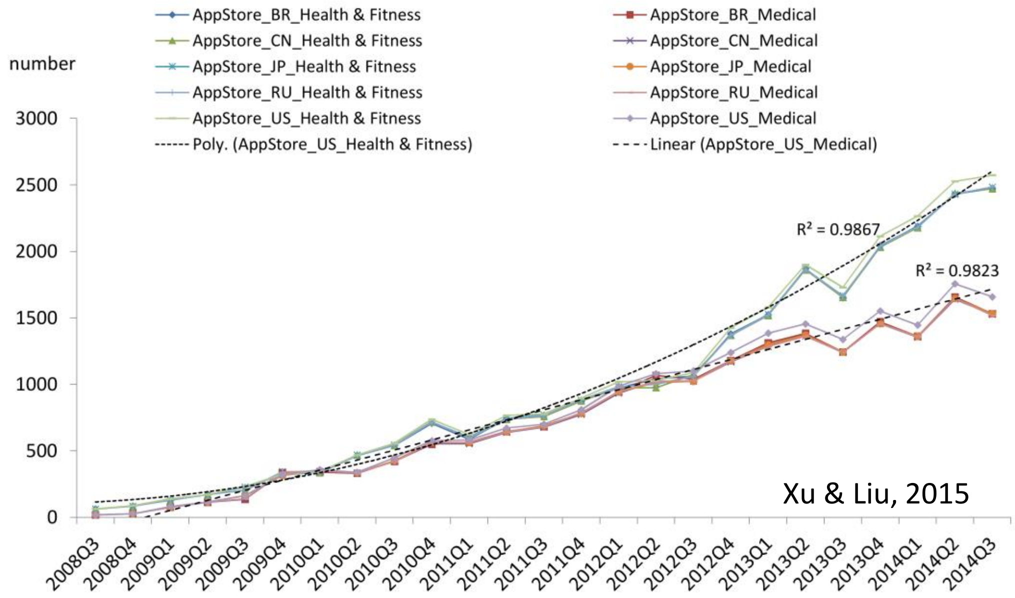
UNIVERSIDAD COMPLUTENSE MADRID

UNIVERSITAS Miguel Hernández

“Nuevas tecnologías aplicadas al ejercicio: Apps & Wearables”

Programa de Doctorado en Ingeniería informática (RD 99/2011)
Curso 2017-18
Profesor: José Manuel Sarabia Marín



Xu & Liu, 2015

> 60.000 APPs

Seguimiento

Gamificación

valoración

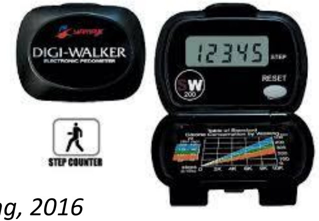
Social

Información rendimiento: Medición de distancia

Información rendimiento: Medición de distancia

r < 0,5

16-50% error



Leong, 2016

Table 2. Mean difference in step counts (pedometer application − tally counter) and mean absolute percent error (APE) for different smartphone locations and walking speeds.

Pedometer applications		RT		PW		TY	
Smartphone location	Speed (mph)	Steps difference	APE (%)	Steps difference	APE (%)	Steps difference	APE (%)
Pant pocket	2.0	−57.0 ± 55.3	26.00	−22.4 ± 81.8**	25.83	−3.8 ± 35.0***	9.06
	2.5	−33.0 ± 46.5	14.91	32.4 ± 40.7	14.84	6.3 ± 27.9**	5.32
	3.0	−21.9 ± 39.5	10.49	45.4 ± 25.0	14.78	5.6 ± 24.7**	4.38
	3.5	−23.3 ± 27.6	8.50	44.0 ± 27.5	14.05	3.0 ± 20.4***	3.85
	4.0	−21.9 ± 21.2	6.84	37.1 ± 25.4	11.57	1.4 ± 14.8***	2.80
Waist	2.0	−65.9 ± 52.7	28.13	−65.9 ± 84.4	33.95	−7.5 ± 53.0***	15.56
	2.5	−33.0 ± 48.3	16.66	−4.6 ± 62.9***	17.69	10.0 ± 23.4	5.88
	3.0	−32.6 ± 42.8	13.80	20.6 ± 40.7	12.26	8.0 ± 19.9	4.40
	3.5	−31.6 ± 27.2	10.69	32.4 ± 29.1	11.96	3.6 ± 13.8**	2.57
	4.0	−34.0 ± 21.5	10.00	44.9 ± 14.9	13.12	2.3 ± 11.0**	2.32
Arm	2.0	−92.4 ± 88.6	39.37	−150.1 ± 79.8	55.41	9.5 ± 63.3***	17.39
	2.5	−52.4 ± 65.9	22.09	−69.0 ± 93.4	30.92	16.7 ± 53.4*	13.12
	3.0	−42.1 ± 42.4	15.24	−33.6 ± 68.5	17.90	6.4 ± 25.1**	6.01
	3.5	−50.2 ± 42.9	15.25	1.2 ± 64.8***	14.15	5.1 ± 24.5**	4.76
	4.0	−49.8 ± 39.0	14.57	18.4 ± 55.4*	13.30	6.3 ± 13.1	3.06
Mean APE			16.84		19.70		6.72

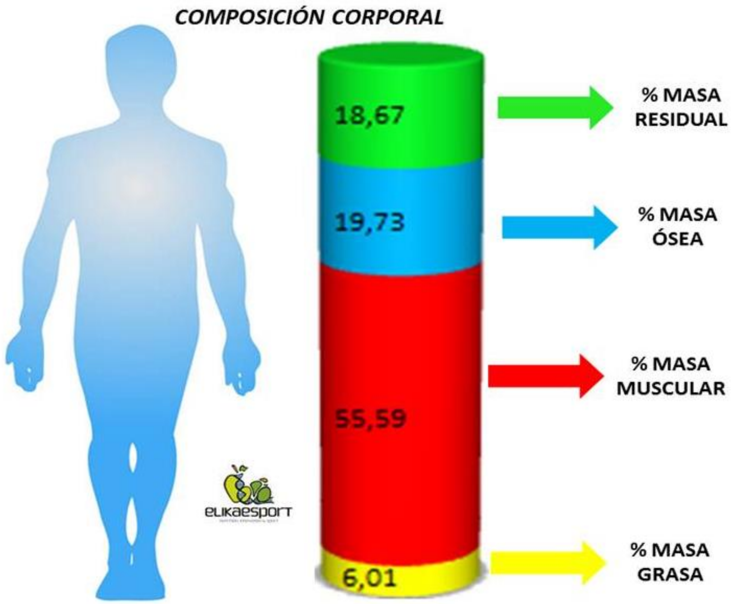
Negative values indicate underestimation and positive values indicate overestimation of mean step counts by a pedometer application relative to criterion count (tally counter).
Significant at $*P < 0.05$, $**P < 0.01$, and $***P < 0.001$ according to 95% equivalence tests between a pedometer application and tally counter step counts.
Abbreviations: TY, Pedometer Tayutau; PW, Pedometer Pacer Works; RT, Runtastic Pedometer

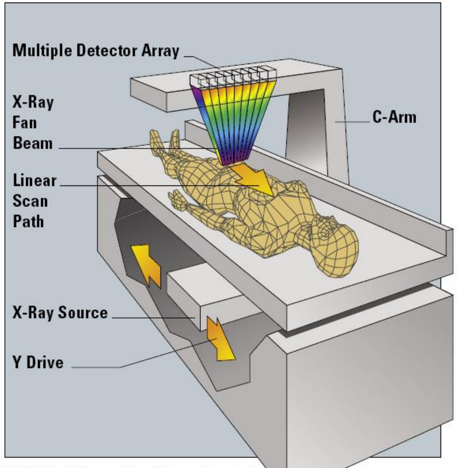
Table 3. Mean step counts and mean absolute percent error (APE) of three pedometer applications for weekdays and weekends in free-living settings.

	RT		PW		TY		Yamax
Pedometer applications	Mean ± SD	APE (%)	Mean ± SD	APE (%)	Mean ± SD	APE (%)	Mean ± SD
Overall	5712.4 ± 2023.7*	16.55	5842.7 ± 2240.8**	18.03	6382.0 ± 1955.9***	16.82	6317.6 ± 1569.4
Weekdays	5492.7 ± 1920.4*	15.45	5614.5 ± 2080.4**	16.93	6178.3 ± 1890.4***	15.53	6080.2 ± 1550.5
Weekend	6261.6 ± 3238.6*	20.89	6413.3 ± 3517.4**	22.71	6891.1 ± 3269.5***	21.24	6911.0 ± 2824.3

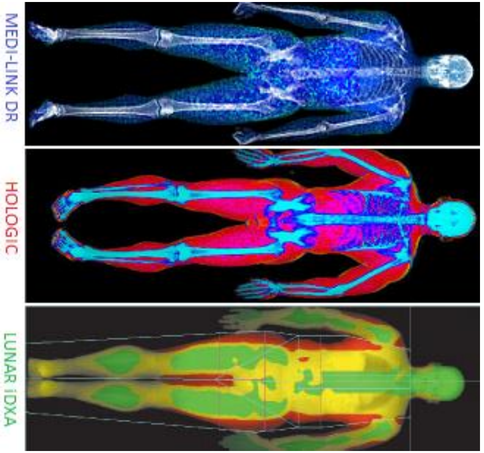
Significant at $*P < 0.05$, $**P < 0.01$, and $***P < 0.001$ according to 95% equivalence tests between a pedometer application and Yamax step counts.
Abbreviation: Yamax, Yamax Digiwalker CW-700; TY, Pedometer Tayutau; PW, Pedometer Pacer Works; RT, Runtastic Pedometer

Información Antropométrica





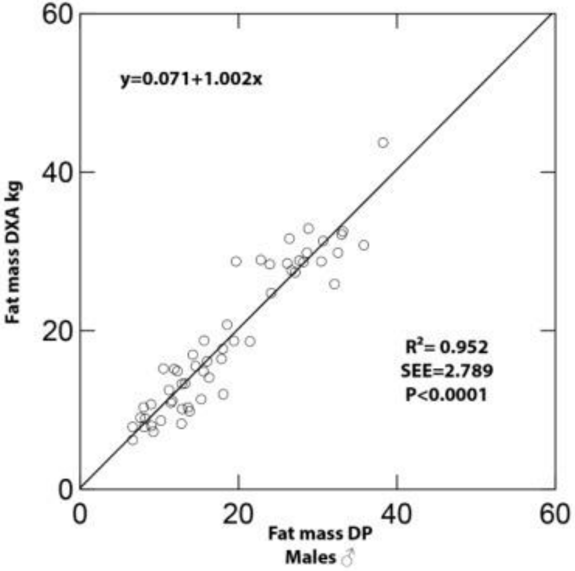
DEXA (Dual Energy Xray Absorptiometry)



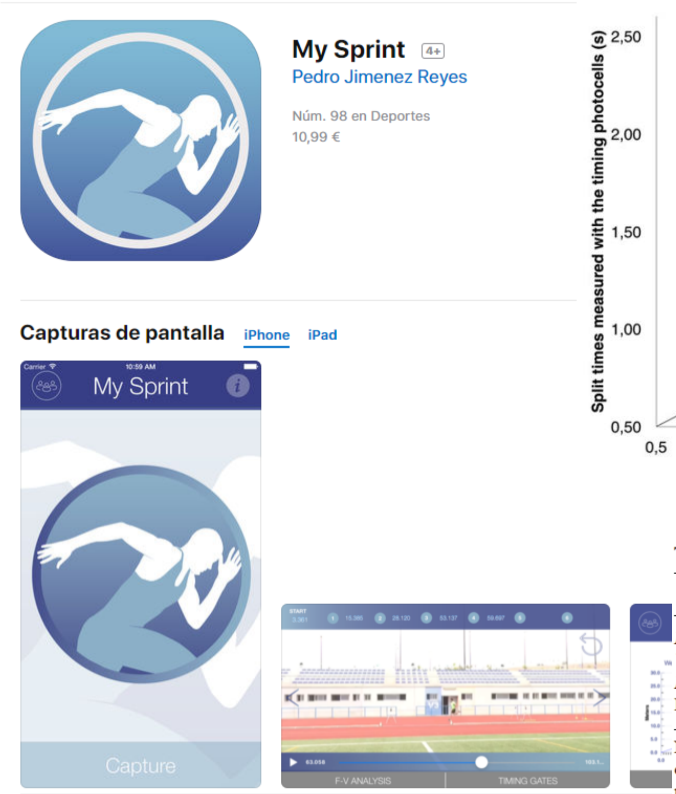
Información Antropométrica

(A) (B) (C) (D)

Farina , 2017



Información rendimiento: Velocidad / Aceleración



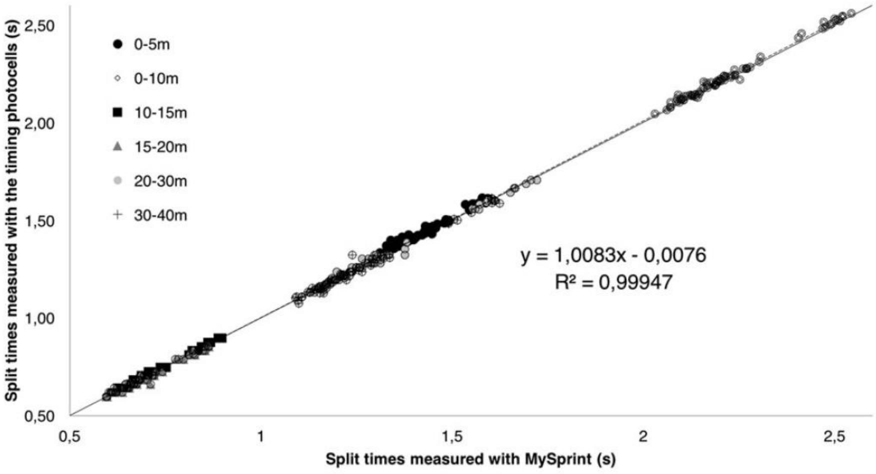


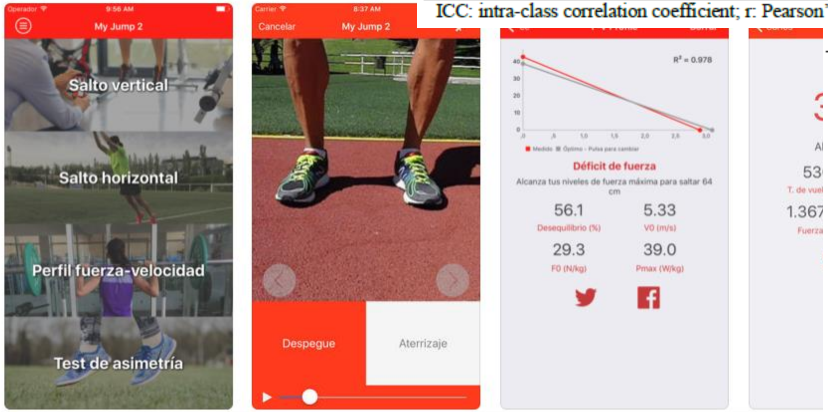
Table I. Concurrent validity and reliability of the radar gun vs. *MySprint* on the measurement of sprint mechanics

	Radar method	*MySprint* method	SEE	*r*	*s*	*i*	ICC (95% CI)
F_0 (N/kg)	6.8 ± 0.6	6.9 ± 0.6	0.09	0.999 (0.998–0.999)	1.04	−0.22	0.999 (0.999–1.000)
V_0 (m/s)	8.28 ± 1.0	8.35 ± 1.0	0.03	0.988 (0.974–0.999)	0.992	0.14	0.987 (0.979–0.992)
P_{max} (W/kg)	14.1 ± 2.4	14.5 ± 2.5	0.19	0.988 (0.974–0.999)	1.032	−0.09	0.998 (0.997–0.999)
DRF (%s/m)	−0.077 ± 0.01	−0.078 ± 0.01	0.001	0.994 (0.990–0.9979	0.97	−0.001	0.994 (0.991–0.996)

Notes: F_0, theoretical maximal force; V_0, theoretical maximal velocity; P_{max}, maximal power output; DRF, slope of the linear decrease on ratio of force as sprint velocity increases; *r*, Pearson's product–moment correlation coefficient; *s*, slope of the regression line; *i*, *y*-intercept of the regression line; ICC, intraclass correlation coefficient; CI, confidence interval; SEE, standard error of estimate.

Romero-Franco, 2016

Información rendimiento: Capacidad de salto



Balsalobre-Fernández, 2017; Gallardo-Fuentes, 2016; Stanton, 2016

Table 1. Jump performance measured with app and contact platform.

	First measurement day					Second measurement day				
	My Jump app	Contact platform	ICC	r	Mean difference (cm)	*My Jump* app	Contact platform	ICC	r	Mean difference (cm)
Squat jump (cm)										
All	35.7 ± 9.1	35.8 ± 8.8	0.99	0.99	0.1 ± 0.7	34.6 ± 9.1	34.9 ± 8.6	0.98	0.99	0.1 ± 1.1
Male	37.9 ± 5.6	37.7 ± 5.7	0.99	0.99	0.1 ± 0.5	36.4 ± 6.1	36.6 ± 6.1	0.98	0.99	-0.1 ± 0.8
Female	28.1 ± 5.0	28.5 ± 5.3	0.97	0.98	0.1 ± 0.9	27.7 ± 7.2	28.4 ± 5.5	0.98	0.96	0.5 ± 1.4
Countermovement jump (cm)										
All	37.0 ± 10.3	37.1 ± 9.9	0.99	0.99	0.0 ± 0.7	36.8 ± 9.5	36.8 ± 9.3	0.99	0.99	0.1 ± 1.0
Male	40.0 ± 7.0	40.0 ± 6.9	0.99	0.99	0.0 ± 0.6	39.2 ± 6.7	39.2 ± 6.7	0.99	0.99	-0.2 ± 0.7
Female	28.0 ± 5.6	28.4 ± 5.7	0.98	0.98	0.1 ± 0.9	29.1 ± 5.9	29.2 ± 5.8	0.98	0.97	0.5 ± 1.4
40 cm drop jump (cm)										
All	31.6 ± 5.9	31.5 ± 5.9	0.99	0.99	0.1 ± 0.8	31.6 ± 7.0	31.7 ± 7.0	0.99	0.99	-0.1 ± 0.7
Male	33.2 ± 5.4	33.2 ± 5.4	0.99	0.99	0.0 ± 0.8	33.5 ± 6.2	33.5 ± 6.2	0.99	0.99	-0.1 ± 0.7
Female	28.1 ± 2.8	27.9 ± 2.9	0.98	0.98	0.1 ± 0.7	27.7 ± 4.8	27.7 ± 4.7	0.99	0.97	-0.2 ± 0.7

ICC: intra-class correlation coefficient; r: Pearson's product moment correlation coefficient.

Table 2. Intra and inter-session reliability of both the *My Jump* app and contact platform.

	My Jump app			Contact platform		
	Intra-session		*Inter-session*	*Intra-session*		*Inter-session*
	α	CV	r	α	CV	r
Squat jump (cm)						
All	0.99	4.82-5.58	0.90	0.99	5.46-6.18	0.90
Male	0.97	5.35-5.63	0.82	0.97	5.54-6.04	0.82
Female	0.98	3.77-5.48	0.93	0.97	5.30-6.46	0.91
Countermovement jump (cm)						
All	0.99	4.63-5.46	0.95	0.99	5.34-5.59	0.95
Male	0.99	4.38-4.64	0.93	0.99	4.65-4.74	0.93
Female	0.99	4.59-7.60	0.86	0.98	6.53-7.50	0.85
40 cm drop jump (cm)						
All	0.98	6.06-6.13	0.87	0.98	5.88-5.91	0.86
Male	0.96	6.05-6.57	0.84	0.96	5.82-6.35	0.84
Female	0.94	5.20-6.06	0.76	0.94	5.00-6.02	0.74

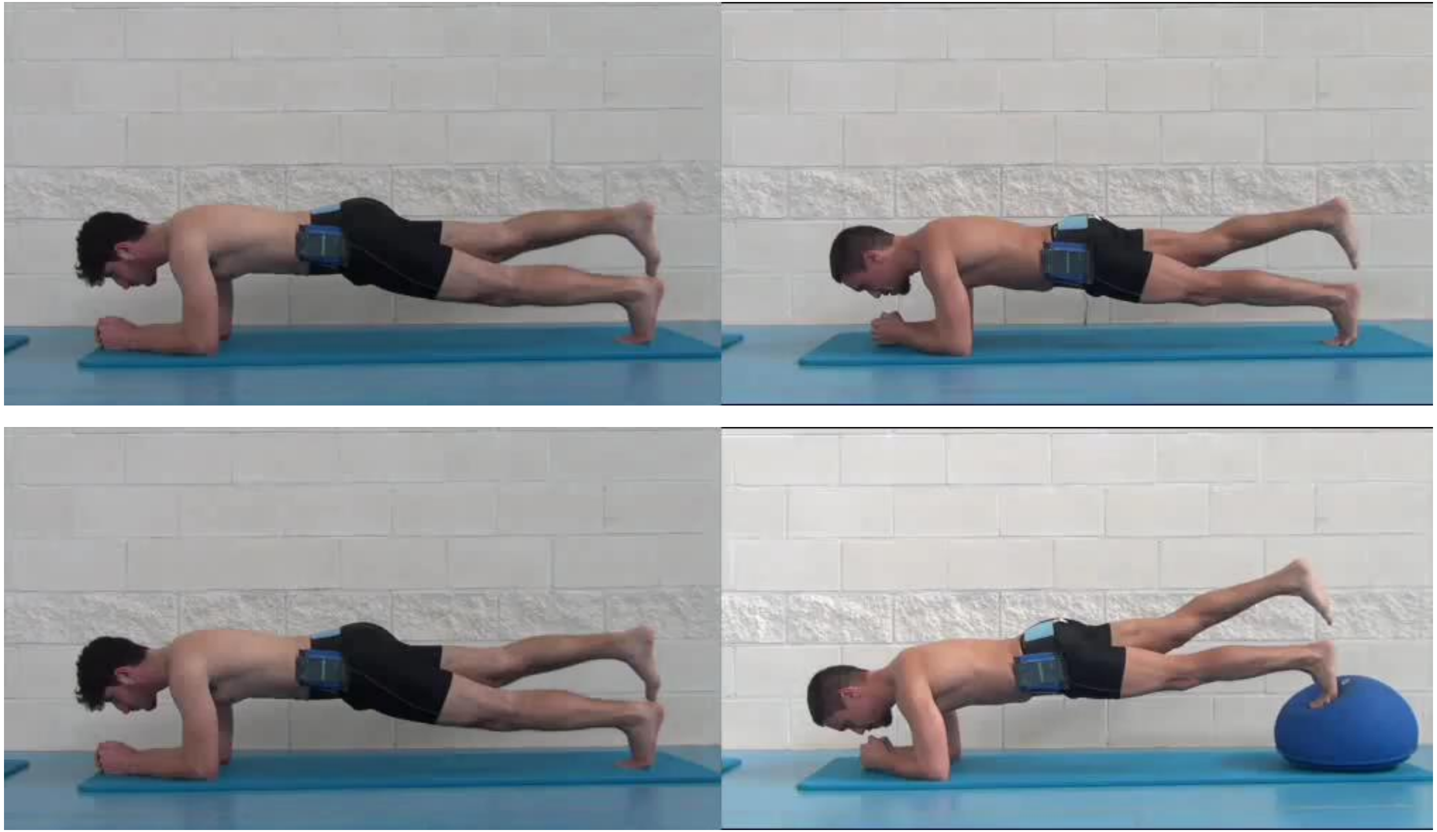
α: Cronbach's alpha; CV: coefficient of variation; r: Pearson's product moment correlation coefficient.

F.I.T.T. PRINCIPLE

FREQUENCY | INTENSITY | TYPE | TIME

Introducción: Valoración de la condición física o el entrenamiento

Estabilidad del tronco



Fuerza Máxima

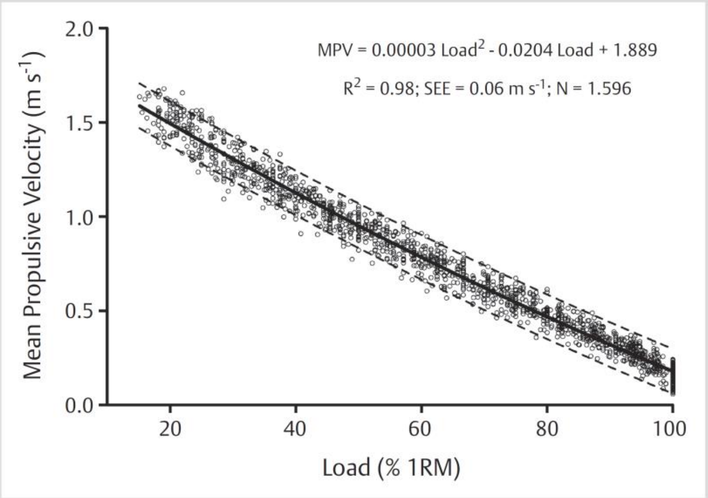


Fig. 1 Relationship between relative load (% 1RM) and MPV directly obtained from 1 596 raw data derived from the 176 incremental tests performed in the BP exercise. Solid line shows the fitted curve to the data, and the dotted lines indicate limits within which 95 % of predictions will fall.

González-Badillo & Sánchez-Medina, 2010

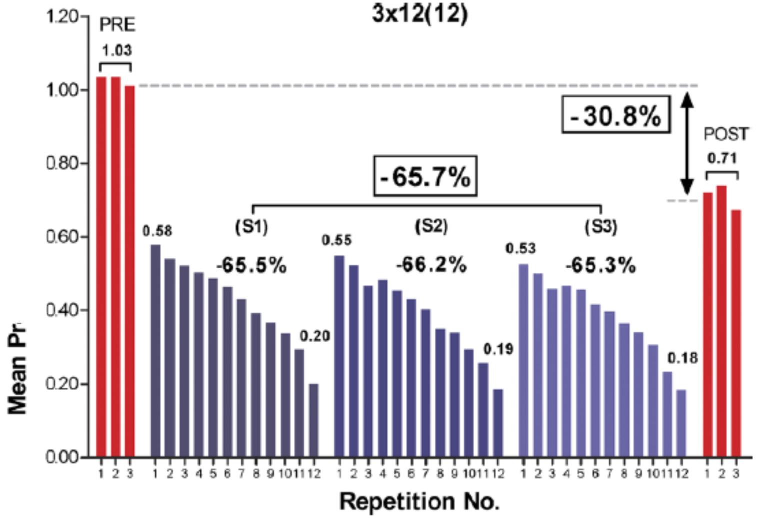


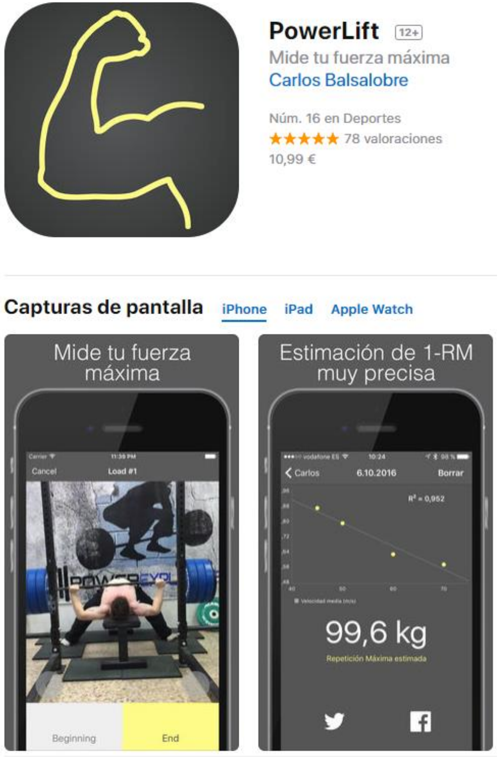
FIGURE 1—Example of quantification of percent velocity losses after a 3 × 12[12] REP for a representative subject in the BP exercise. Both MPV loss over three sets (−65.7%) and MPV pre–post exercise against the $V_{1\ m\cdot s^{-1}}$ load (−30.8%) were calculated.

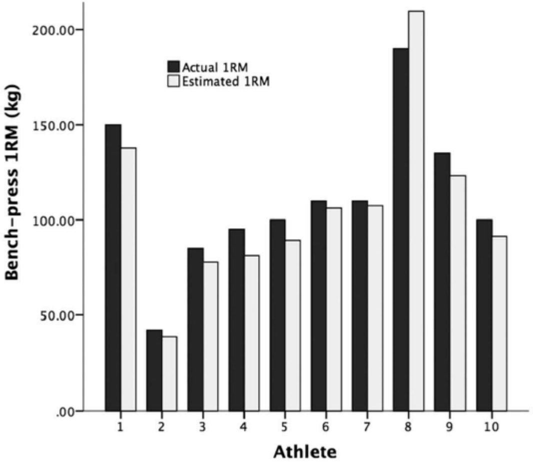
Sánchez-Medina & González-Badillo, 2011

Fuerza Máxima

Balsalobre-Fernández et al., 2016

Fuerza Máxima





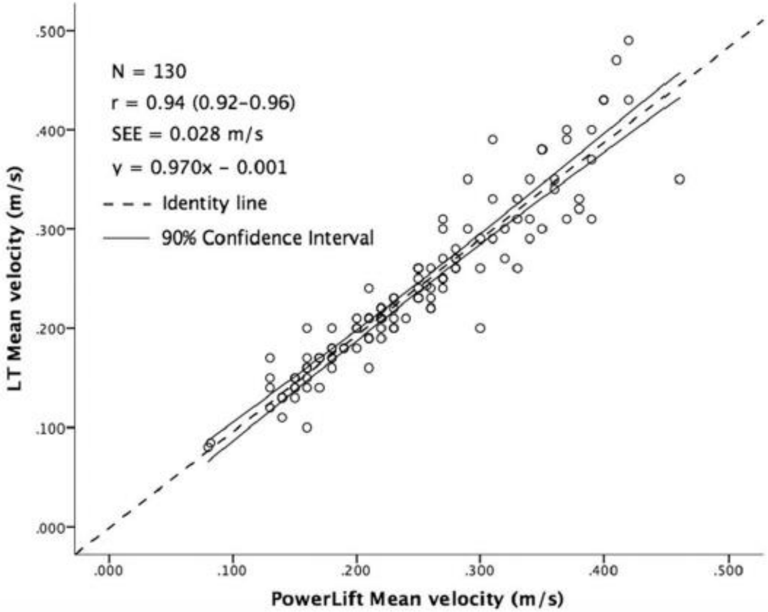
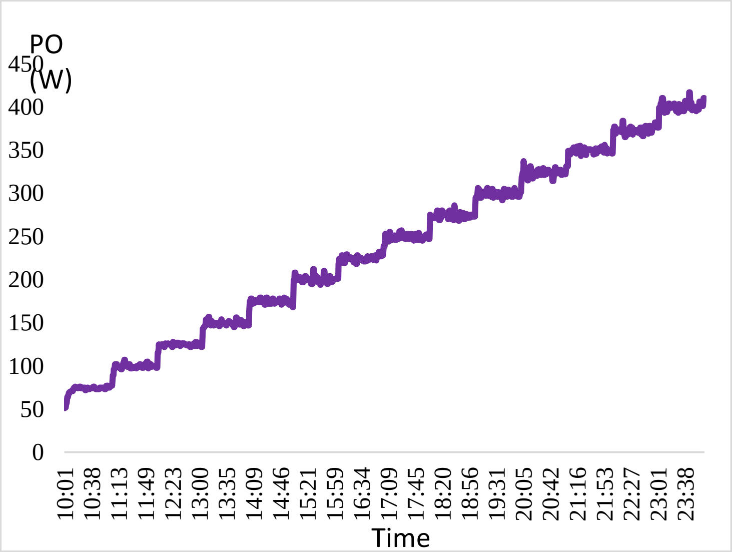


Figure 2. Concurrent validity between PowerLift's and linear transducer's mean velocity. LT = linear transducer.

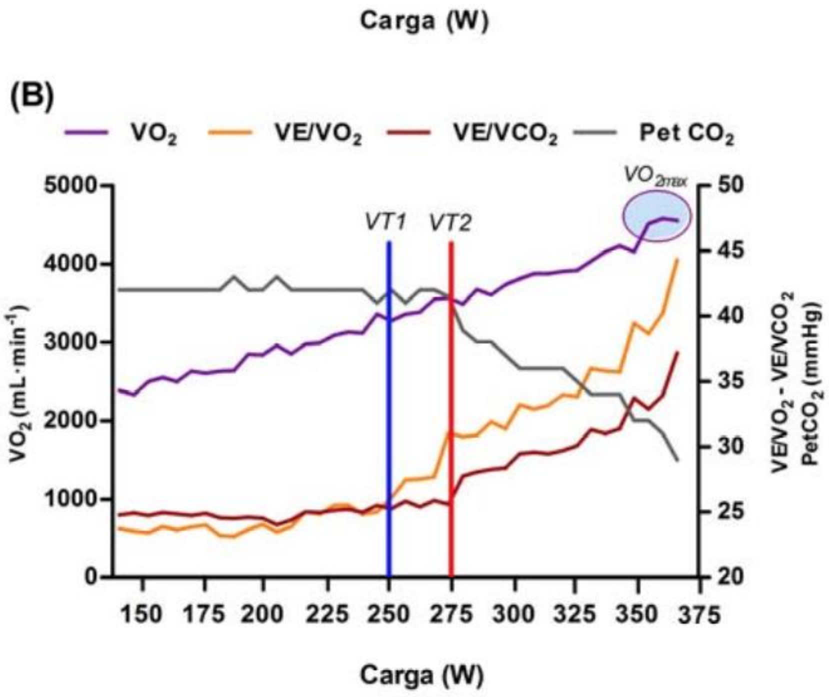
Balsalobre-Fernández, 2017

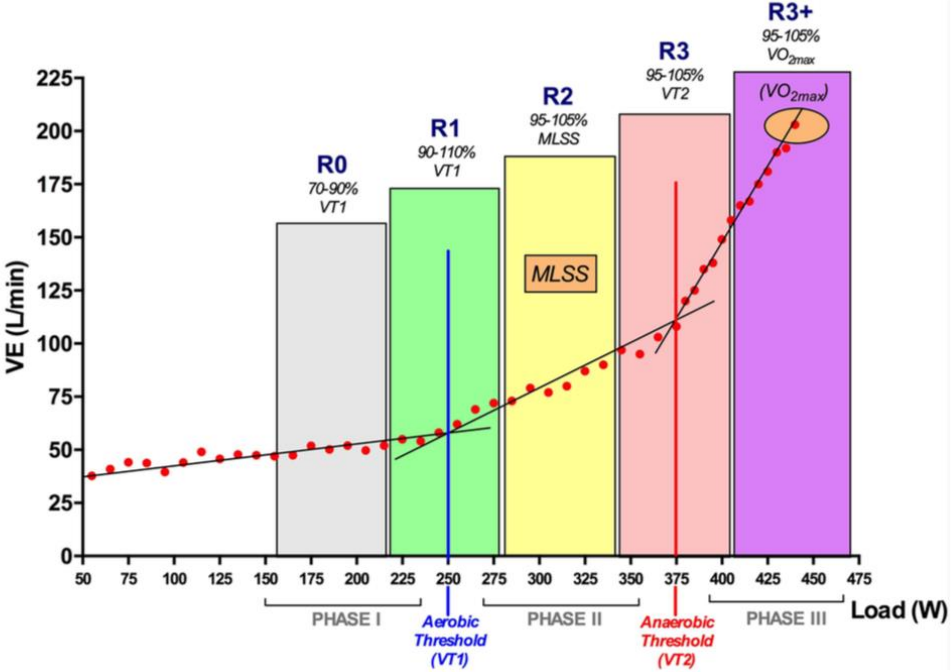
Determinación de umbrales de esfuerzo

Graded Exercise Test (GXT) o test incremental



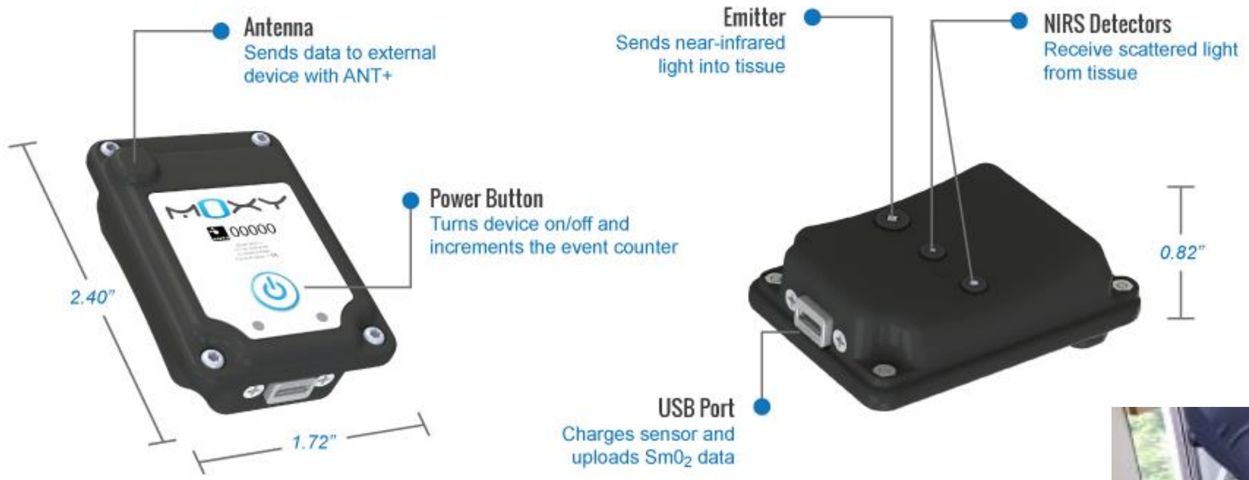
Determinación de umbrales de esfuerzo



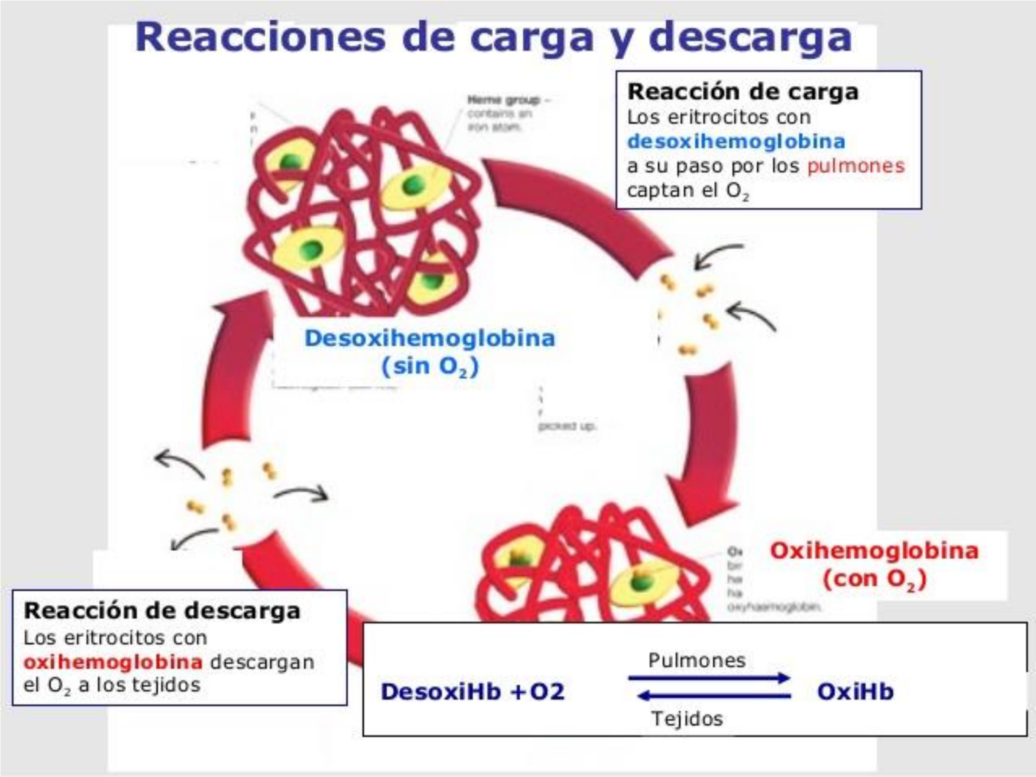


Pallarés, 2016

Determinación de umbrales de esfuerzo

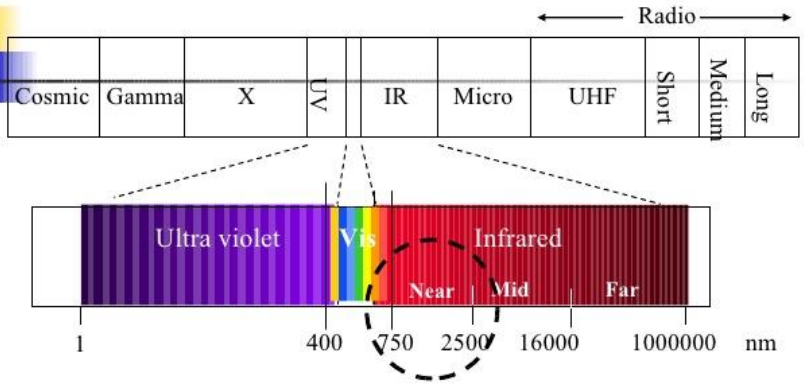


Determinación de umbrales de esfuerzo



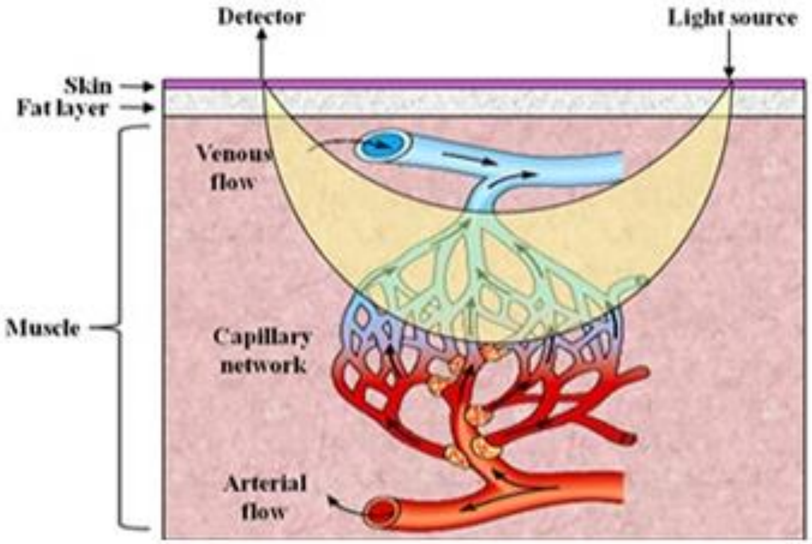
Determinación de umbrales de esfuerzo

NIR Spectra

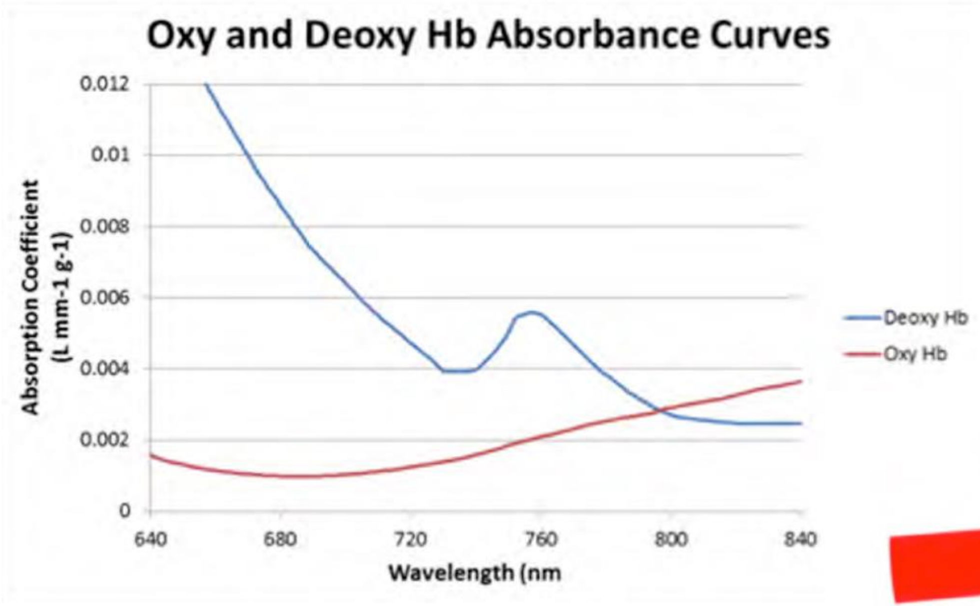


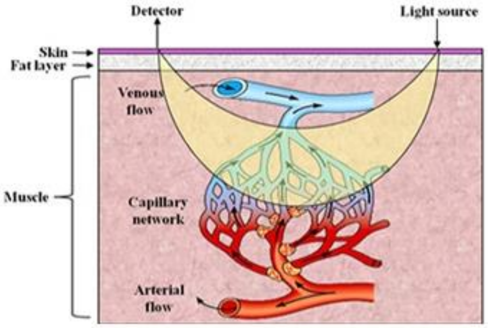
- The NIR spectrum extends from ≈ 800nm – 2500nm.

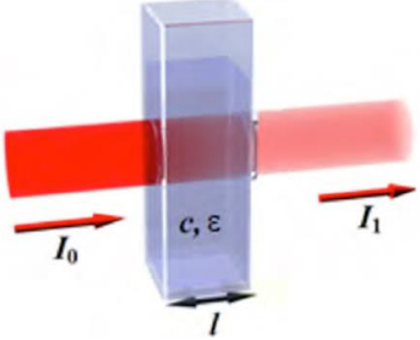
espectroscopia



Determinación de umbrales de esfuerzo







$$\log \frac{I_0}{I_1} = \varepsilon l c$$

Grassi et al, 2003; McCully & Hamaoka, 2000

Determinación de umbrales de esfuerzo

Determination of Maximal Lactate Steady State in Healthy Adults: Can NIRS Help?

CECILIA BELLOTTI, ELISA CALABRIA, CARLO CAPELLI, and SILVIA POGLIAGHI

Department of Neurological, Neuropsychological, Morphological and Exercise Sciences, School of Exercise and Sport Sciences, University of Verona, ITALY

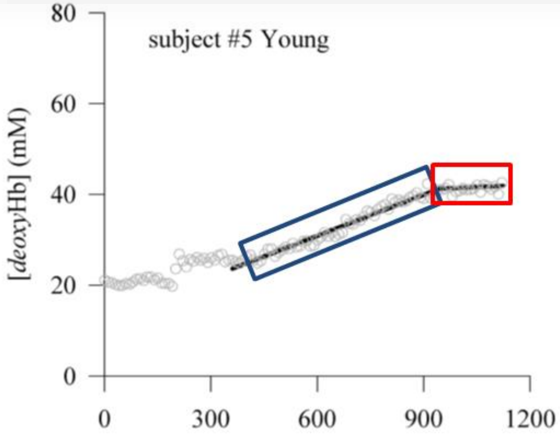


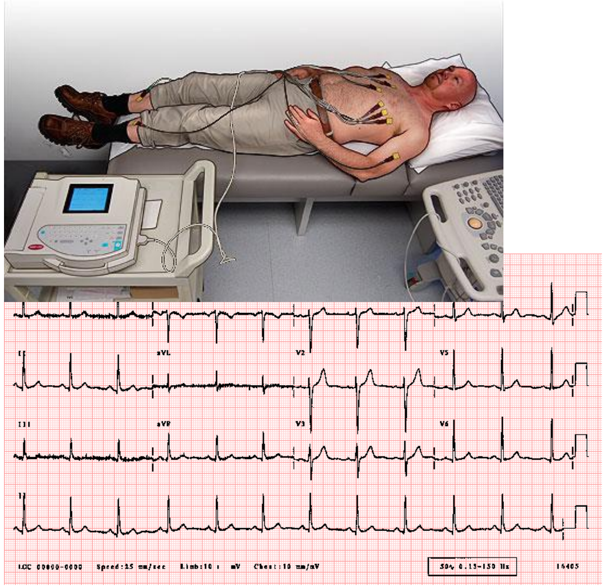
TABLE 3. Mean ± SD at maximum lactate steady state (MLSS) and NIRS-derived MLSS ($NIRS_{MLSS}$) of oxygen consumption ($\dot{V}O_2$), percent maximal oxygen consumption ($\%\dot{V}O_{2max}$), HR, and percent maximal HR ($\%HR_{max}$).

	MLSS	$NIRS_{MLSS}$
$\dot{V}O_2$ ($L\cdot min^{-1}$)	2.25 ± 0.54	2.23 ± 0.59
$\%\dot{V}O_{2max}$	76 ± 9	76 ± 9
HR (bpm)	133 ± 14	136 ± 17
$\%HR_{max}$	81 ± 7	82 ± 8

Bellotti, 2013

Frecuencia cardiaca

ECG (1927)

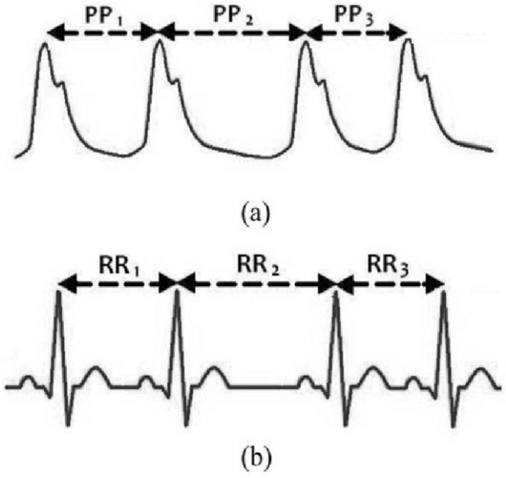


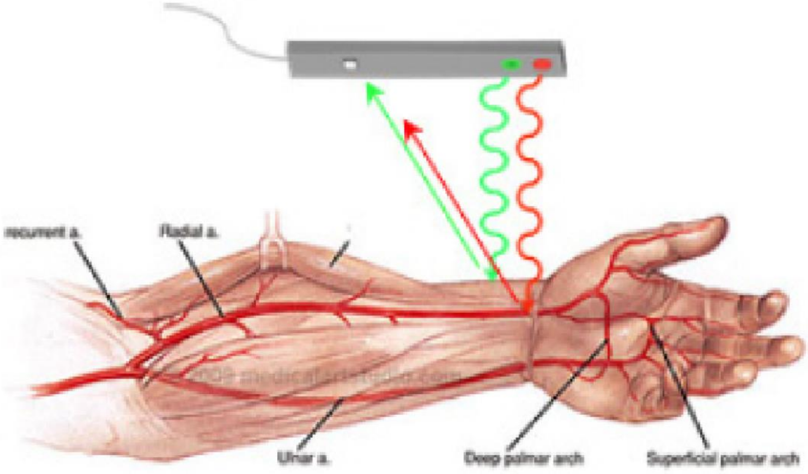
Pulsioxímetro (1972)

Pulsómetro (1982)

Frecuencia cardiaca

Photoplethysmografía (PPG)





Garner & Wagner, 2013

Frecuencia cardiaca

Wackel, 2014

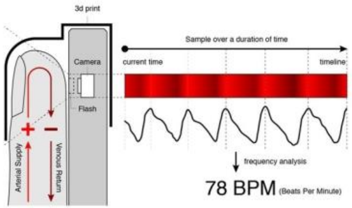
Losa-Iglesias, 2016

Wackel, 2014

vs

r = 0,9-0,99

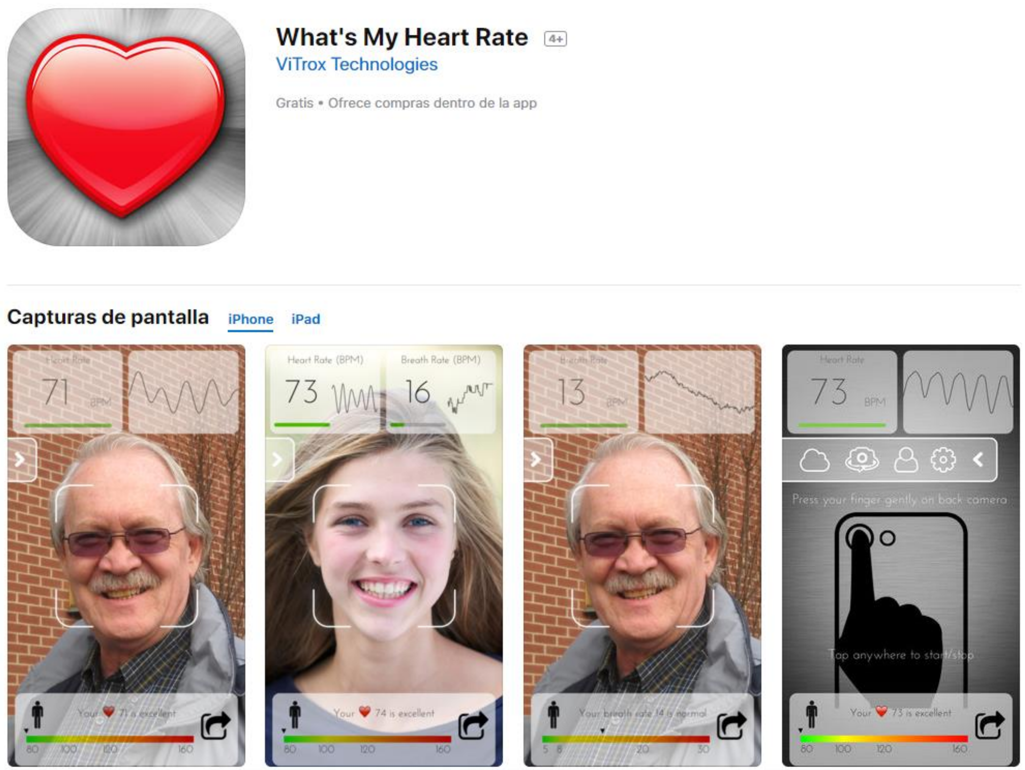
3-4 lpm de diferencia



r = 0,56

18-47 lpm

Frecuencia cardiaca



Peart , 2014

En reposo

r = 0,918

3-4 lpm de diferencia

Peart , 2014

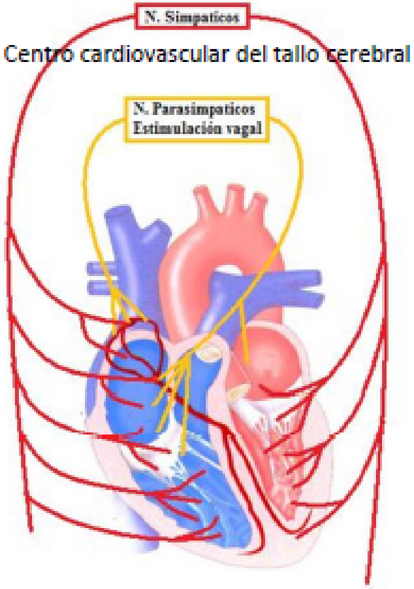
1’ post-test

CV = 31%

129 Vs 84 lpm

Peart , 2014

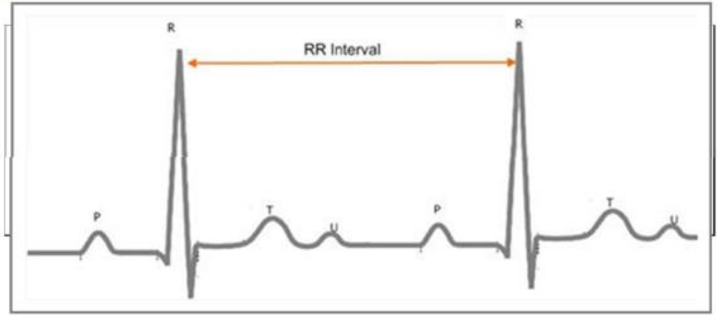
Variabilidad Frecuencia Cardiaca (HRV)



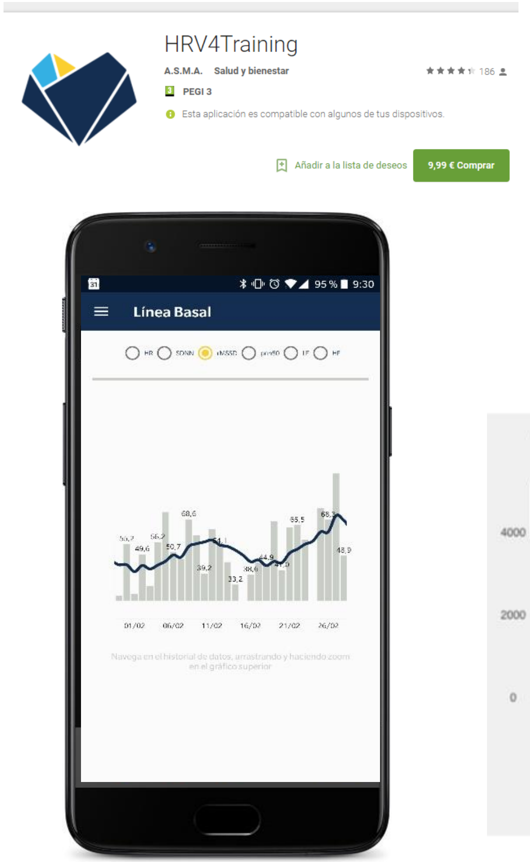
La **estimulación simpática** actúa acelerando la despolarización del nodo sinusal, produciendo taquicardia

La **estimulación parasimpática** produce liberación de acetilcolina, lo que disminuye el ritmo de descarga del nodo sinusal, produciendo bradicardia

Rodas el al. (2008) lo definieron como la variación de la frecuencia del latido cardiaco durante un intervalo de tiempo definido con anterioridad (nunca superior a 24 horas) en un análisis de periodos circadianos consecutivos.



Variabilidad Frecuencia Cardiaca (HRV)

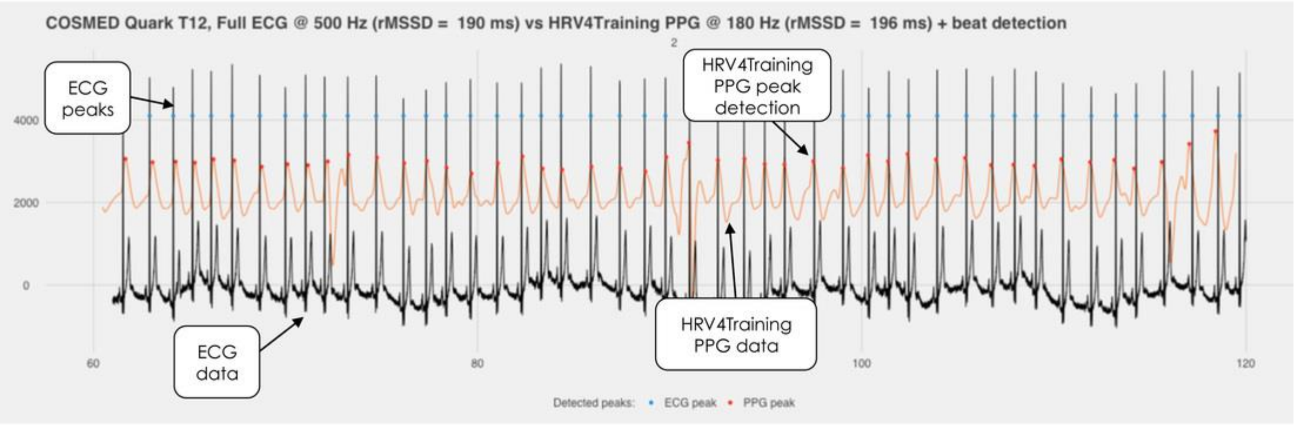


vs

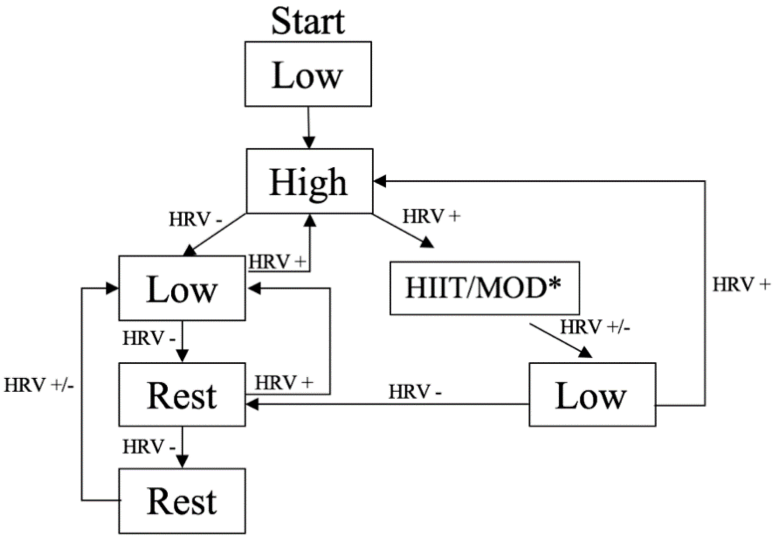
rMSSD

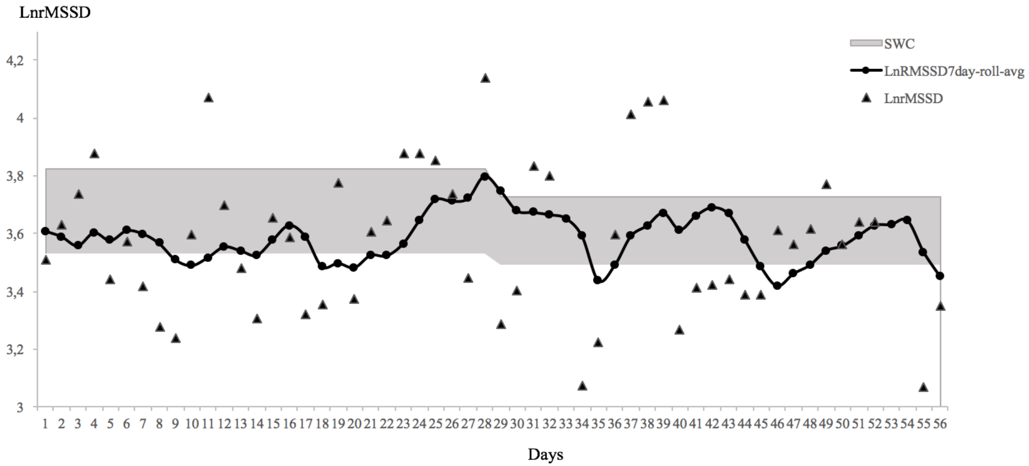
r = 0,99

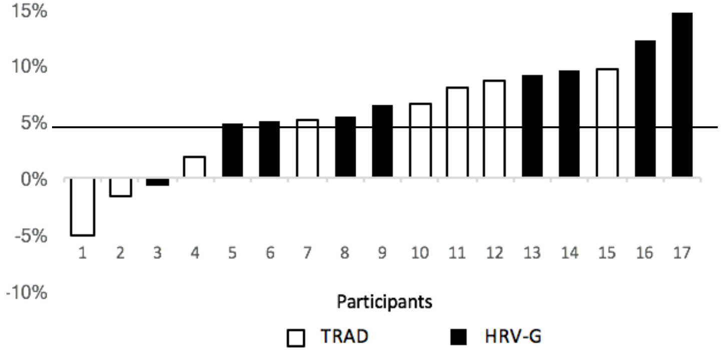
Plews , 2017



Variabilidad Frecuencia Cardiaca (HRV)



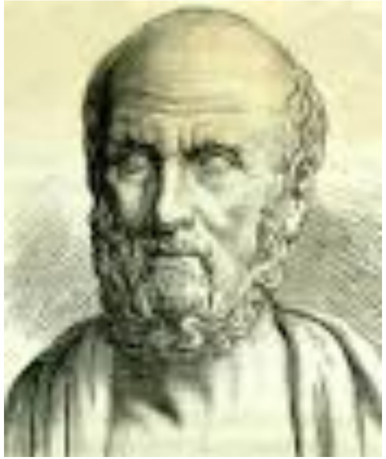




La monitorización de la carga de entrenamiento

¿QUÉ ES LA **CARGA DE ENTRENAMIENTO**?

"Si pudiéramos dar a cada individuo la cantidad adecuada de alimento y ejercicio, no demasiado poco y no demasiado, hubiésemos encontrado el camino más seguro para la salud."



Hipócrates 400 a.C.

¿Por qué monitorizar la carga de entrenamiento?

1. Determinar si hay **adaptación** al entrenamiento.
2. Prevenir sobreentrenamiento.
3. Evitar lesiones.
4. Explicar **qué está provocando la mejora** o el detrimento del rendimiento.
5. Determinar si el deportista está preparado para la competición.
6. **Involucrar** al deportista en nuestro programa.

Halson, 2014

Variables para la monitorización

Table 1 Summary and Evaluation of Some Common Methods Used to Monitor Athlete Training Load and/or Responses

Method	Cost	Hardware needed	Software needed	Ease of use	Valid	Reliable	Used to interpret	Used to prescribe	Variables
Internal Measures									
RPE	L	N	Y/N	H	M–H	M–H	Y	Y	Single variable in AU (time dependent)
Session rating of perceived exertion	L	N	Y/N	H	M–H	M–H	Y	Y	Single variable in AU (time dependent)
TRIMP[4]	L–M	Y	Y	M	M–H	M–H	Y	N	Single variable in AU (time dependent)
Wellness questionnaires*	L	N	Y/N	M–H	M	M–H	Y	Y/N	Ratings, checklists, AU scale measures
Psychological inventories (eg, POMS, Rest-Q-Sport)*	L–M	N	Y/N	M–H	M–H	M–H	Y	Y	Ratings, checklists, AU scale measures
Heart-rate indices	L–M	Y	Y	H	H	M–H	Y	Y	Heart rate, time in zones, HR variability/recovery measures, etc
Oxygen uptake	H	Y	Y	L	H	H	Y	Y	VO_2, metabolic equivalents
Blood lactate	M	Y	Y/N	M	H	H	Y	Y	Concentration
Biochemical/hematological assessments	M–H	Y	Y/N	L	H	M–H	Y	Y	Concentrations, volumes

Bourdon et al 2017

Variables para la monitorización

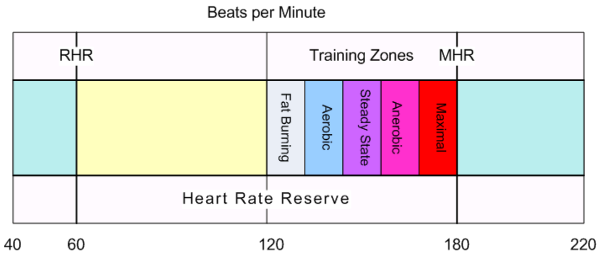
External Measures									
Time	L	Y	Y/N	H	H	H	Y	Y	Units of time (s, min, h, d, wk, y)
Training frequency	L	N	N				Y	Y	Session count
Distance/mileage	L	Y/N					Y	Y	Units of distance (m, km)
Movement repetition counts	L	Y/N						Y	Activity counts (eg, steps, jumps, throws)
Training mode	L	Y/N						Y	Weight training, run, cycle, swim, row, etc
Power output	M–H	Y						Y	Relative (W/kg) and absolute power (W)
Speed	L–M	Y						Y	Speed measures (m/s, m/min, km/h)
Acceleration	L–M	Y						Y	Acceleration measures (m/s^2)
Functional neuromuscular tests	L–M	Y						Y	Countermovement-jump and drop-jump measures
Acute:chronic-workload ratio	L–M	Y/N					Y	Y	Size of acute training load relative to chronic load
GPS measures	M	Y					Y	Y	Velocity, distance, acceleration, time in zones, location
Metabolic power	M	Y	Y				Y	N	Energy equivalent
Time–motion analysis video (automated)	H	Y	Y				Y	Y	Velocity, location, acceleration
Time–motion analysis video (nonautomated)	M–H	Y	Y	L		M	Y	Y	Velocity, location, acceleration
Accelerometry	M	Y	Y	L–M	M–H	M	Y	N	x-y-z g force
Player load	M	Y	Y	M	M	M	Y	Y	Single variable in AU (time dependent)

Abbreviations: L, low; M, medium; H, high; Y, yes; N, no; AU, arbitrary units.
*Measures of training response.

Bourdon et al 2017

$$\text{Men: duration (min)} \times (\text{HRex} - \text{HRrest})/(\text{HRmax} - \text{HRrest}) \times 0.64e^{1.92x}$$

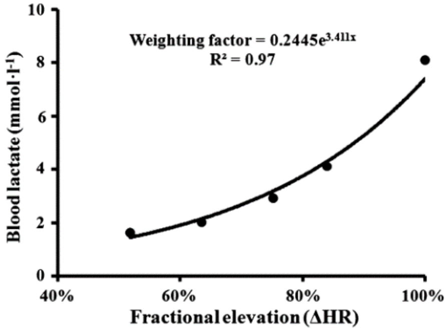
$$\text{Women: duration (min)} \times (\text{HRex} - \text{HRrest})/(\text{HRmax} - \text{HRrest}) \times 0.86e^{1.67x}$$



t' ×

Table 1	Scale for Session Rating of Perceived Exertion[a]
0	Rest
1	Really easy
2	Easy
3	Moderate
4	Sort of hard
5	Hard
6	
7	Really hard
8	
9	Really, really hard
10	Just like my hardest race

[a] From Foster et al.[10]



$$\text{TRIMP (arbitrary units (AU); pseudo integral)} = \text{time (min)} \times \Delta\text{HR} \times y$$

TRAINING PEAKS™

$$\text{TSS} = [\,(t \times \text{NP}^{\text{TM}} \times \text{IF}^{\text{TM}}) / (\text{FTP} \times 3600)\,] \times 100$$

"Methods of Monitoring Training Load and Their Relationships to Changes in Fitness and Performance in Competitive Road Cyclists" by Sanders D et al.

International Journal of Sports Physiology and Performance

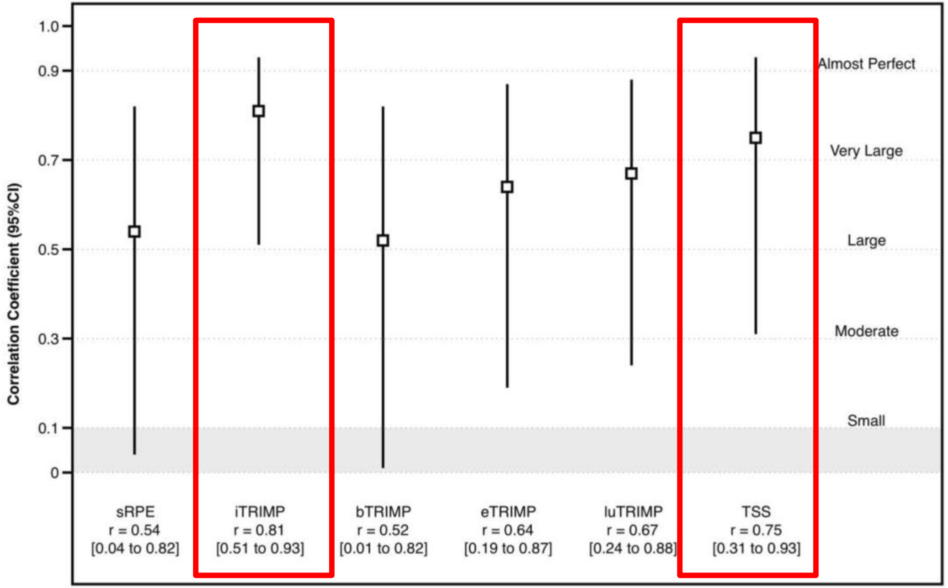


Figure 2: Relationship between all the measures of training load and percentage changes in power output at 2 mmol·L^{-1} lactate. Correlation coefficients (r) are presented with 95% confidence intervals. Interpretation of the strength of the correlation coefficient was based on guidelines provided by Hopkins[19].

Eur J Appl Physiol (2009) 106:839–847
DOI 10.1007/s00421-009-1084-8

ORIGINAL ARTICLE

A mathematical model for quantifying training

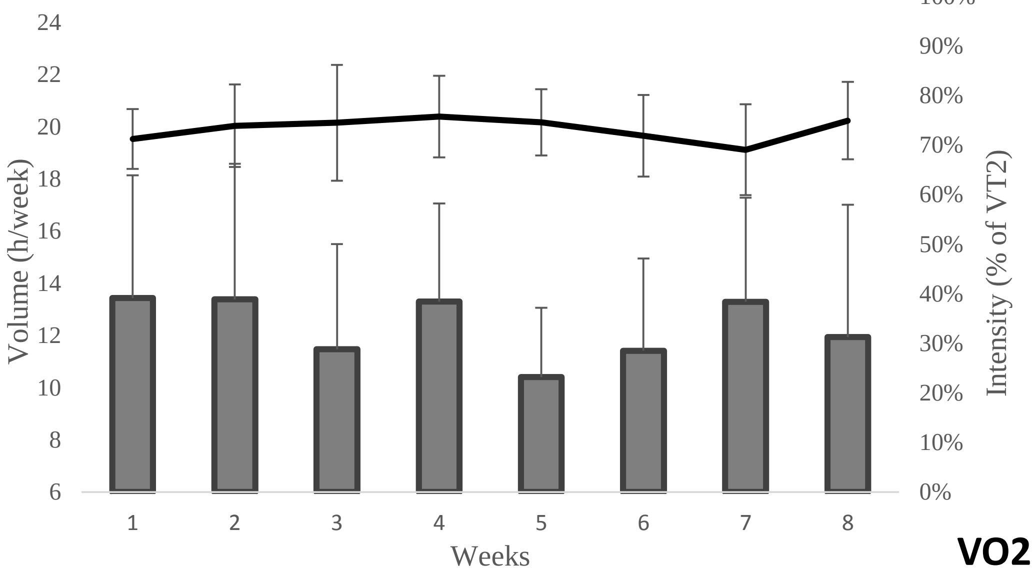
Philip R. Hayes · Mike D. Quinn

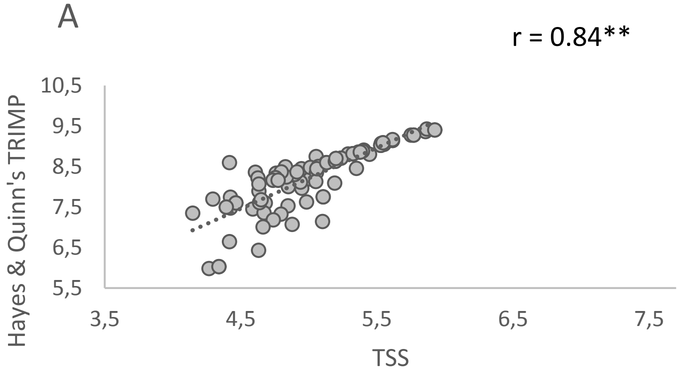
$$W = I(D_{\mathrm{act}}) \times C(D_{\mathrm{act}}) \times D$$
$$= \left(\frac{v_{\mathrm{act}}}{v_{\mathrm{opt}}} + \frac{v_{\mathrm{act}} - v_{\mathrm{crit}}}{v_{\mathrm{max}} - v_{\mathrm{crit}}}\right) \times \left(1 + \frac{I(nD_{\mathrm{act}}) - I(D_{\mathrm{act}})}{I(D_{\mathrm{act}})} e^{-\sigma_1 \frac{\tau_{\mathrm{rec}}}{\tau_{\mathrm{effort}}}}\right)$$
$$\times\, nD_{\mathrm{act}}\left(q_D + (q_{nD} - q_D) e^{-\frac{\tau_{\mathrm{rec}}}{\tau_{\mathrm{effort}}}}\right) \qquad (21)$$

Recovery	Period of reduced intensity or inactivity between repetitions
Rest	Period of reduced intensity or inactivity between sets
n	Number of repetitions in one set
m	Number of sets of repetitions in a training session
v_{max}	Maximum instantaneous velocity obtained from the three-parameter model
v_{crit}	Critical velocity obtained from the three-parameter model
τ_{effort}	Time of one repetition
D_{act}	Actual distance of one repetition
v_{act}	Actual average velocity of one repetition
D_{opt}	Optimal distance run in τ_{effort} based on the three-parameter model
v_{opt}	Optimal velocity of a repetition run in τ_{effort} based on the three-parameter model
$v_{\mathrm{cut\text{-}off}}$	Cut-off velocity where intensity is zero
τ_{rec}	Recovery time between repetitions
v_{rec}	Average recovery velocity between repetitions
σ_1	Recovery parameter dependent on v_{rec}
τ_{rest}	Rest time between sets of repetitions up to a maximum of two hours
v_{rest}	Average rest velocity between sets of repetitions
σ_2	Rest parameter dependent on v_{rest}

“Hayes & Quinn’s TRIMP Validity for Cycling”

Javaloyes, A., Sarabia, J.M., Moya-Ramón, M.



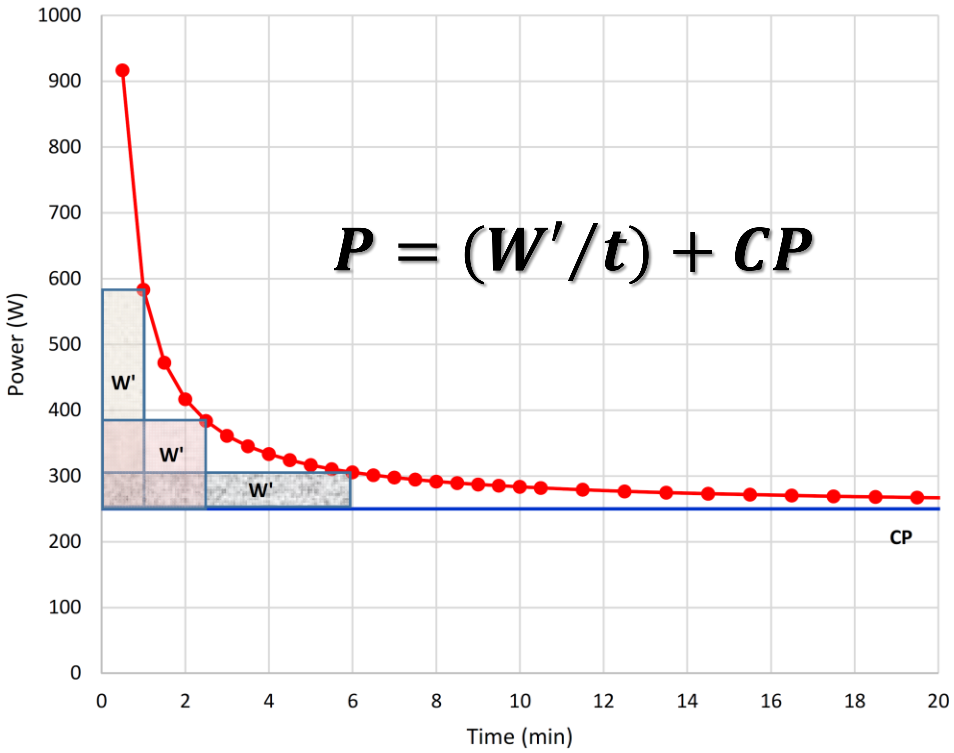


	RPE	BANISTER	TSS	HAYES
VO2max	0.06	0.13	-0.03	0.01
MAP	0.38	0.16	0.28	0.45
WVT2	0.55	0.51	0.51	0.60
Wvt1	0.15	-0.01	0.05	0.19

Capacidad anaeróbica de trabajo (W’)

Hill, 1925; Monod & Scherrer, 1965; Skiba et al., 2012

Información biológica: Capacidad anaeróbica de trabajo (W’)



P	Potencia
W’	Capacidad Anaeróbica de Trabajo
t	Tiempo hasta la extenuación
CP	Potencia Critica

V	Velocidad
D’	Distancia Anaeróbica de Trabajo
t	Tiempo hasta la extenuación
CV	Velocidad Critica

Hill, 1925; Monod & Scherrer, 1965; Skiba et al., 2012

Información biológica: Capacidad anaeróbica de trabajo (W')

Modeling the Expenditure and Reconstitution of Work Capacity above Critical Power

PHILIP FRIERE SKIBA, WEERAPONG CHIDNOK, ANNI VANHATALO, and ANDREW M. JONES

Department of Sport and Health Sciences, College of Life and Environmental Sciences, St. Luke's Campus, University of Exeter, Exeter, Devon, UNITED KINGDOM

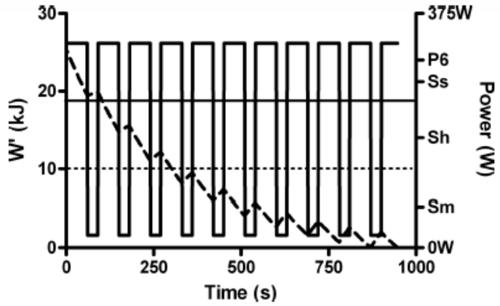


FIGURE 1—Model of W'_{bal} (*dashed line*) and power output (*continuous line*) for a representative subject in the S_{20} trial. The *dotted and horizontal solid lines* indicate the subject's GET and CP, respectively. *Hash marks* on the right axis indicate power outputs for the S_S, S_H, and S_M recovery trials. In this example, the subject exercises in the severe domain for 60 s and recovers at 20 W, repeating the process until exhaustion.

1. 20 W (S_{20}).
2. Moderate-intensity recovery (S_M) at a power output of 90% of the GET.
3. Heavy-intensity recovery (S_H) at a power output of GET + 50% of the difference between the GET and CP.
4. Severe-intensity recovery (S_S) at a power output equal to P_6 − 50% of the difference between the CP and P_6.

Skiba et al., 2012

Información biológica: Capacidad anaeróbica de trabajo (W')

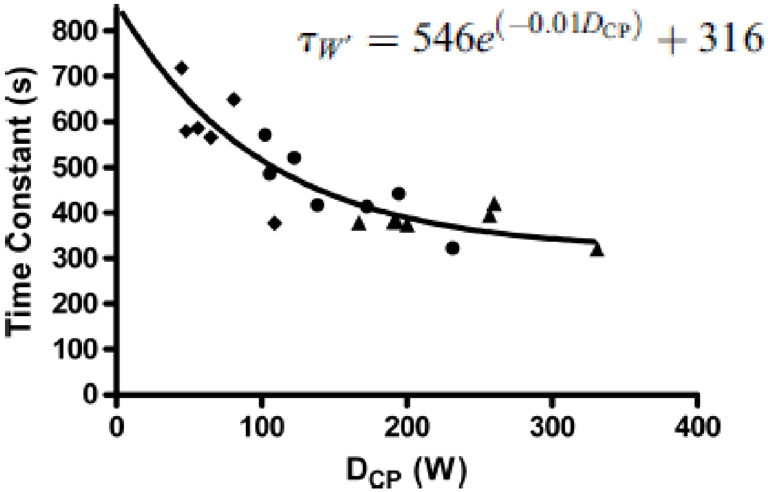
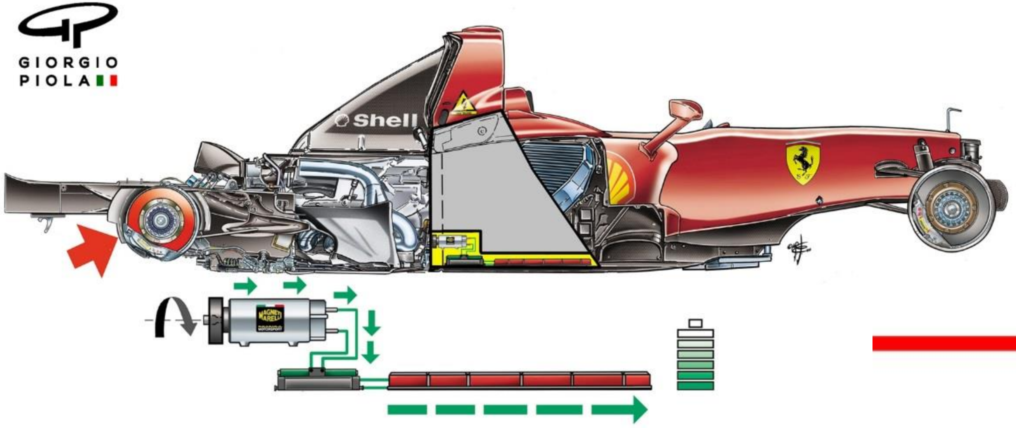


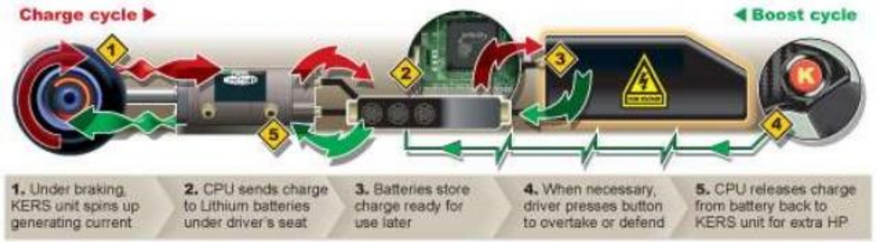
FIGURE 2—Graphical depiction of time constant of W' reconstitution ($\tau_{W'}$) as a function of D_{CP}. Individual recovery levels are represented by a common symbol, where S_{20} = *triangles*, S_M = *circles*, and S_H = *diamonds*. Note that the overall relationship could also be well described by a bilinear fit.

Skiba et al., 2012

Información biológica: Capacidad anaeróbica de trabajo (W')



Electrical KERS



Información biológica: Capacidad anaeróbica de trabajo (W')

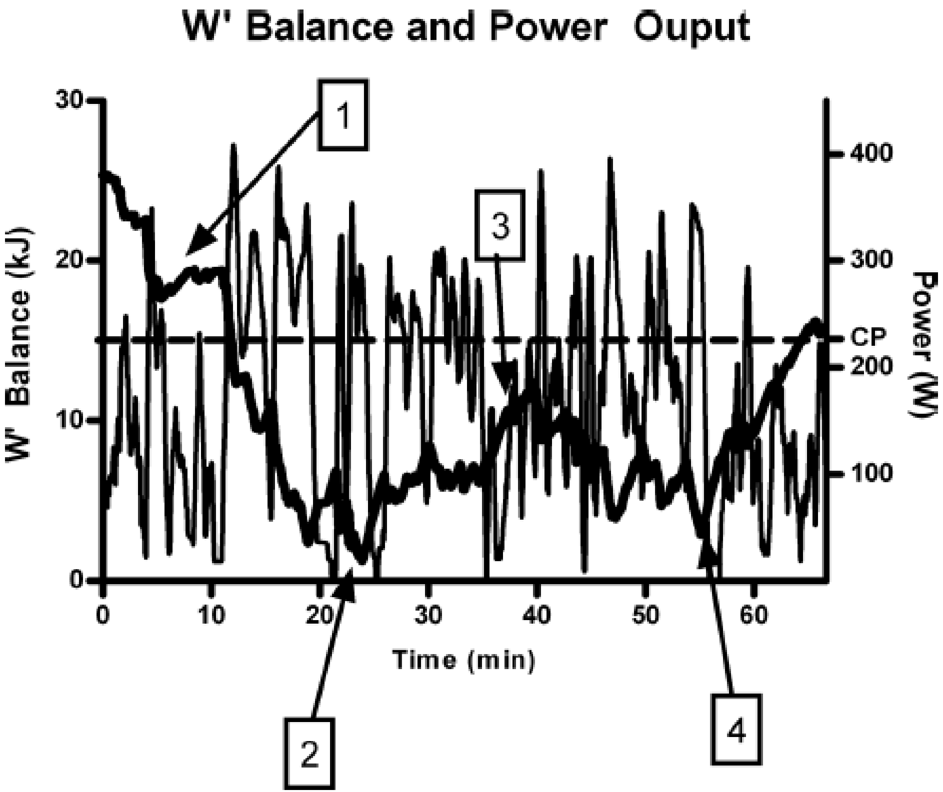


FIGURE 4—Modeled *W′* expended (*heavy solid line*) and athlete power output (*thin solid line*). The athlete's CP (227 W) is denoted by the *dashed line*. Peak power output was 409 W. *Numbers* indicate important points as race unfolds. 1: athlete establishes position in pack. 2: athlete has attacked but has severely depleted the *W′*, forcing recovery. 3: athlete attacks again. 4: athlete again depletes *W′* and is forced to withdraw from race as lead pack escapes.

Skiba et al., 2012

Información biológica: Capacidad anaeróbica de trabajo (W’)

Skiba et al., 2012

Información biológica: Capacidad anaeróbica de trabajo (W')

Step	**W' TANK** (%)	W' (kJ)
1	100%	20.0
2	70%	14.0
3	90%	18.0
4	60%	12.0
5	80%	16.0
6	50%	10.0
7	70%	14.0
8	40%	8.0
9	60%	12.0
10	30%	6.0
11	50%	10.0
12	20%	4.0
13	40%	8.0
14	10%	2.0
15	30%	6.0
16	0%	0.0
17	100%	20.0

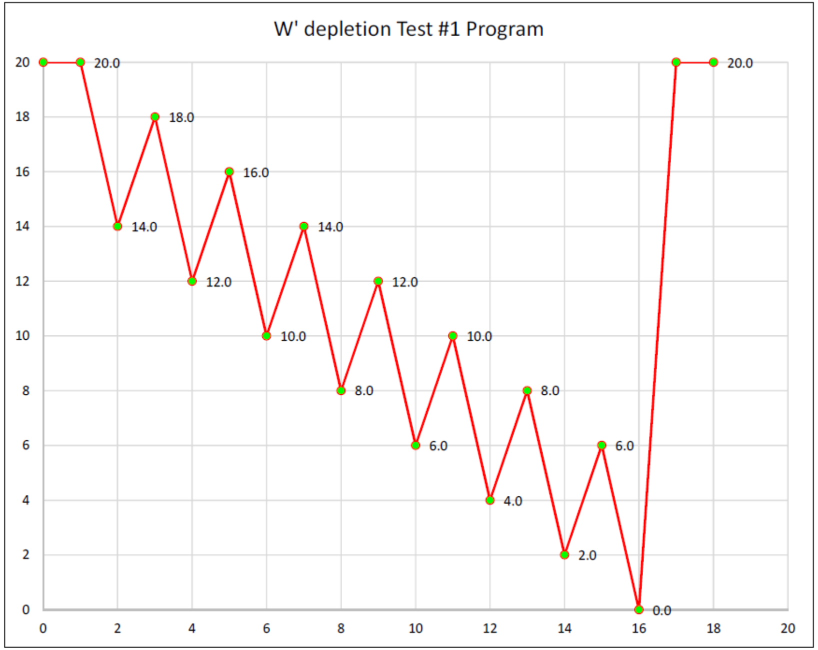
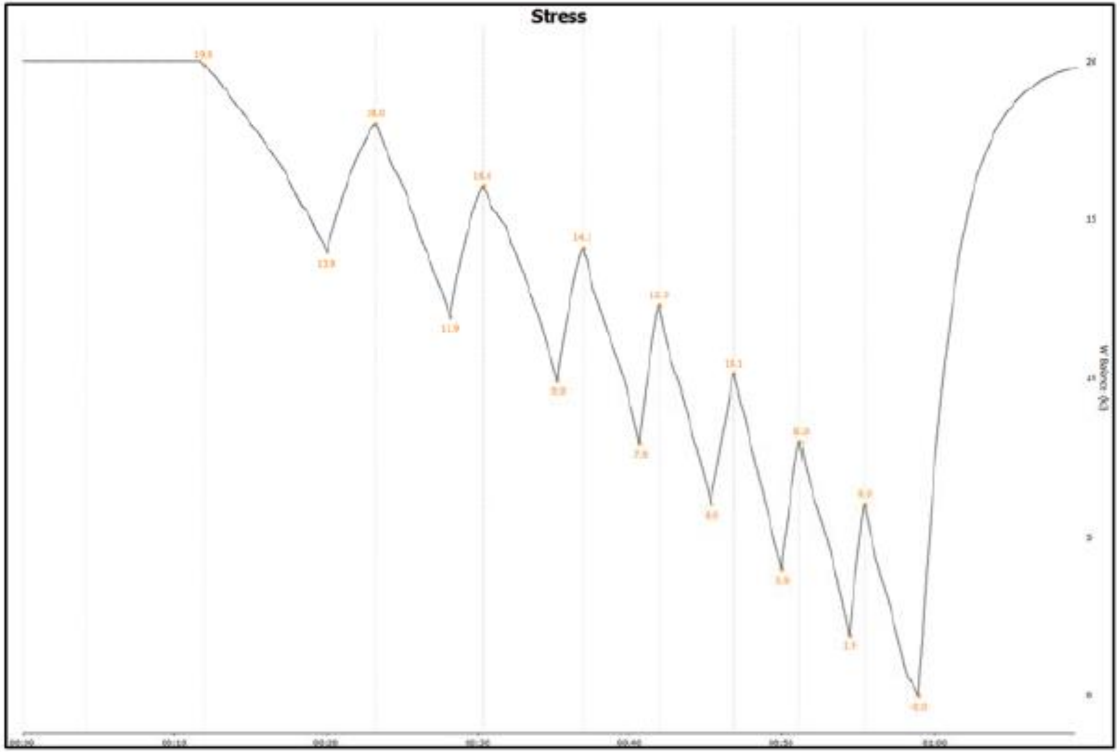


Figure 10 – Test 1 plan: Deplete 30% Reconstitute 20% (W'=20.0 kJ).

Mantica, 2015

Información biológica: Capacidad anaeróbica de trabajo (W’)



Mantica, 2015

Información rendimiento: Potencia

GOVSS (Skiba, 2006)

$$\text{Power (W/kg)} = (C_i \cdot n_V - (C_i \cdot n_V \cdot (.5 \cdot (V \cdot 8.33^{-1})))) + C_{aero} \cdot V + C_{kin} \cdot V$$

$$C_i = 155.4i^5 - 30.4i^4 - 43.3i^3 + 46.3i^2 + 19.5i + 3.6$$

$$C_{aero} = k \cdot n^{-1} \cdot d^2 \cdot t^{-2} \quad (\text{in } kg^{-1} \cdot m^{-1})$$

$n = 0.5$

$$C_{kin} = 0.5 \cdot n^{-1} \cdot d \cdot t^{-2}$$

$n = 0.25$

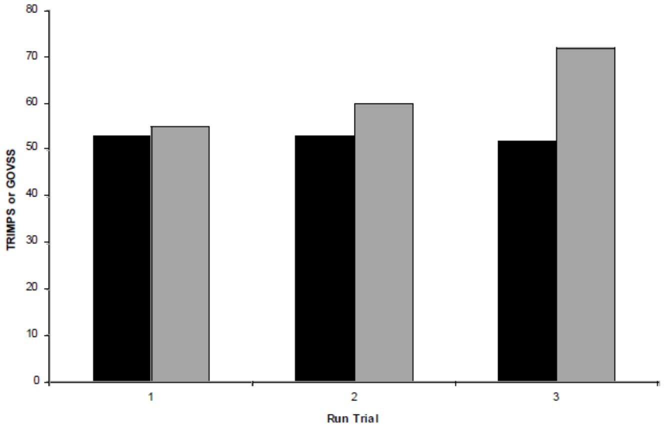
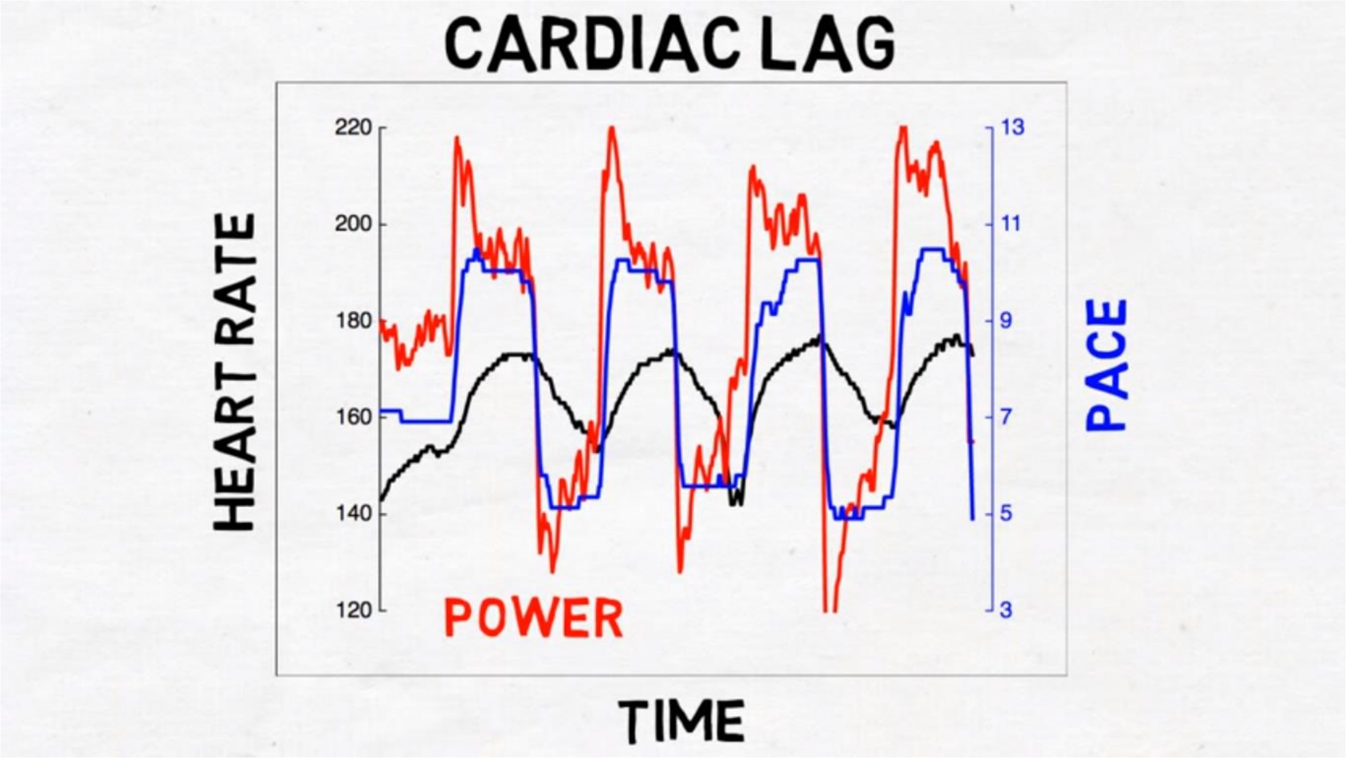
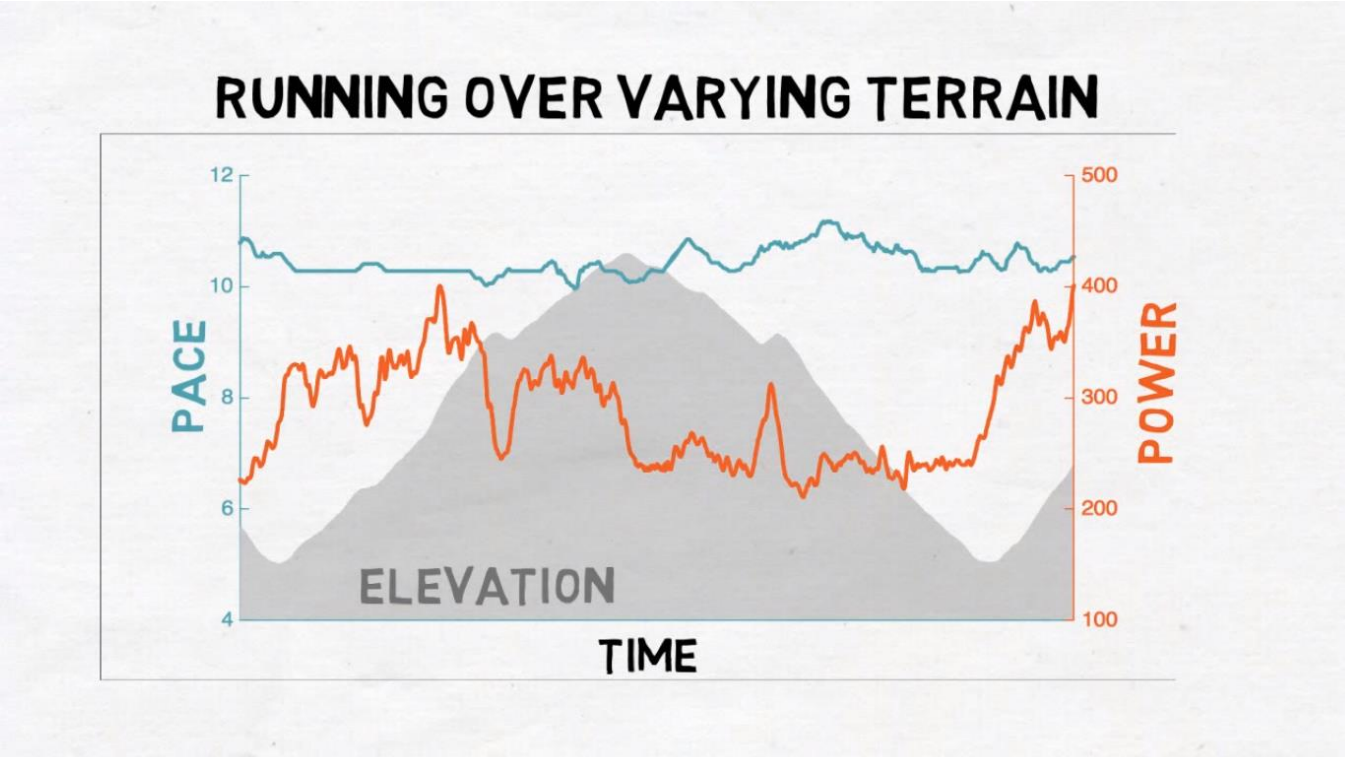


Figure 5: Graphical representation of the relationship between TRIMPS (gray) and GOVSS (black) for the same 6.5k run conducted on different days. Run 3 was conducted at an environmental temperature 10 degrees centigrade warmer than Runs 1 and 2. Data from: Skiba, 2006 (in press).

Información rendimiento: Potencia



Información rendimiento: Potencia



Información rendimiento: Potencia

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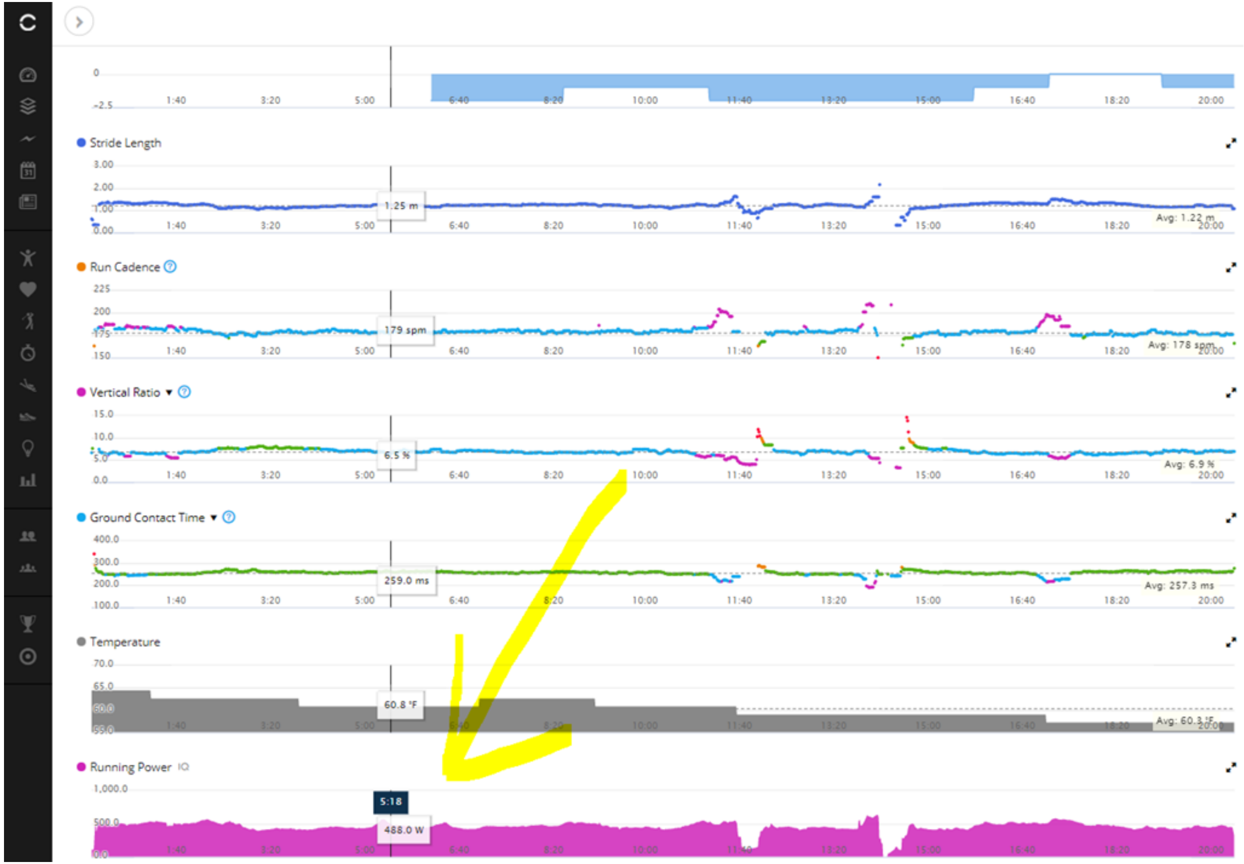
Información rendimiento: Potencia



Información rendimiento: Potencia

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GARMIN.

MODELO IMPULSO-RESPUESTA

A

Initial performance level

PTE (fitness) — NTE (fatigue)

$$p(t) = p(0) + k_1 \sum_{s=0}^{t-1} e^{-(t-s)/\tau_1} w(s) - k_2 \sum_{s=0}^{t-1} e^{-(t-s)/\tau_2} w(s)$$

Sum of training impulses, each modified by an exponential decay term

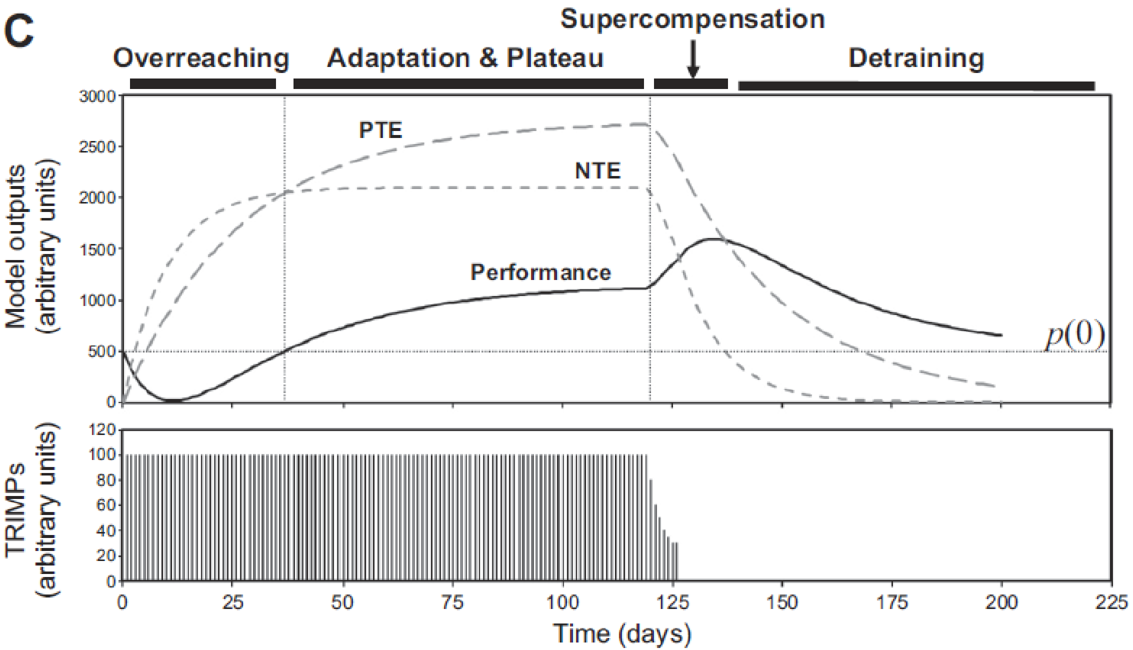
B

$$g(t) = g(t-s)e^{-s/\tau_1} + w(t)$$

$$h(t) = h(t-s)e^{-s/\tau_2} + w(t)$$

$$p(t) = p(0) + \underbrace{k_1 g(t)}_{\text{PTE}} - \underbrace{k_2 h(t)}_{\text{NTE}}$$

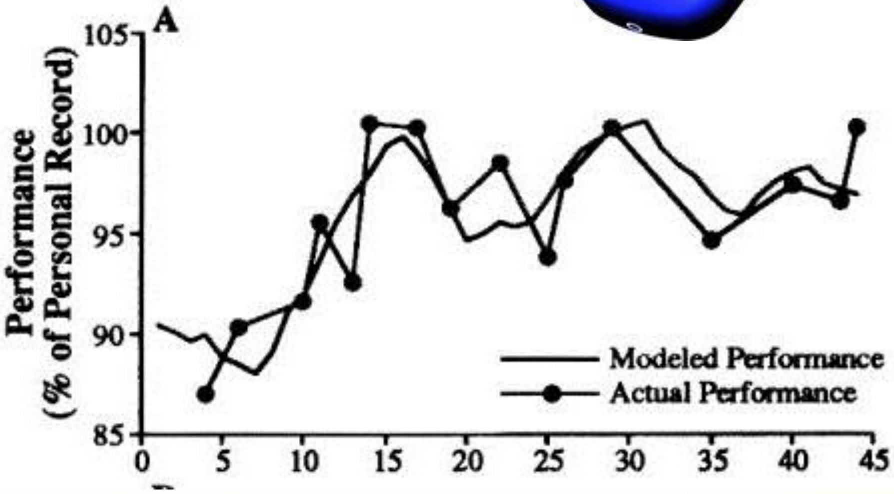
C

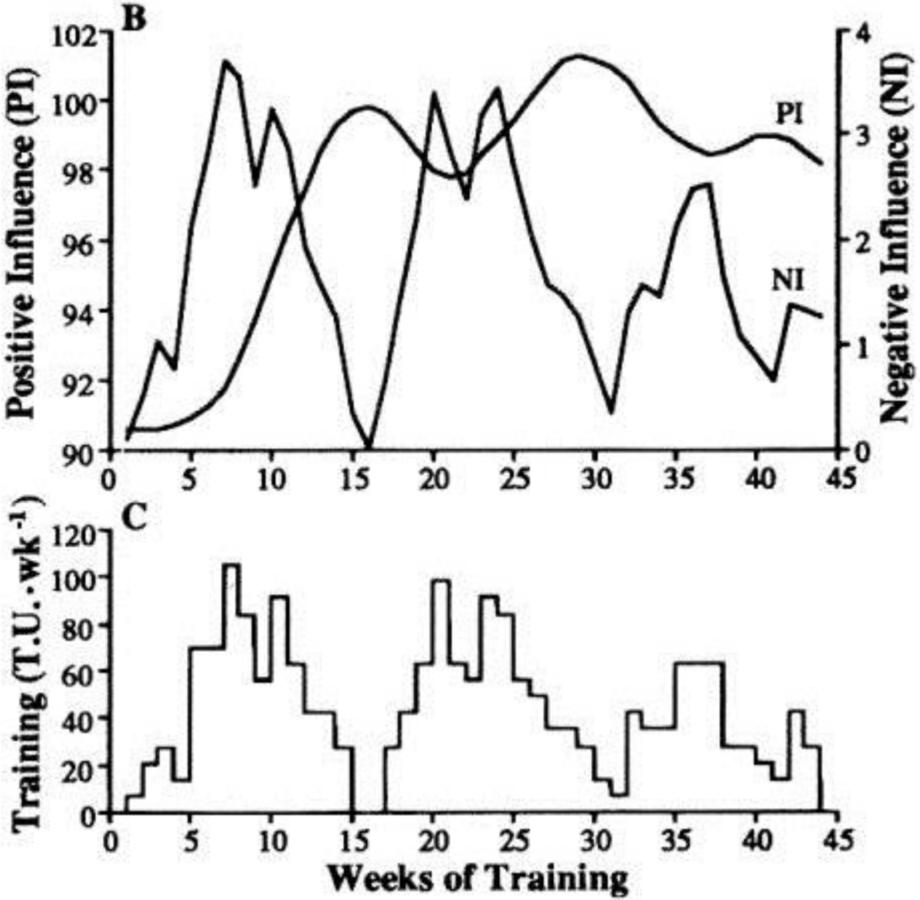


Banister et al., 1975

Modeled responses to training and taper in competitive swimmers

IÑIGO MUJIKA, THIERRY BUSSO, LUCIEN LACOSTE, FRÉDÉRIC BARALE, ANDRÉ GEYSSANT, and JEAN-CLAUDE CHATARD



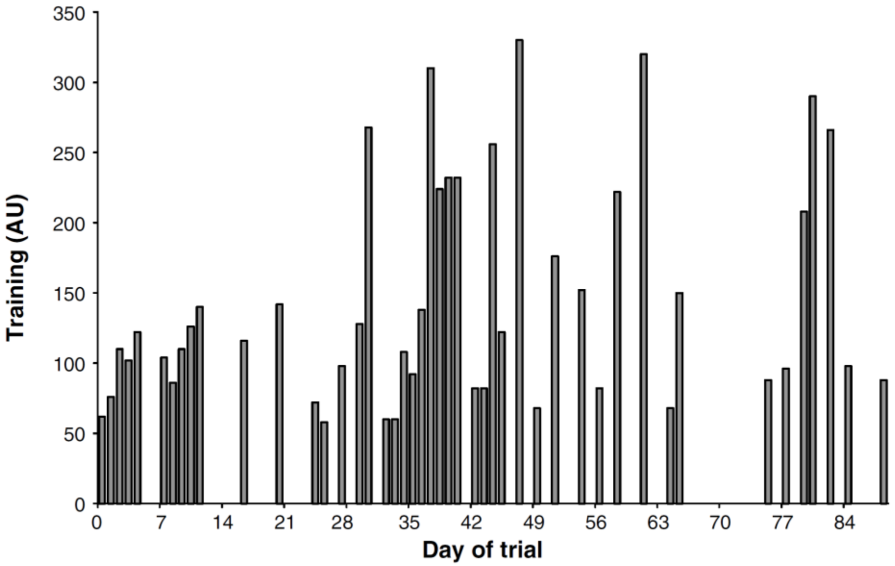


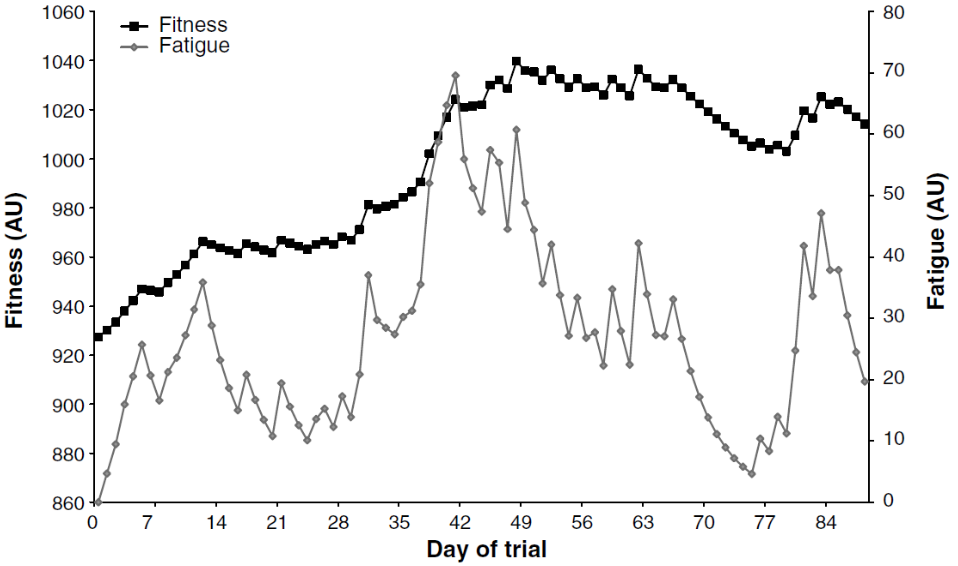
Eur J Appl Physiol (2005) 94: 310–316
DOI 10.1007/s00421-005-1319-2

ORIGINAL ARTICLE

Rachel Elise Wood · Scott Hayter · David Rowbottom
Ian Stewart

Applying a mathematical model to training adaptation in a distance runner





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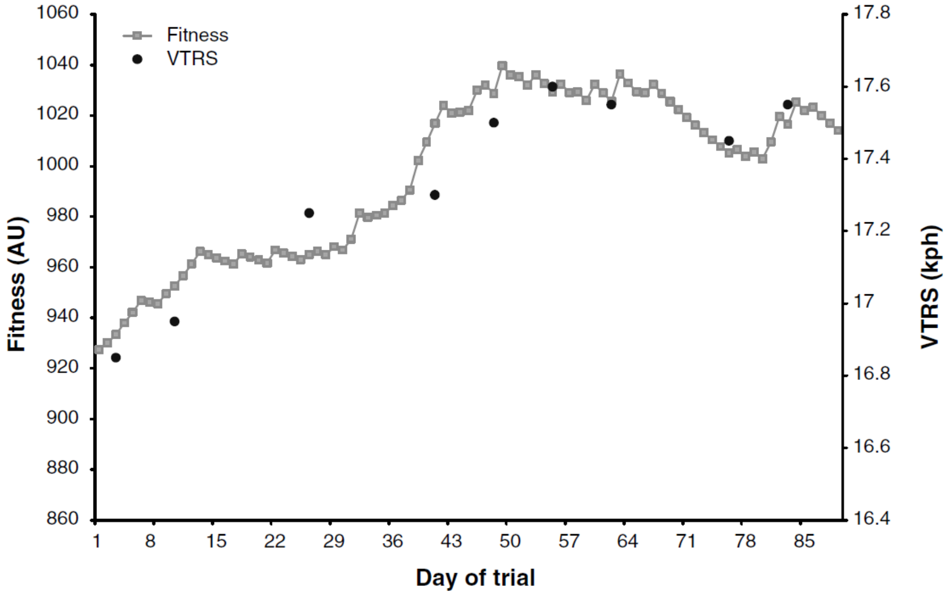
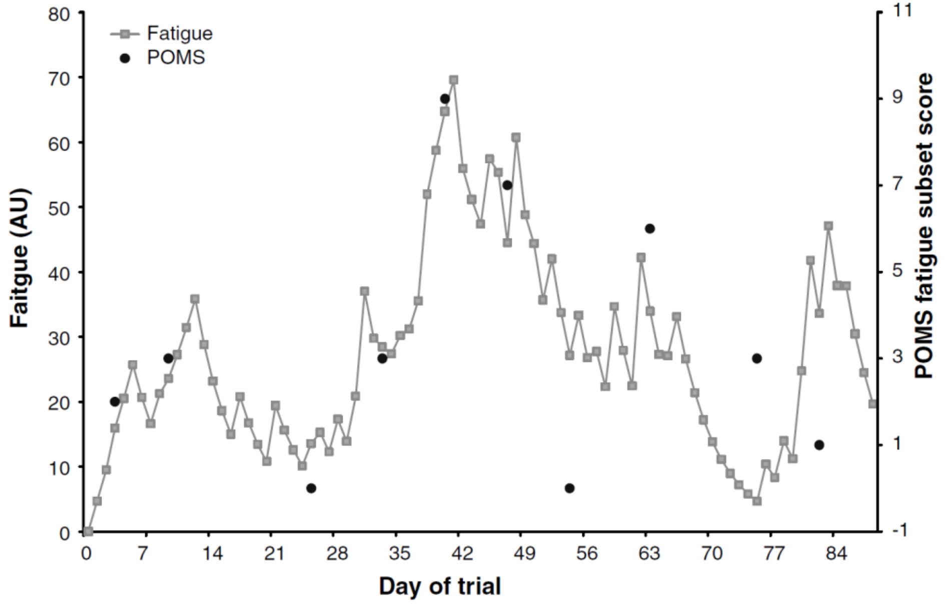




Applying a Systems Model of Training to a Patient with Coronary Artery Disease

STEPHANIE LE BRIS[1], BERTRAND LEDERMANN[2], ROBIN CANDAU[1], JEAN MARC DAVY[3], PATRICK MESSNER-PELLENC[2], and DANIEL LE GALLAIS[1]

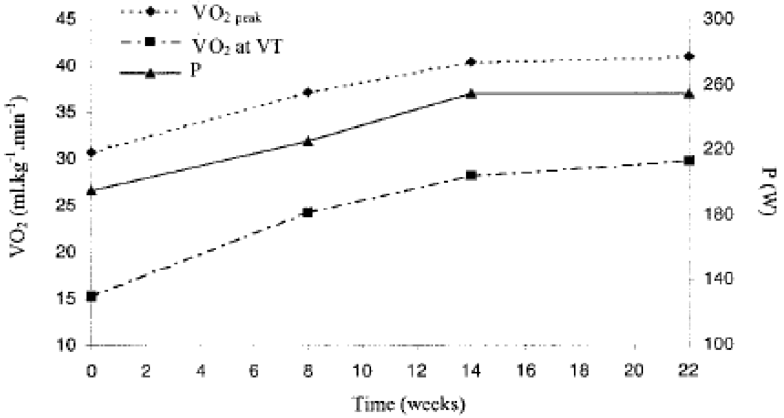


FIGURE 2—Changes in graded exercise test data throughout the study: oxygen uptake at exhaustion ($\dot{V}O_{2peak}$) and ventilatory threshold ($\dot{V}O_2$ at VT); power (P).

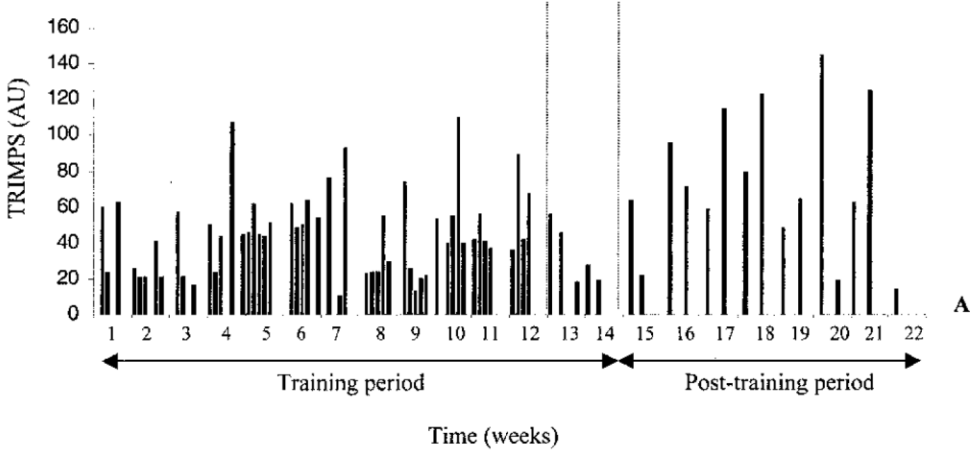
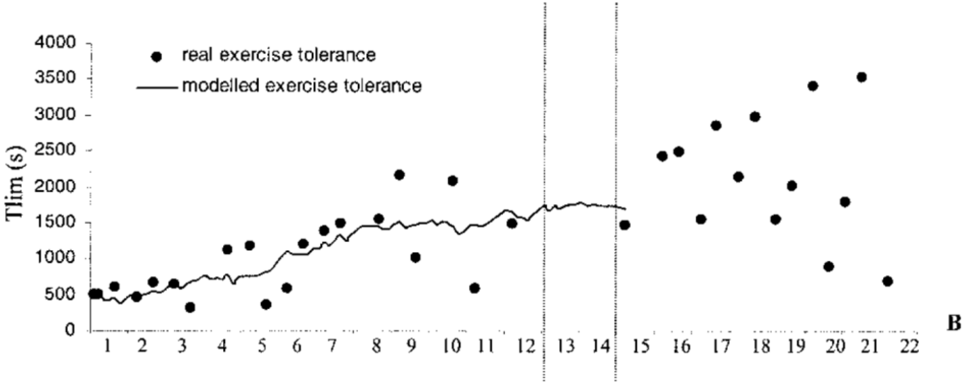
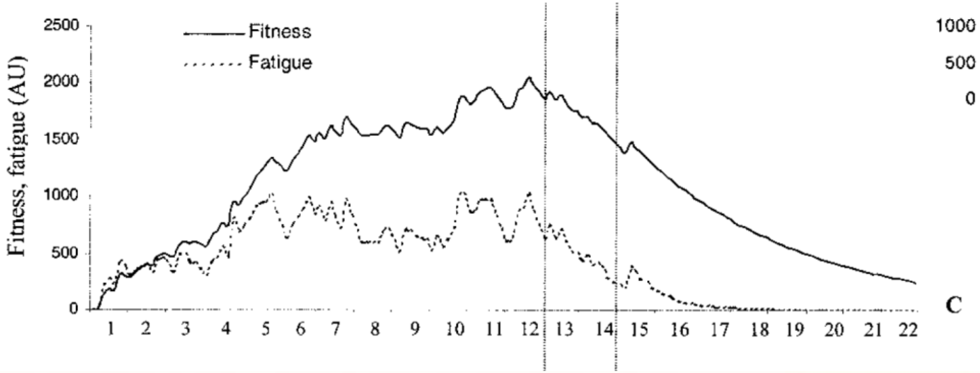


FIGURE 3—A. Daily training impulse (training + exercise tolerance test + graded exercise test). B. Model exercise tolerance fitted with real exercise tolerance. C. Fitness and fatigue curves; *dotted lines*, tapering.

Applying a Systems Model of Training to a Patient with Coronary Artery Disease

STEPHANIE LE BRIS[1], BERTRAND LEDERMANN[2], ROBIN CANDAU[1], JEAN MARC DAVY[3], PATRICK MESSNER-PELLENC[2], and DANIEL LE GALLAIS[1]





A systems model of training for patients in phase 2 cardiac rehabilitation

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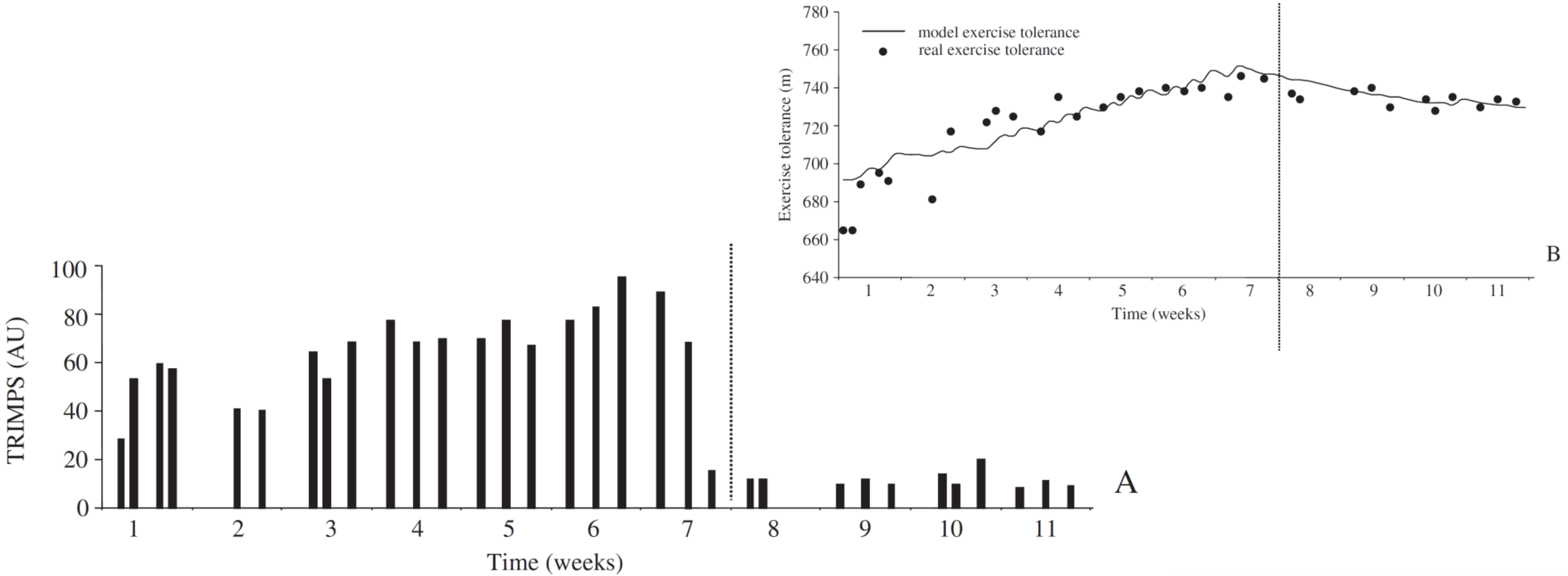
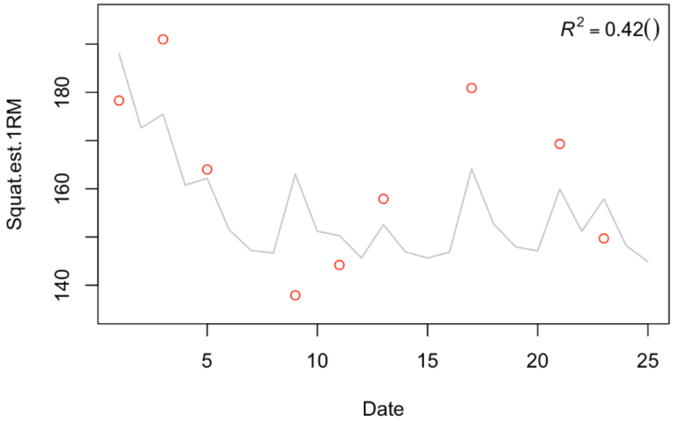
Patrick Messner-Pellenc [b], Daniel Le Gallais [a]

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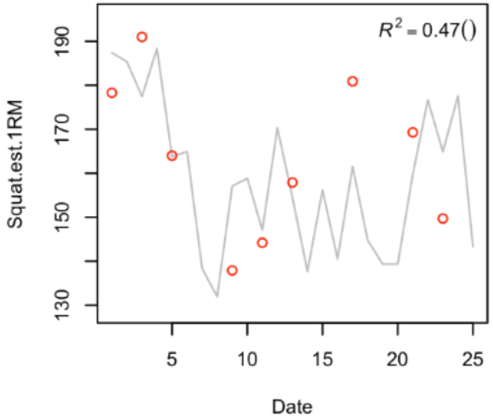
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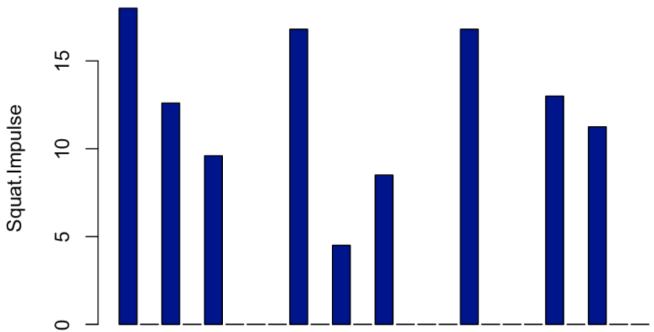
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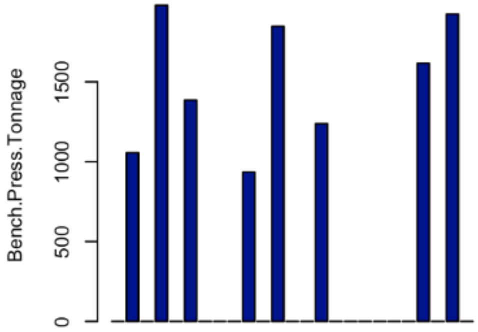
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From an indirect response pharmacodynamic model towards a secondary signal model of dose-response relationship between exercise training and physical performance

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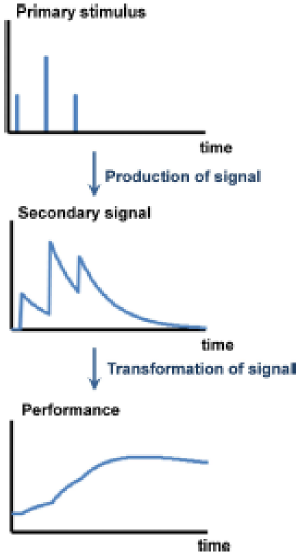
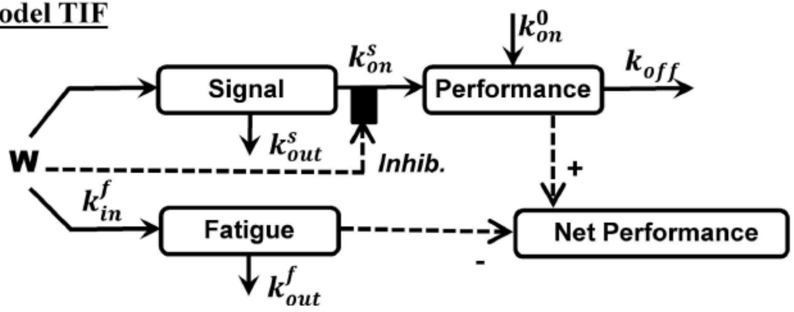
Thierry Busso

The aim of this study was to test the suitability of using indirect responses for modeling the effects of physical training on performance. We formulated four different models assuming that increase in performance results of the transformation of a signal secondary to the primary stimulus which is the training dose. The models were designed to be used with experimental data with daily training amounts ascribed to input and performance measured at several dates ascribed to output. The models were tested using data obtained from six subjects who trained on a cycle ergometer over a 15-week period. The data fit for each subject was good for all of the models. Goodness-of-fit and consistency of parameter estimates favored the model that took into account the inhibition of production of training effect. This model produced an inverted-U shape graphic when plotting daily training dose against performance because of the effect of one training session on the cumulated effects of previous sessions. In conclusion, using secondary signal-dependent response provided a framework helpful for modeling training effect which could enhance the quantitative methods used to analyze how best to dose physical activity for athletic performance or healthy living.



Model TIF



Variables utilizadas para monitorizar la carga

¿PODEMOS COMBINAR LA RESPUESTA FISIOLÓGICA PROVOCADA POR EL EJERCICIO (CARGA INTERNA) Y LA REALIZACIÓN DEL PROPIO EJERCICIO (CARGA EXTERNA)?

Training Load Monitoring in Team Sports: A Novel Framework Separating Physiological and Biomechanical Load-Adaptation Pathways

Jos Vanrenterghem[1,2] · Niels Jensby Nedergaard[2] · Mark A. Robinson[2] · Barry Drust[2] (2017)

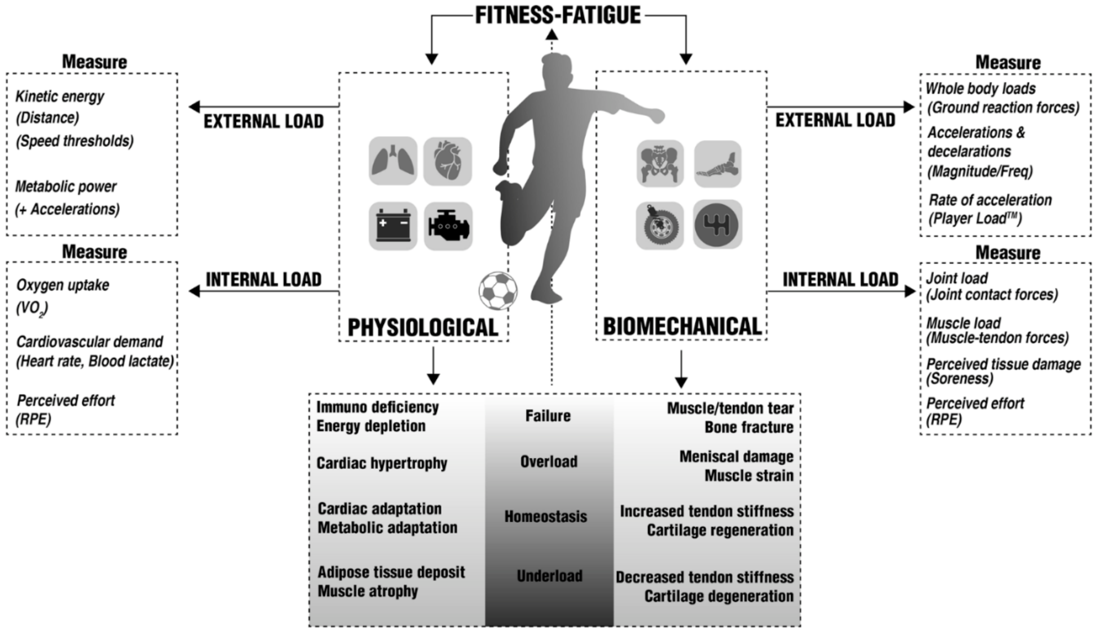


Fig. 1 A new player load monitoring framework outlining the cyclical nature in which physiological and biomechanical load leads to adaptation of the biological system as a whole. *RPE* rating of perceived exertion, *Freq* frequency

Key Points

Easy access to a huge diversity of training load data in modern team sports has caused confusion about the load-adaptation mechanisms to which different data are expected to be associated.

We propose a new theoretical framework in which physiological and biomechanical load-adaptation pathways are considered separately, and for which the distinction between internal and external load measures is revisited.

Load-adaptation pathways have different response rates, which has consequences for the planning of training and/or rehabilitation sessions when attempting to enhance performance and prevent (re-)injury.

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