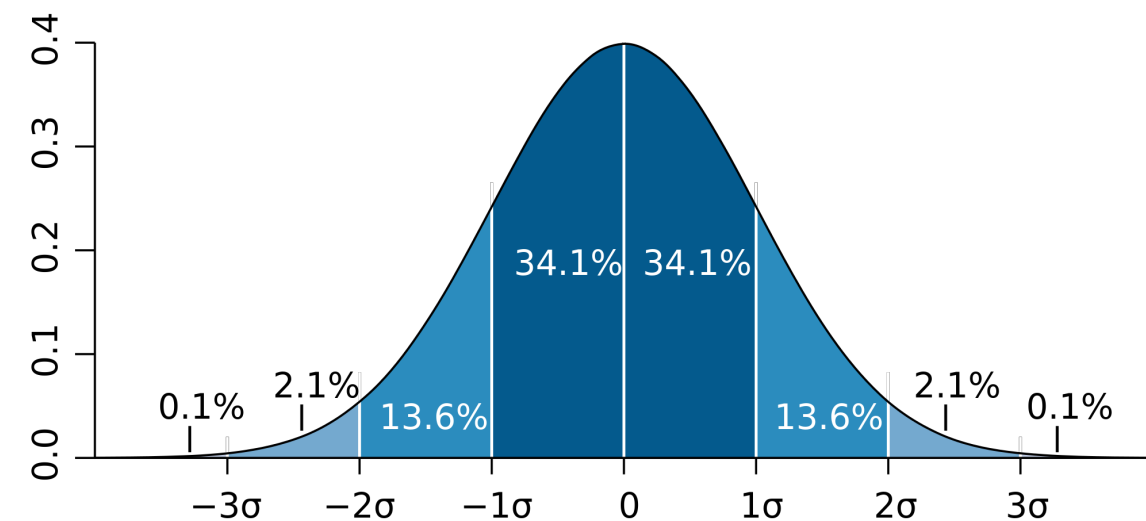
Load-velocity profiling



Gonzalez-Badillo, J. J., and Sánchez-Medina, L. (2010). Movement Velocity as a Measure of Loading Intensity in Resistance Training. *Int J Sports Med* 31, 347–352.

Load (%RM)	Bench press	Bench pull	Full squat	Half-squat	Leg press
30	1.29	1.50	1.25	1.17	1.4
35	1.20	1.42	1.18	1.11	1.32
40	1.11	1.35	1.12	1.05	1.23
45	1.02	1.28	1.05	0.99	1.15
50	0.94	1.20	0.99	0.93	1.06
55	0.85	1.13	0.92	0.87	0.97
60	0.77	1.06	0.85	0.81	0.89
65	0.69	0.99	0.79	0.75	0.79
70	0.61	0.92	0.72	0.69	0.71
75	0.53	0.85	0.66	0.63	0.63
80	0.46	0.79	0.59	0.57	0.54
85	0.38	0.72	0.52	0.51	0.45
90	0.31	0.65	0.46	0.45	0.37
95	0.24	0.59	0.39	0.39	0.28
100	0.17	0.52	0.33	0.33	0.19

Mean values ok, but what about SD??



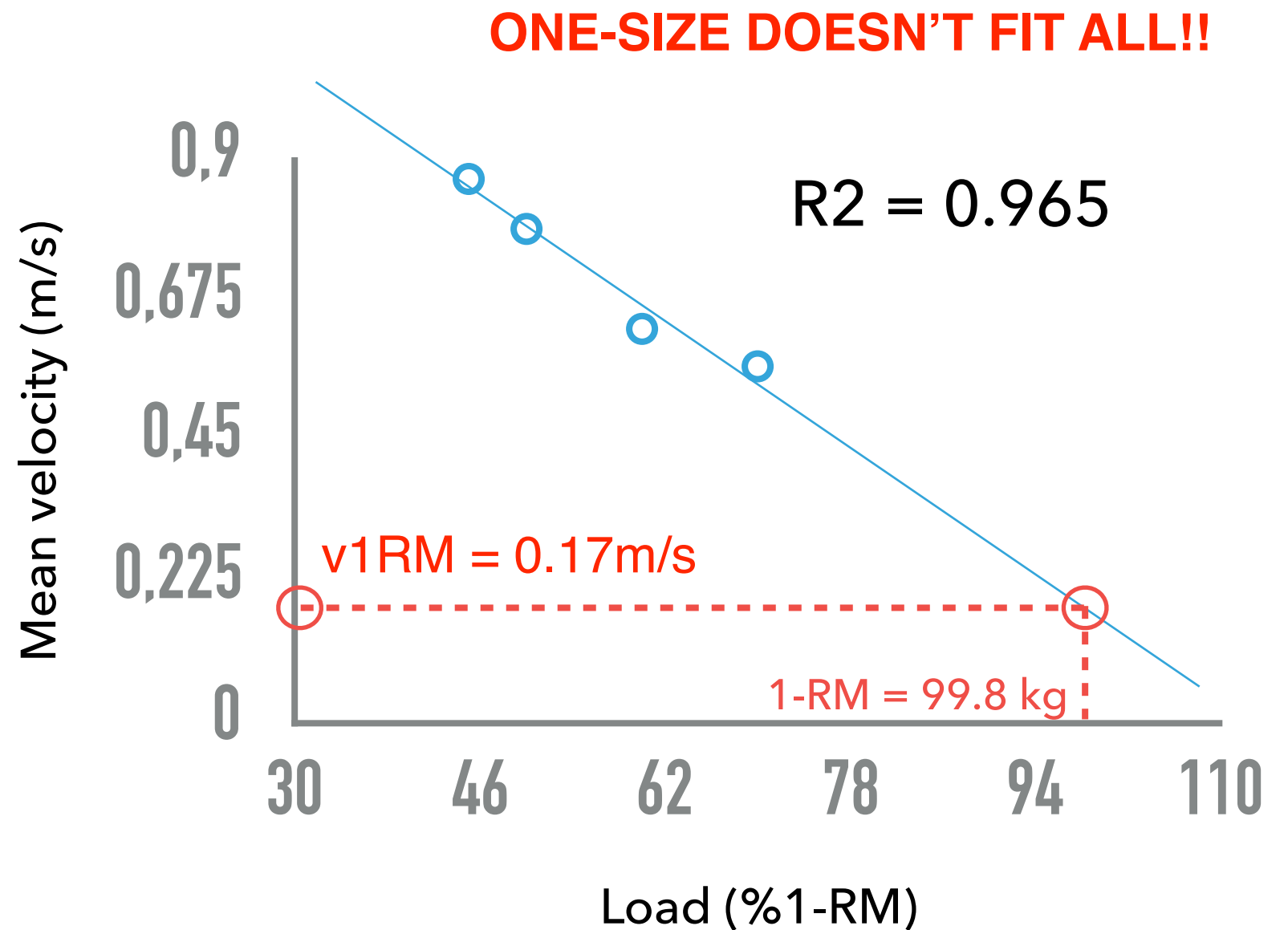
SOLUTION

STEP 1

STEP 1: INDIVIDUAL Load-velocity profiling



- Do an incremental test with 4-5 loads
- Measure the individual velocity with each load
- Plot the values to create the individual profile and **estimate 1-RM**
- **REPEAT EVERY 2 MONTHS**

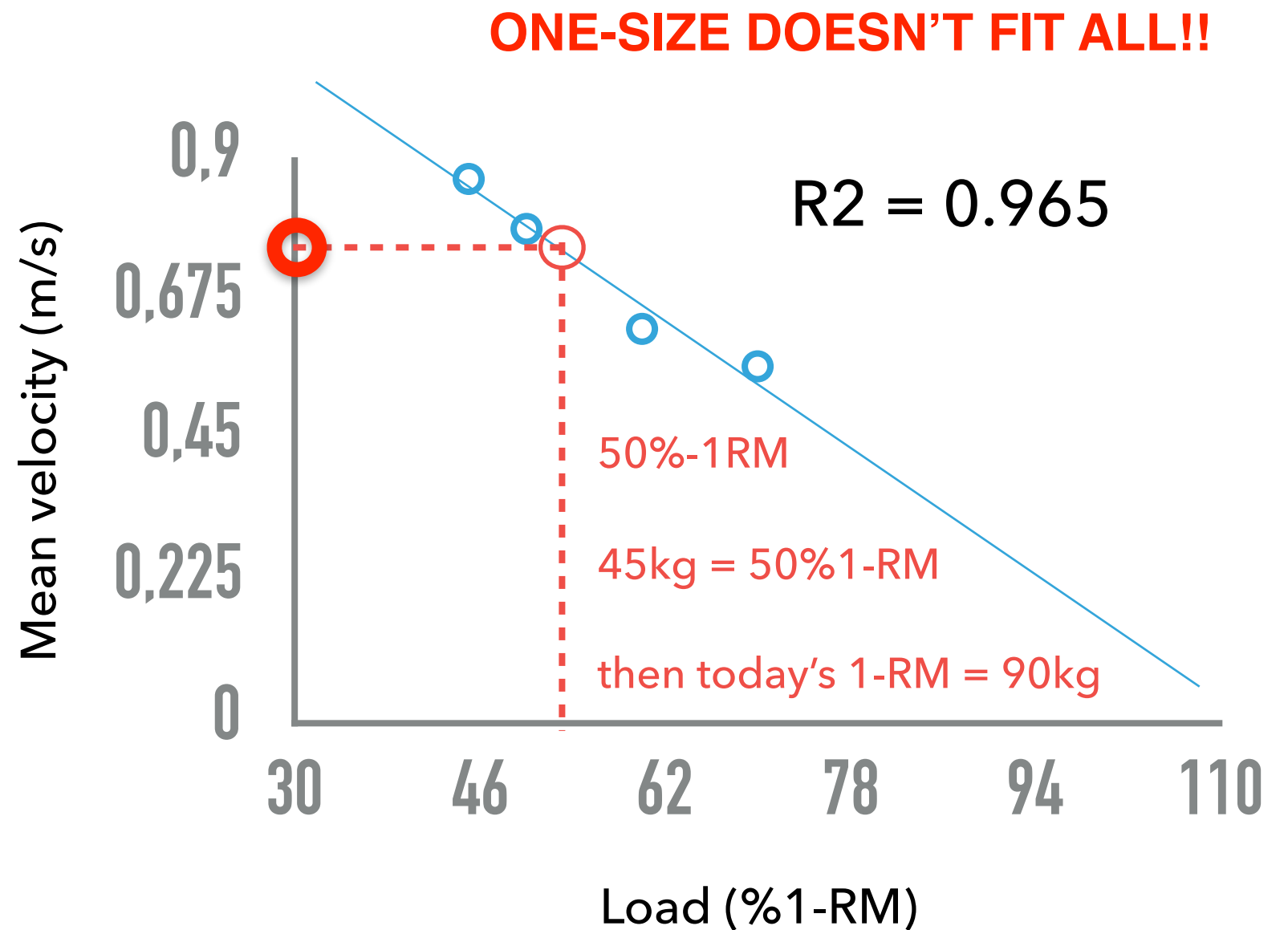


STEP 2

STEP 2: Daily estimation of 1-RM

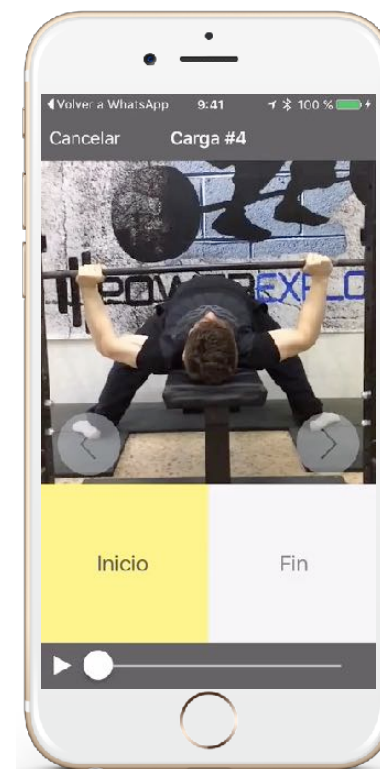


- Measure the individual velocity with ONE LOAD (i.e. 45kg)
- **Put that velocity in the individual profile and get the daily 1-RM**

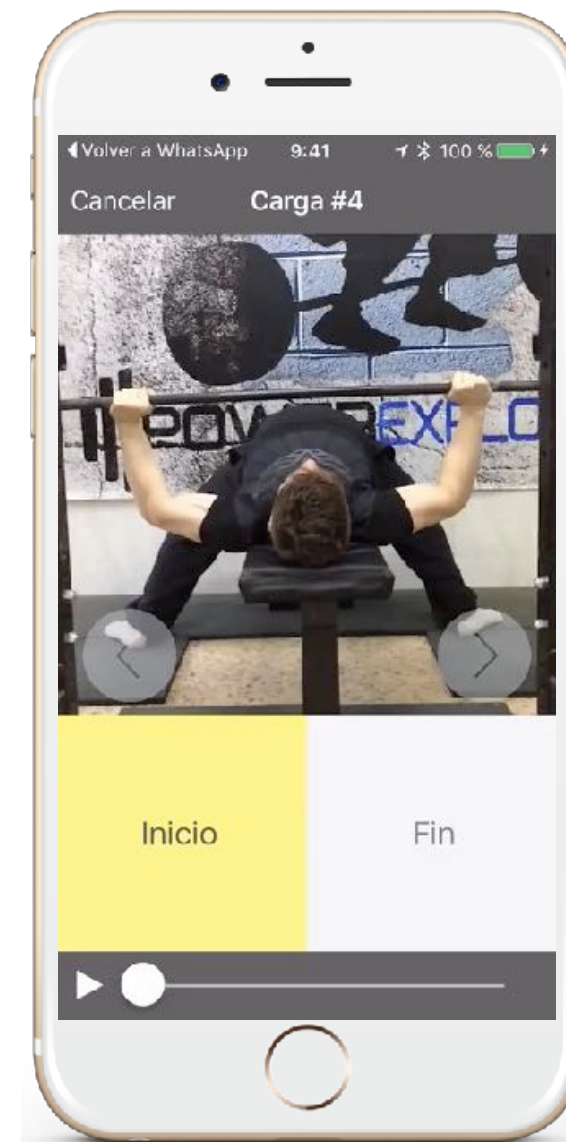




TECHNOLOGY

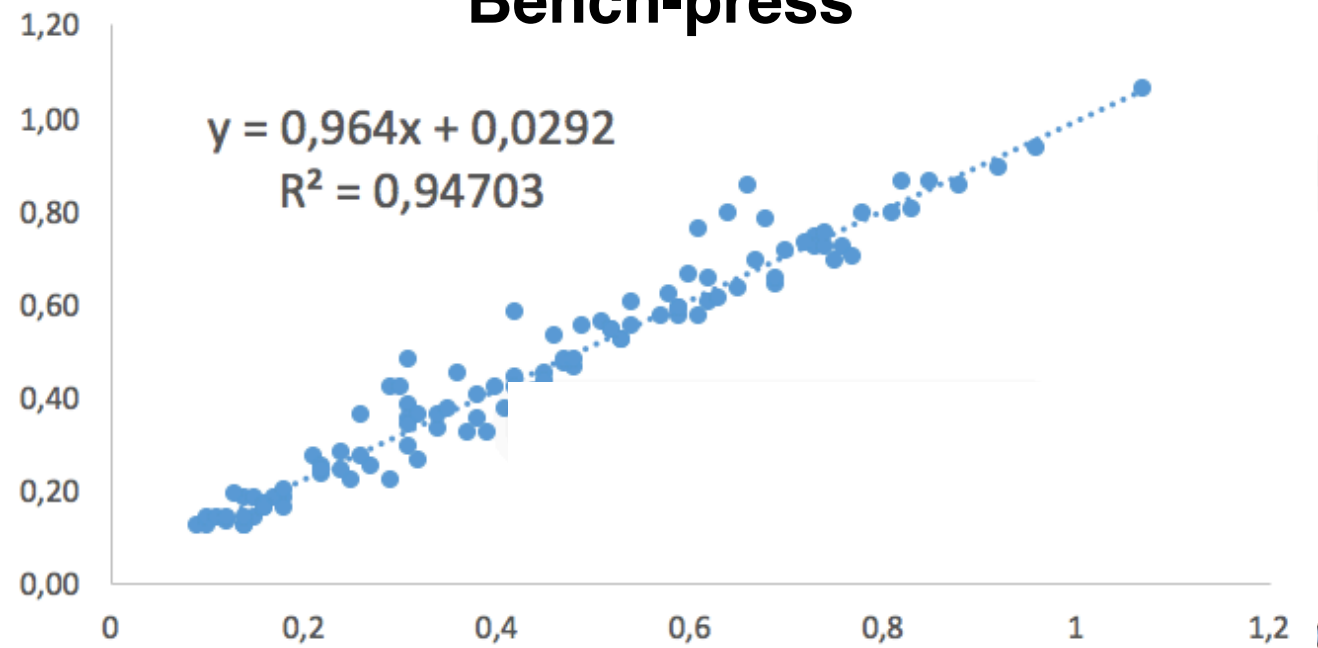


PowerLift

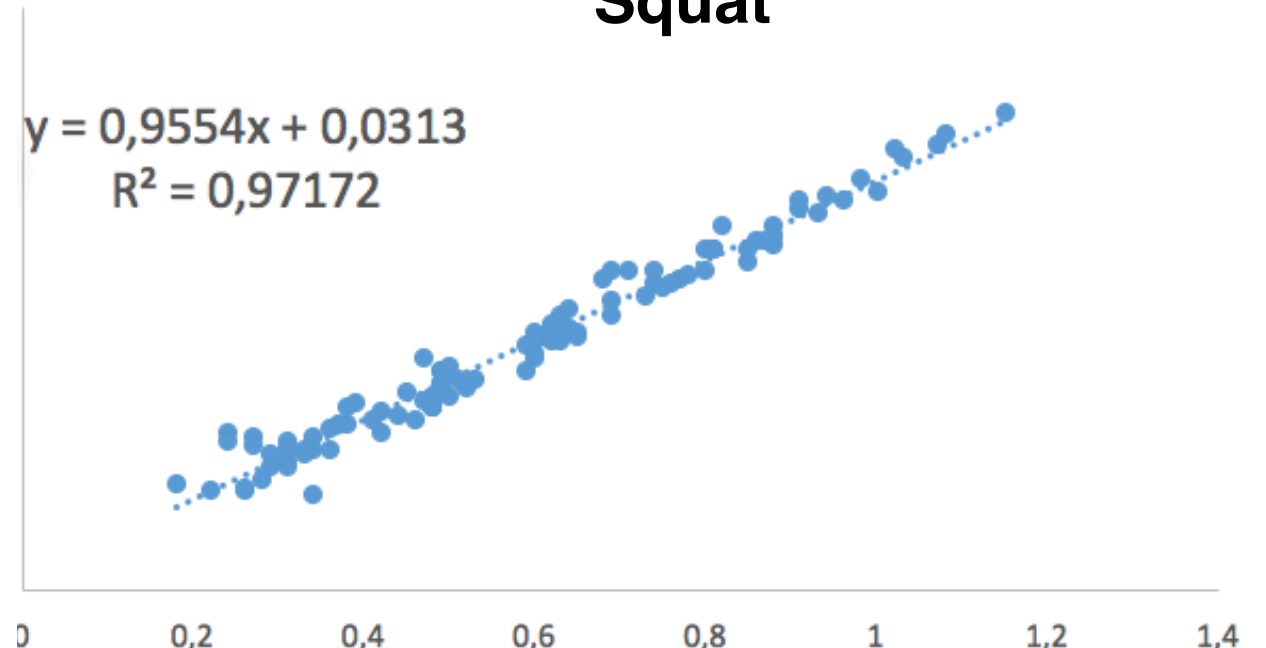


Estimates 1-RM by measuring barbell displacement velocity, using high-speed video analysis

Bench-press

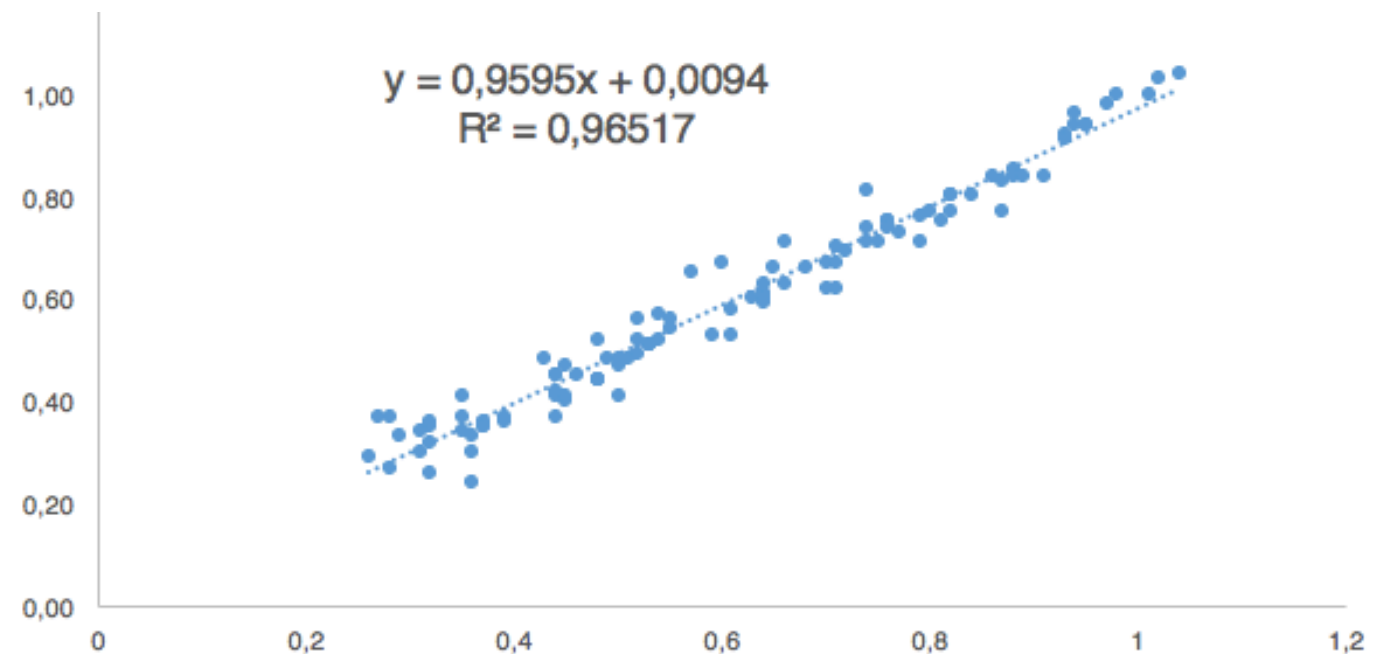


Squat



Balsalobre-Fernandez
 et al. 2017, Frontiers in
 Physiology

Hip-thrust



Differences encoder-PowerLift



0.01m/s

$r = 0.97$



0.005m/s

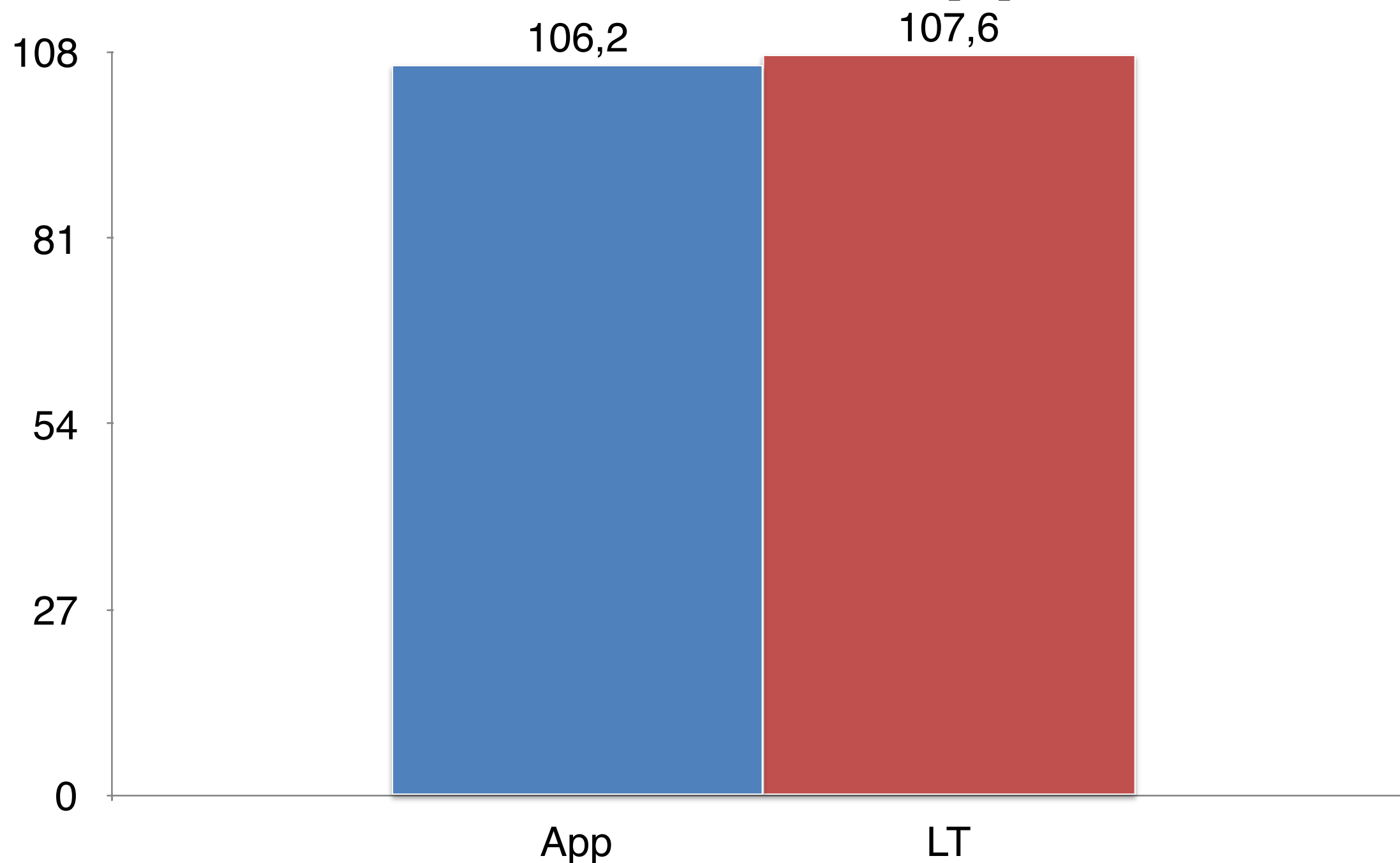
$r = 0.98$



0.02m/s

$r = 0.98$

Estimated 1-RM App vs LT



Barbell velocity

Jump FV profile

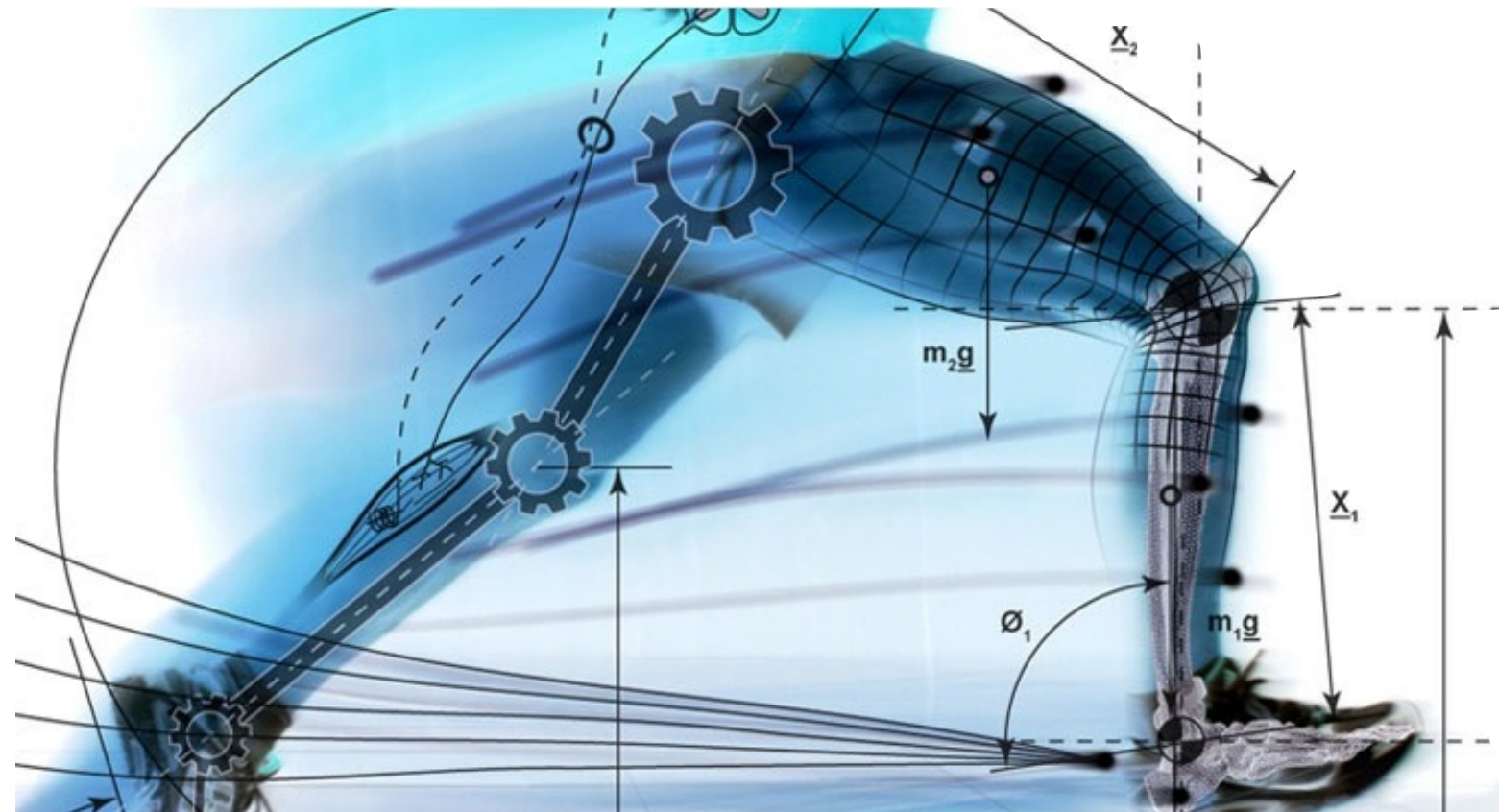


Running/sprinting

ROM

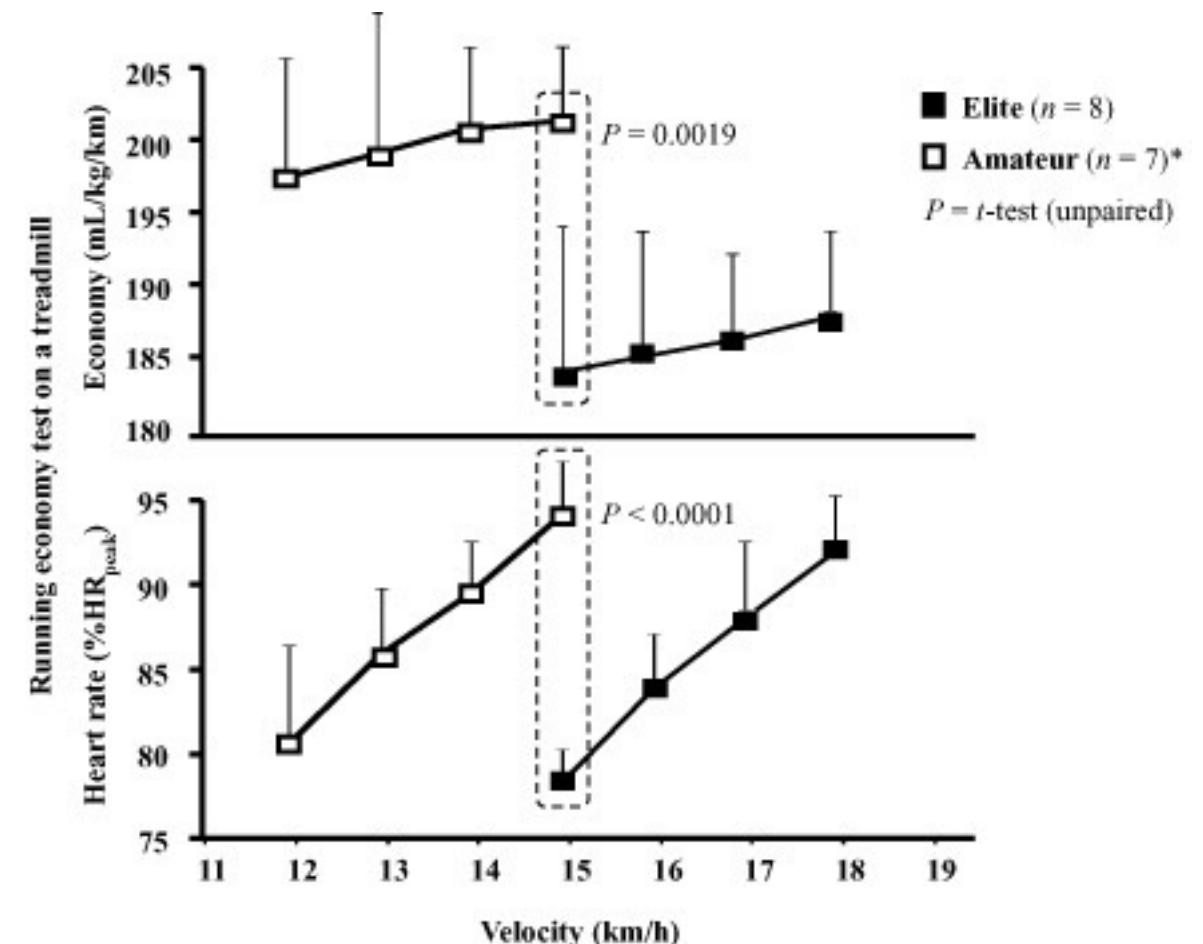
Running mechanics

- Analyze technique
efficiency-running
economy
- Analyze inter-limb
asymmetries AND
post injury scores



Running economy

- Oxygen consumption at a certain speed
- Changes in VO2Max not relevant in elite populations
- Performance more likely linked to exercise economy
- Running mechanics like contact time linked to RE
- **Lower** oxygen consumption for a given speed means **better** economy

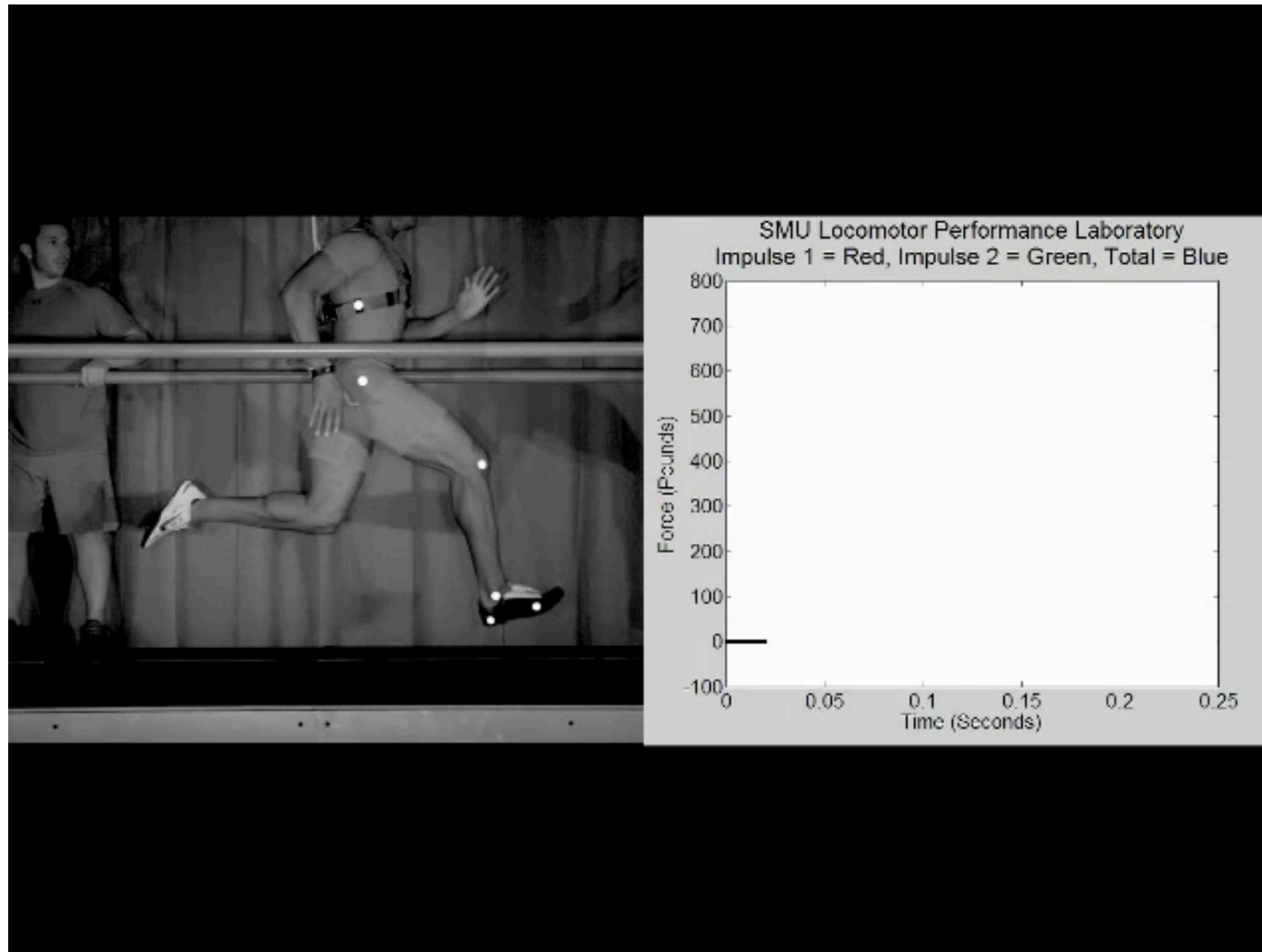


↑ Economy

↓ Effort for = speed

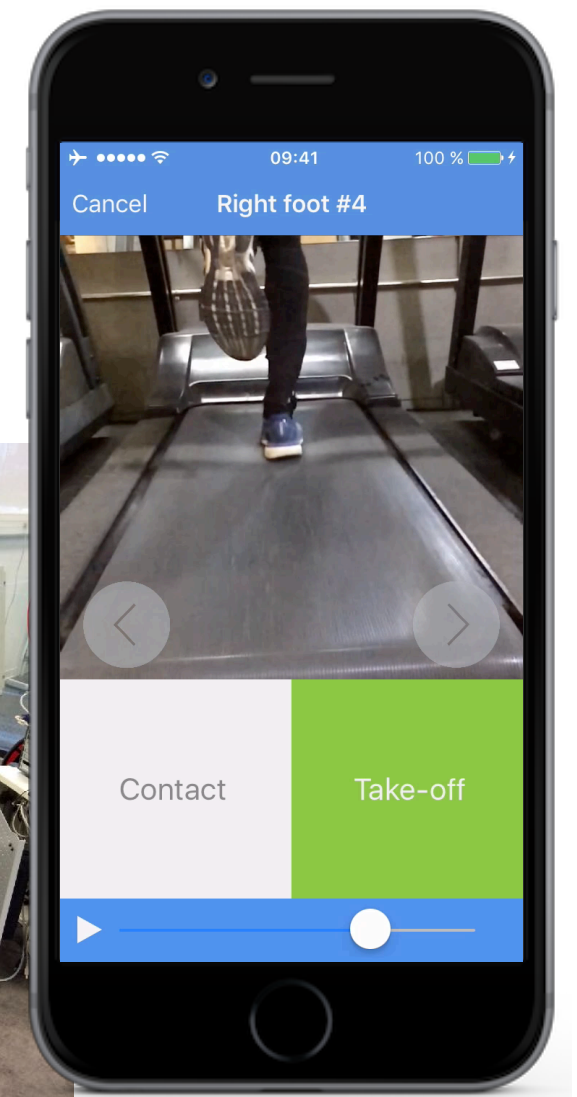
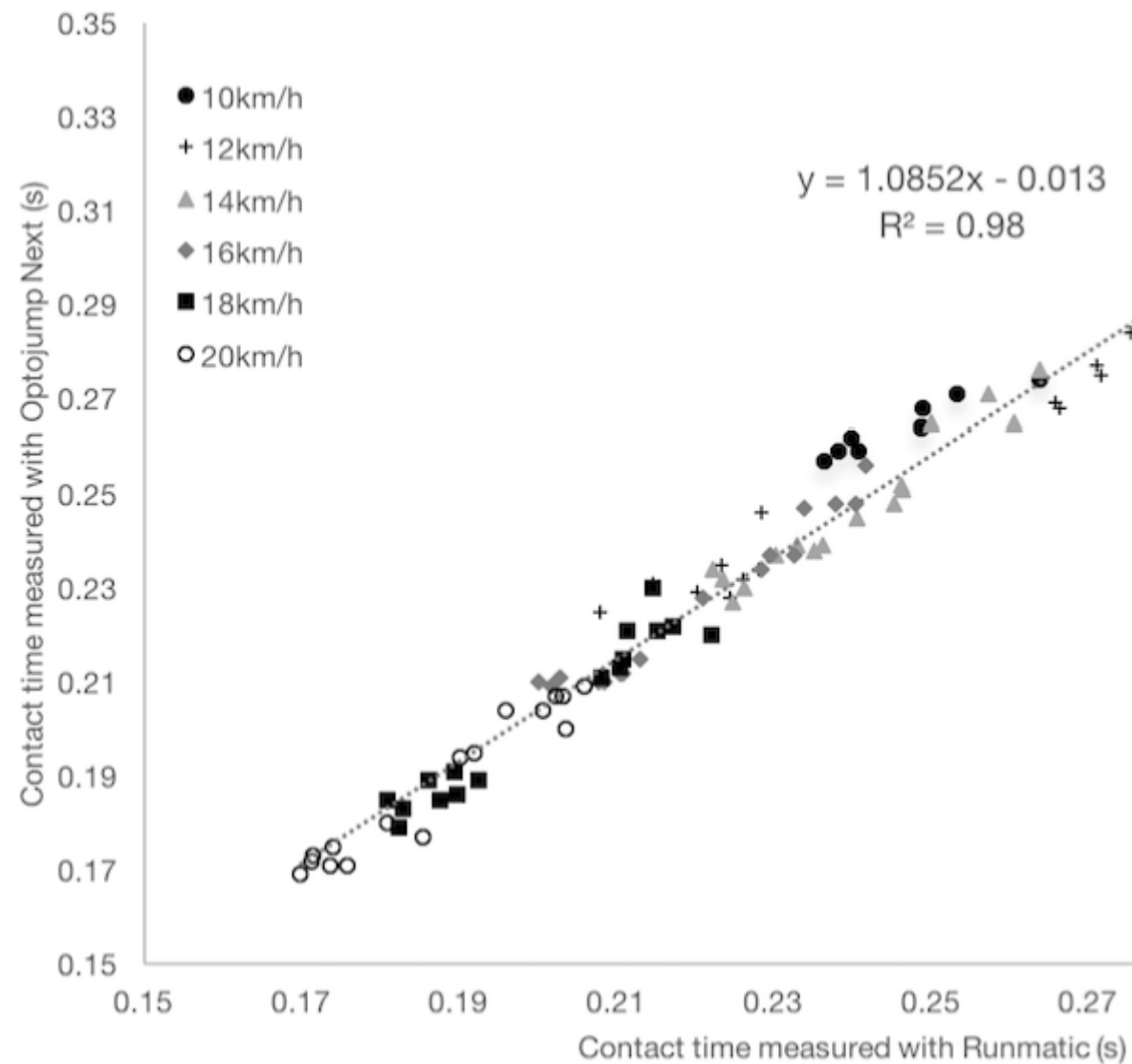
↑ Speed for = effort

How to measure running mechanics



Gold standard

How to measure running mechanics



Balsalobre-Fernández C, Agopyan H, Morin J-B. The Validity and Reliability of an iPhone App for Measuring Running Mechanics. *J Appl Biomech.* 2016 Dec 5;1–16.

Barbell velocity

Jump FV profile



Running/sprinting

ROM

Dorsiflexion

- Strong evidence have linked reduced dorsiflexion with increasing risk of lower limb injuries such as plantar fasciitis or ACL



Dorsiflexion

- Strong evidence have linked reduced dorsiflexion with increasing risk of lower limb injuries such as plantar fasciitis or ACL



Accepted Manuscript

Title: The Effect of Reduced Ankle Dorsiflexion on Lower Extremity Mechanics during Landing: A systematic review of the literature

Author: A.R. Mason-Mackay C. Whatman D. Reid



i.e. reduced dorsiflexion alters landing mechanics

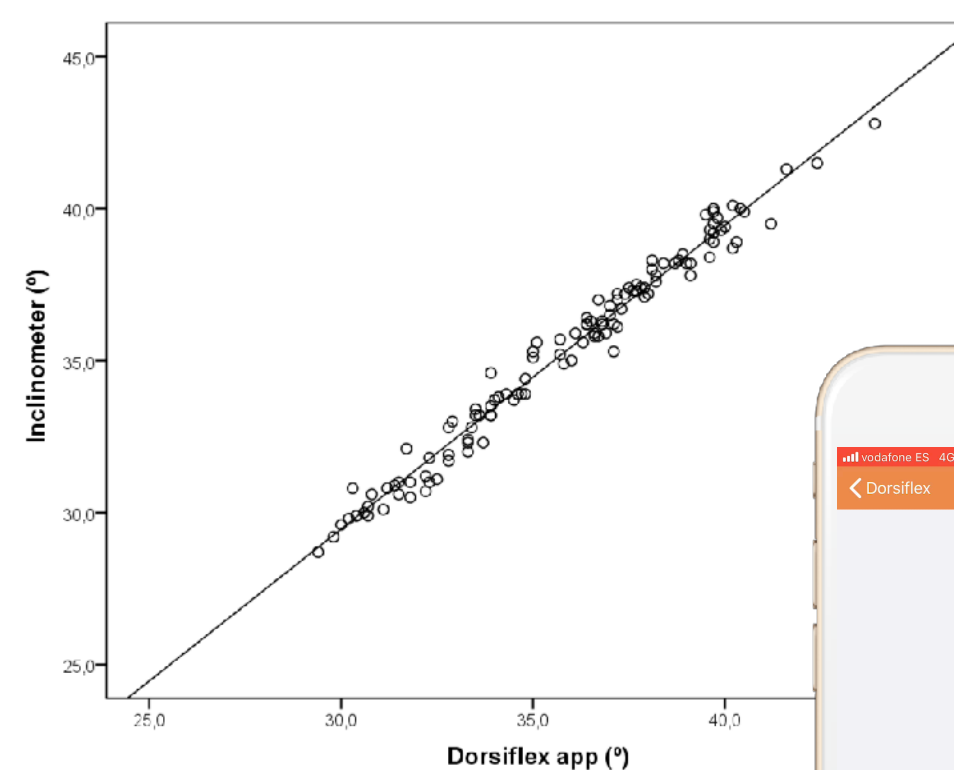
Dorsiflexion: Measurement

- Traditional: knee-to-wall test
- Distance between toes and wall
- Much more advanced and precise: goniometers.



Dorsiflex

- Measure dorsiflexion angles using 3D gyroscopes on the iPhone
- Highly valid and reliable in comparison with pro goniometers
- 0.5° difference
- $r = 0.99$
- iOS only



JOURNAL OF SPORTS SCIENCES
<https://doi.org/10.1080/02640414.2018.1494908>

 **Routledge**
Taylor & Francis Group

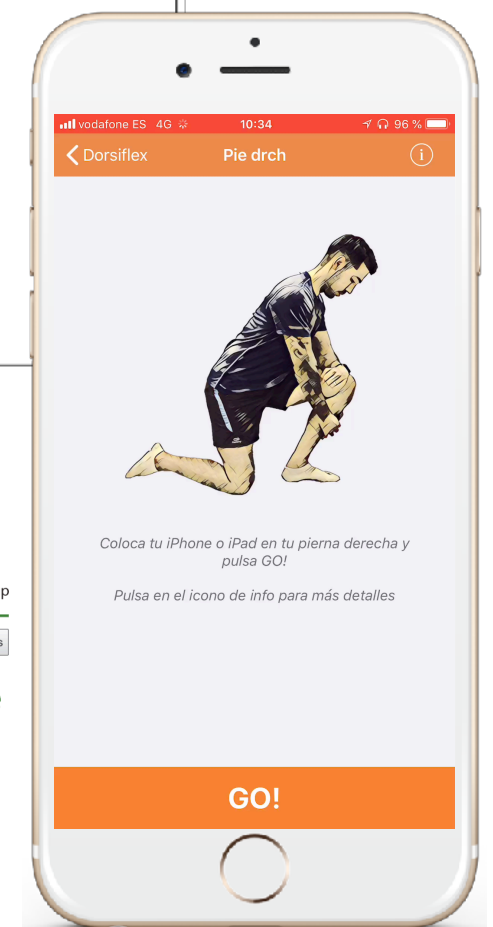
 Check for updates

Concurrent validity and reliability of an iPhone app for the measurement of ankle dorsiflexion and inter-limb asymmetries iPhone

Carlos Balsalobre-Fernández^{a,b}, Natalia Romero-Franco^c and Pedro Jiménez-Reyes^d

^aDepartment of Physical Education, Sport and Human Movement, Universidad Autónoma de Madrid, Madrid, Spain; ^bLaboratory of Exercise Physiology Research Group, Department of Health and Human Performance, School of Physical Activity and Sport Sciences-INEF, Universidad Politécnica de Madrid, Madrid, Spain; ^cNursing and Physiotherapy Department, University of the Balearic Islands, Palma de Mallorca, Spain;

^dFaculty of Sport, Catholic University of San Antonio, Murcia, Spain



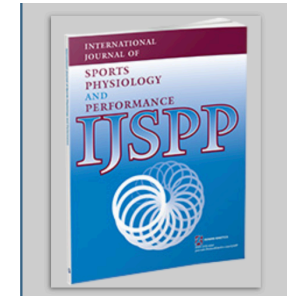
How to analyze the data...?



Putting the 'i' back in TEAM!

- Each athlete is a $N = 1$ population
- Coach doesn't want group trends
- Analyze individual trends (MBI, SPC, Mixed models)
- **IS HE/SHE READY TO PLAY OR NOT?**

INVITED COMMENTARY Putting the "I" Back in Team

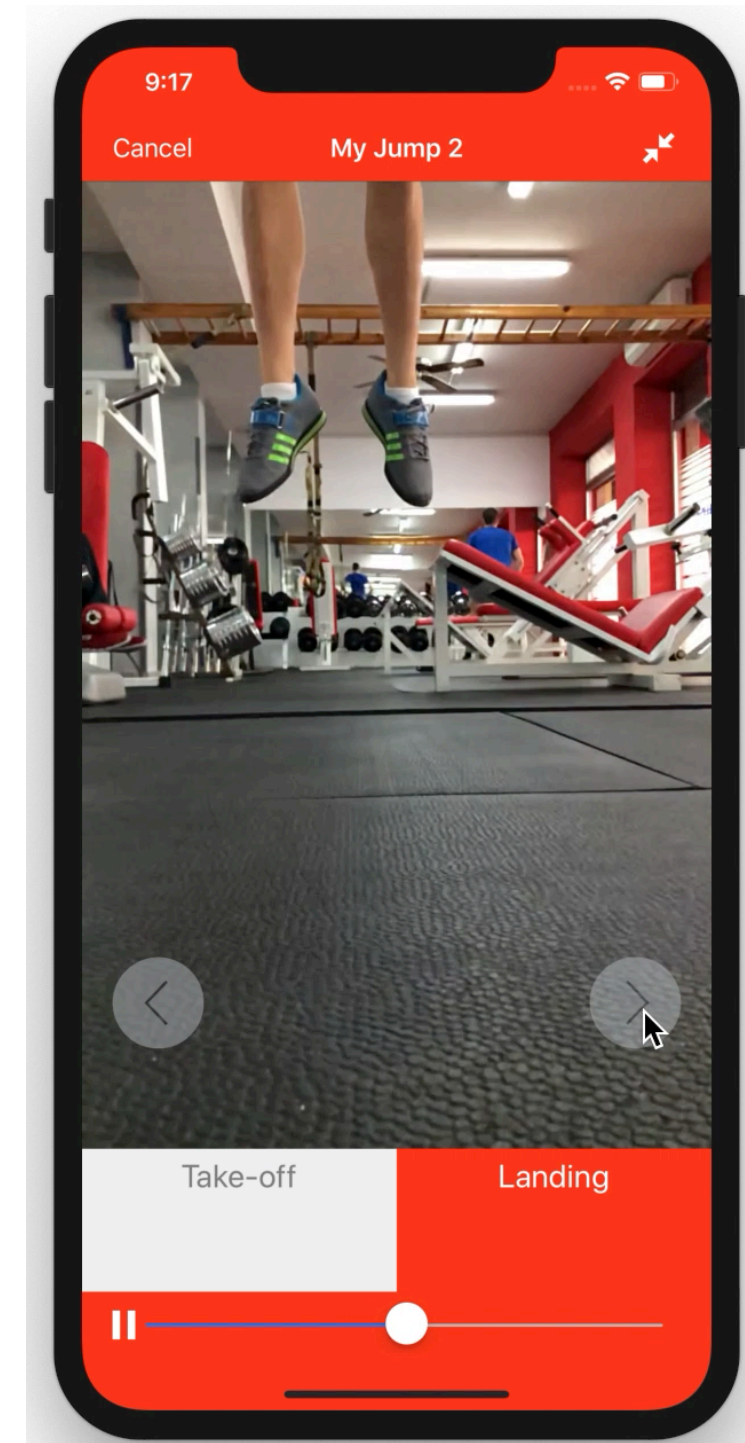


Authors: Patrick Ward, * Aaron J. Coutts, * Ricard Pruna, * and Alan McCall *

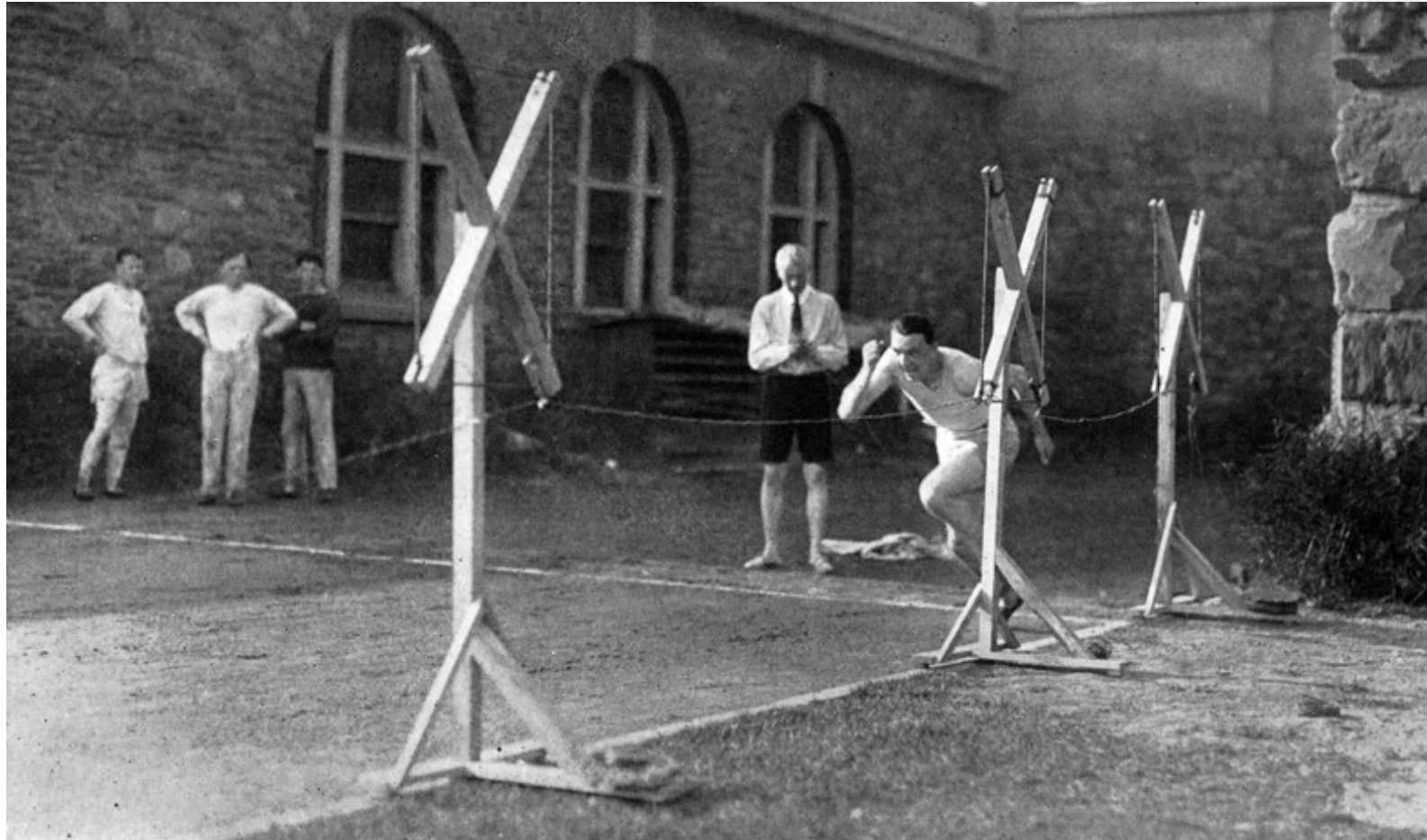


My implementation of this

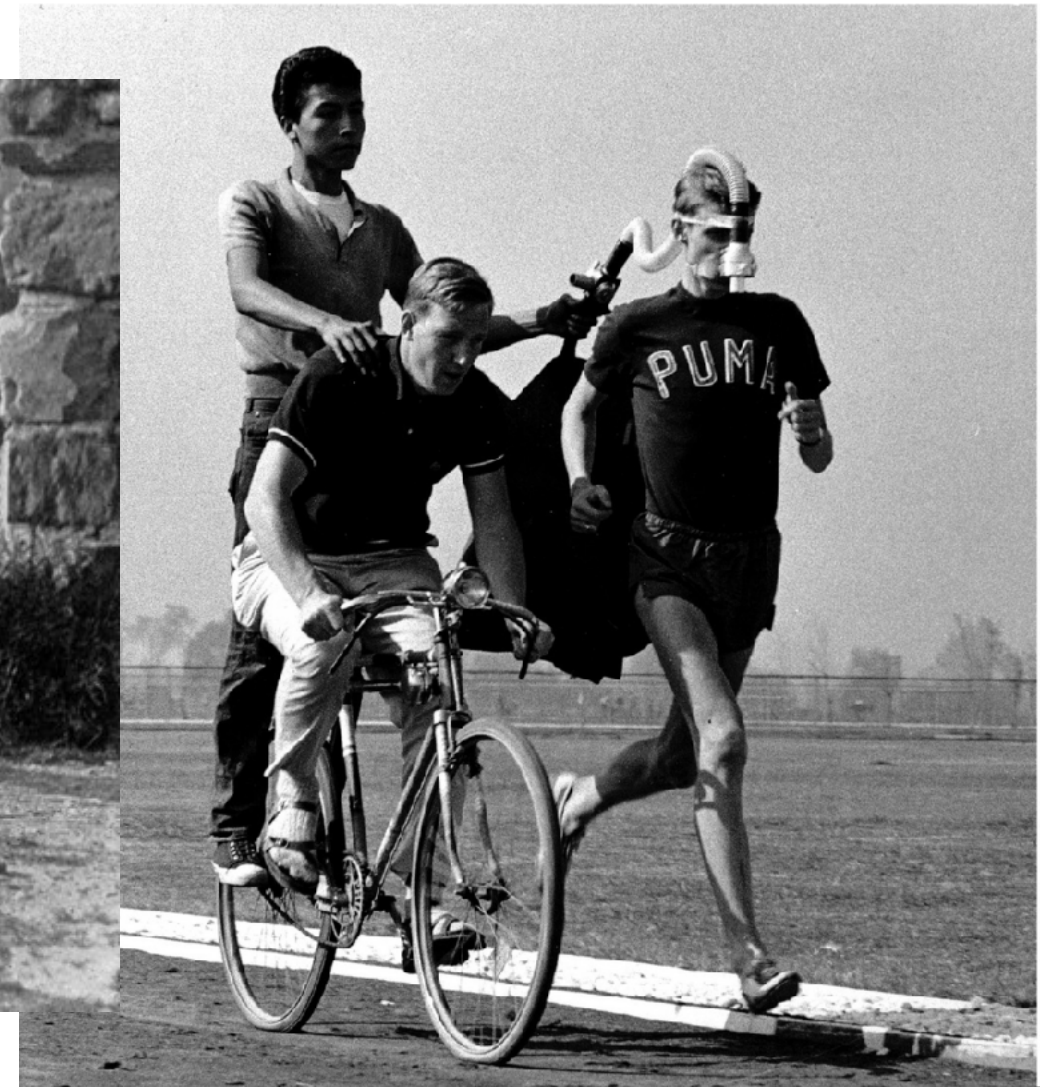
- Compare daily scores to average of prev 2 months
- If $> 1SD$, orange
- If $> 1.5SD$, red
- Otherwise you are OK
- (You can change these thresholds)



Not so long ago...



Hill, 1929



Saltin, 1965



2012

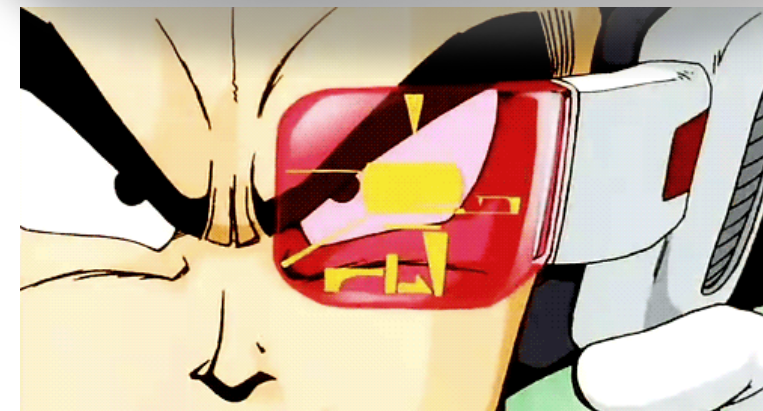


2018

Present & Future...



Wearables



Augmented reality

Augmented reality



Dr Adam Kiefer, Cincinnati Children's Hospital Medical Center



QUESTIONS?

carlos.balsalobre@icloud.com

