Máster Universitario en
Alto Rendimiento en Deportes Cíclicos

HP SPORTS SCIENCE

Running with Power

Un nuevo horizonte en el entrenamiento de carrera de larga distancia

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INEOS
FINISH
01:59:40
FINISH
INEOS
INEOS
1:59
CHALLENGE
01:59:40
#NOHUMANISLIMITED
1:59

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Contextualización

Evidencia Científica

Wearables para medir potencia

Aplicación Práctica

Take-home Message


MATHIEU VAN DER POEL
STRADE BIANCHE
4:45:55
ENTIRE WORKOUT
186 KM
DISTANCE
389 WATTS
NORMALIZED POWER
1:30:00
FINAL 60 KM
439 WATTS
NORMALIZED POWER
ROTOR 3D
SRM
PowerControl 7
PRO
MODE
SET
60 SECONDS
SECTOR LE TOLFE
738 WATTS
AV POWER
20 SECONDS
SPRINT SIENA
1004 WATTS
AV POWER
186
MAX HEART RATE
Alpecin
FENIX
CANYON
@ALPECINFENIX

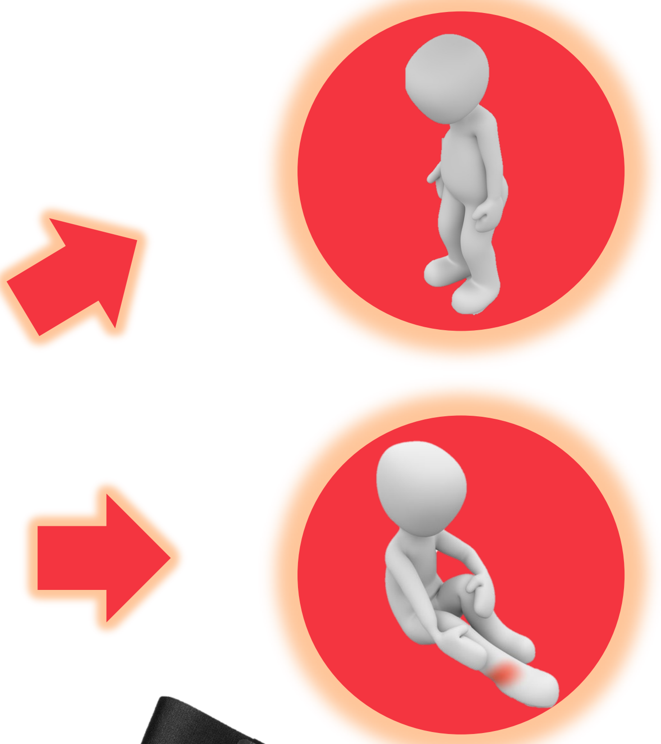

KIPCHOGE
RunScribe

TABLE 1 — **Definitions of Various Metrics Used to Quantify Running Training**

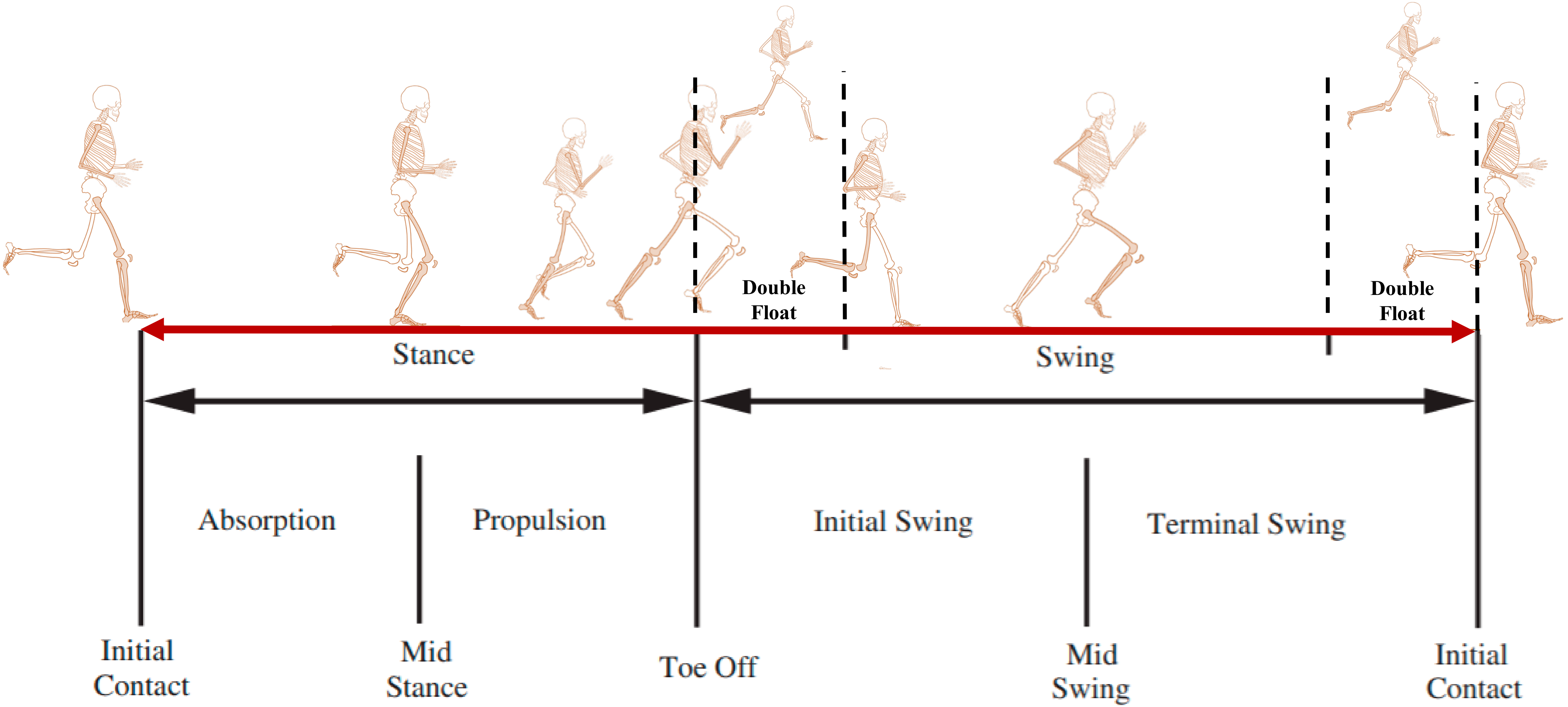
Metric	Definition	Example	Unit
Training stress[3,9,20]	General term to describe physiological stress resulting directly from training sessions	External load, physiological internal load, tissue internal load, and workloads	See below
Daily stress	General term to describe physiological/psychological stress resulting from nontraining factors	Work, family/relationships, sleep, and financial stress	Visual analog scales and questionnaires
External load[25]	Global term used to define the mechanical physical stresses applied to an athlete	• Duration • Distance • Pace • Ground reaction forces • Contact time • Peak tibial or sacral acceleration • Number of steps • Other biomechanical variables	• Minutes • Miles or kilometers • Minutes per mile or per kilometer • Newtons per body weight • Seconds • Units of gravity • Steps • Varies
Physiological internal load[10,18,25]	Global term used to define the physiological and psychological stresses in response to external loads and daily stress	• Perceived exertion (sRPE) • Heart rate • Heart rate variability • Blood lactate • Other physiological variables	• Scales: 6-20 or 0-10 • Beats per minute • Variability in interbeat time interval • Millimole • Varies
Tissue internal load	Global term used to define internal loads placed on musculoskeletal tissue in response to external loads	• Stress • Strain • Force • Stiffness • Young's modulus	• Pascals • Unitless • Newtons • N/deformation (mm)
Training load[18]	Specific term defined as the product of external and physiological internal loads	• Duration × sRPE • Peak tibial acceleration × sRPE • Number of steps × sRPE	Arbitrary units for all

Abbreviation: sRPE, session rating of perceived exertion.

(Paquette et al., 2020)

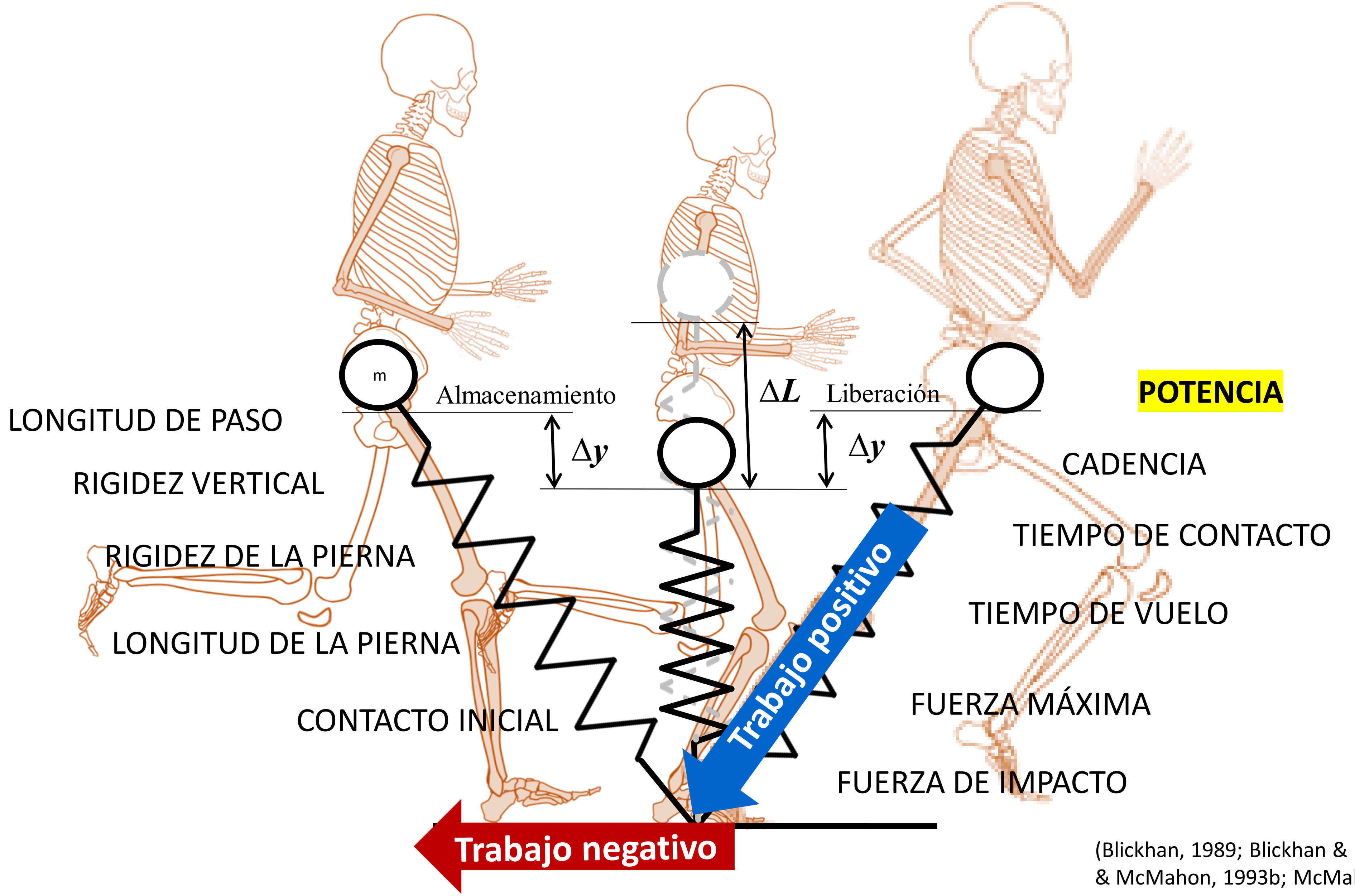


Ciclo de la Carrera



Phases and components of the running gait cycle. Reprinted from 'The biomechanics of walking and running', by S. Ounpuu, 1994, *Clinics in sports medicine*, 13(4), 843-863. Copyright 1994 by Elsevier Inc.

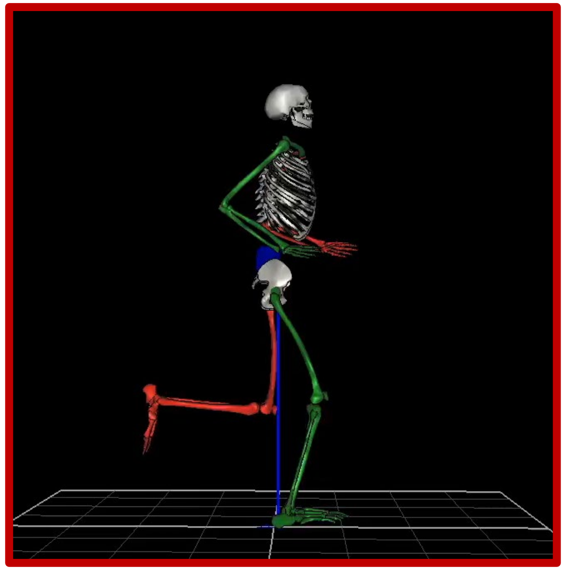
Modelo masa-muelle

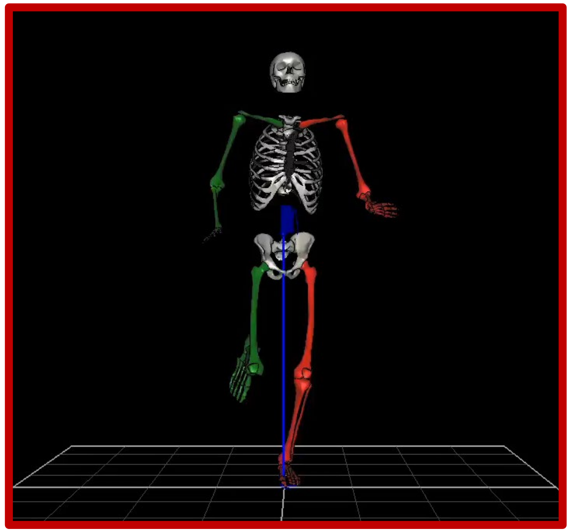


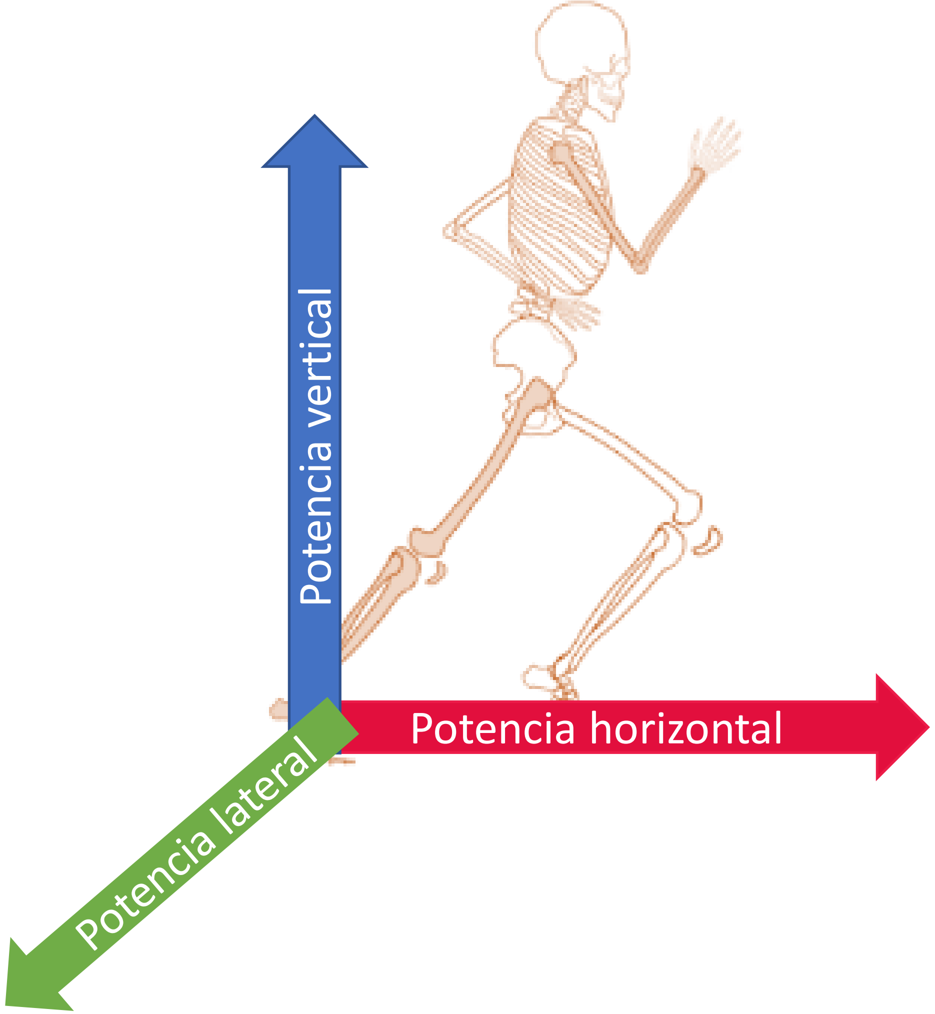
(Blickhan, 1989; Blickhan & Full, 1993; Farley, Glasheen, & McMahon, 1993b; McMahon & Cheng, 1990b)

Potencia (W) = Fuerza (N) x Velocidad (m/s)

Potencia (W) = Trabajo (J) x Tiempo (s)







Potencia vertical

- Destinada a la fase vertical del salto

Potencia lateral

- Fluctuaciones laterales

Potencia horizontal

- Permite el avance hacia adelante

Potencia (W) = Fuerza (N) x Velocidad (m/s)

Potencia (W) = Trabajo (J) x Tiempo (s)

- El entrenamiento de la carrera de larga distancia a través de la potencia puede traer un gran **beneficio a la relación entrenador-atleta**.
- No hay necesidad de cambiar la filosofía de trabajo fundamental del entrenador ni sus principios de entrenamiento. El uso de **la potencia permite al entrenador tener mayor eficacia** en el entrenamiento de sus corredores.
- La potencia permite prescribir **entrenamientos más precisos**, con una **mayor precisión de ejecución por parte de los atletas** y **mejorar la monitorización del rendimiento del atleta** por parte del entrenador.
- Al final, el entrenador proporciona al atleta el mayor valor de todos – **MEJORES RESULTADOS**

Potencia en Carrera

Evidencia científica actual

Máster Universitario en Alto Rendimiento de Deportes Cíclicos

sensors MDPI

Review

Mechanical Power in Endurance Running: A Scoping Review on Sensors for Power Output Estimation during Running

Diego Jaén-Carrillo [1], Luis E. Roche-Seruendo [1], Antonio Cartón-Llorente [1], Rodrigo Ramírez-Campillo [2] and Felipe García-Pinillos [3,4,*]

Training & Testing
Thieme

Reliability of Trail Walking and Running Tasks Using the Stryd Power Meter

Authors
James Wilfred Navalta[1], Jeffrey Montes[1], Nathaniel G. Bodell[1, 2], Charli D. Aguilar[1], Kara Radzak[1], Jacob W. Manning[3], Mark DeBeliso[3]

Contents lists available at ScienceDirect
Physiology & Behavior
journal homepage: www.elsevier.com/locate/physbeh

Running power meters and theoretical models based on laws of physics: Effects of environments and running conditions

Víctor Cerezuela-Espejo, Alejandro Hernández-Belmonte, Javier Courel-Ibáñez, Elena Conesa-Ros, Alejandro Martínez-Cava, Jesús G Pallarés*
Universidad de Murcia, Spain

Gait & Posture
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Full length article

Prediction of power output at different running velocities through the two-point method with the Stryd™ power meter

Felipe García-Pinillos [a], Pedro Á. Latorre-Román [b], Luis E. Roche-Seruendo [c], Amador García-Ramos [d, e]

Institution of MECHANICAL ENGINEERS
Journal of SPORTS ENGINEERING AND TECHNOLOGY

Original Article

Absolute reliability and agreement between Stryd and RunScribe systems for the assessment of running power

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Antonio Cartón-Llorente[1], Luis E Roche-Seruendo[1], Diego Jaén-Carrillo[1], Noel Marcen-Cinca[1] and Felipe García-Pinillos[2,3]

Are we ready to measure running power? Repeatability and concurrent validity of five commercial technologies

Víctor Cerezuela-Espejo, Alejandro Hernández-Belmonte, Javier Courel-Ibáñez, Elena Conesa-Ros, Ricardo Mora-Rodríguez & Jesús G. Pallarés

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Are we ready to measure running power? Repeatability and concurrent validity of five commercial technologies

Víctor Cerezuela-Espejo, Alejandro Hernández-Belmonte, Javier Courel-Ibáñez, Elena Conesa-Ros, Ricardo Mora-Rodríguez & Jesús G. Pallarés

- Relación consumo de oxígeno y potencia en carrera
- Determinar la fiabilidad de los dispositivos en el laboratorio y en el campo

- 12 corredores y triatletas entrenados

Edad: 25.7 ± 7.9 años; Masa corporal: 73.0 ± 8.7 kg; Altura: 177.8 ± 4.9 cm; % Masa grasa: 11.6 ± 1.4%; VO_{2max}: 61.3 ± 5.6 ml·kg^{-1}·min^{-1}; Experiencia en carrera: 6.7 ± 2.4 años

Metodología

Protocolo de cinco sesiones

VO2 + lactato

Familiarización → Lab 1 → Lab 2 → Outdoor 1 → Outdoor 2

Determinar VO_{2max}

T1 – Incremental de velocidad

- 9 $km \cdot h^{-1}$ + 1$km \cdot h^{-1}$ / 3 : 4

T2 – Incremental BW

- +0 kg, +2.5 kg, +5 kg

T3 – Incremental de pendiente

- −6%, −3%, 1%, +3%, +6%

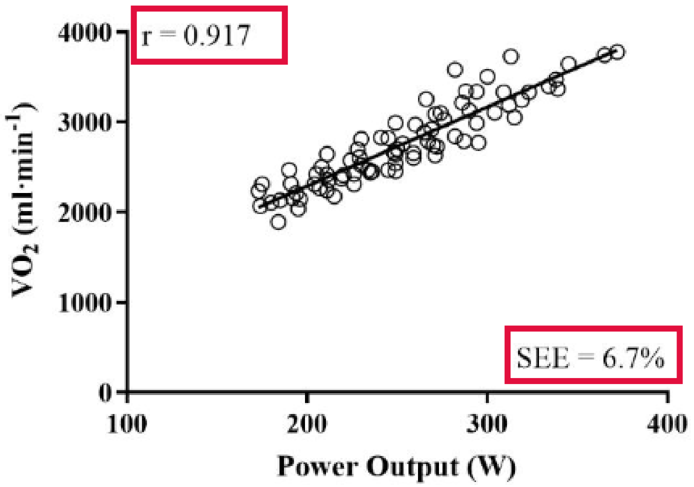
T1 – Incremental de velocidad

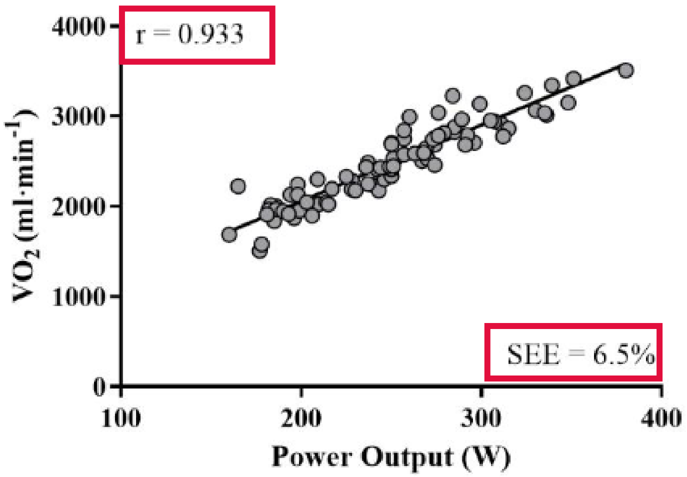
- 9 $km \cdot h^{-1}$ + 1$km \cdot h^{-1}$ / 3 : 4

Resultados

INDOOR | **OUTDOOR**

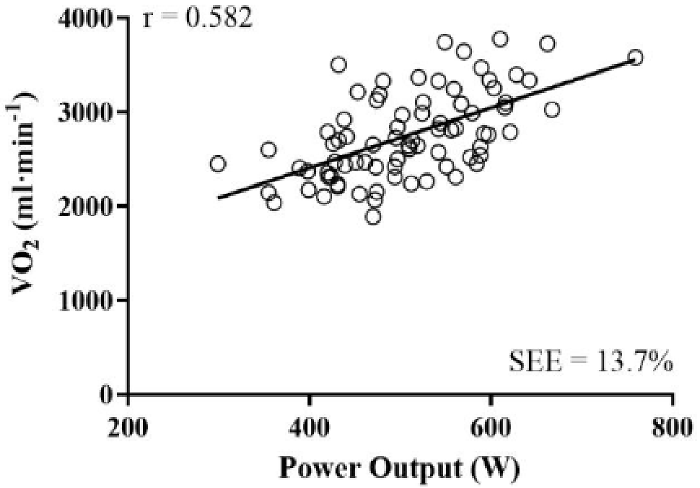
Stryd$_{App}$ vs. VO_2

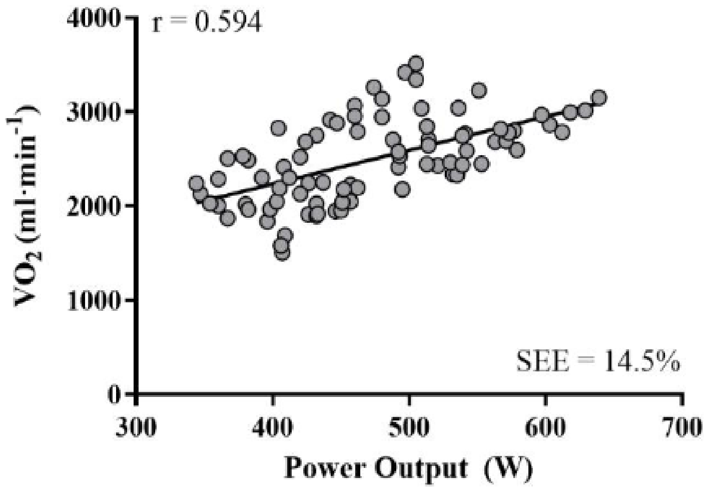




Mejor validez concurrente Pw – VO_2

RunScribe





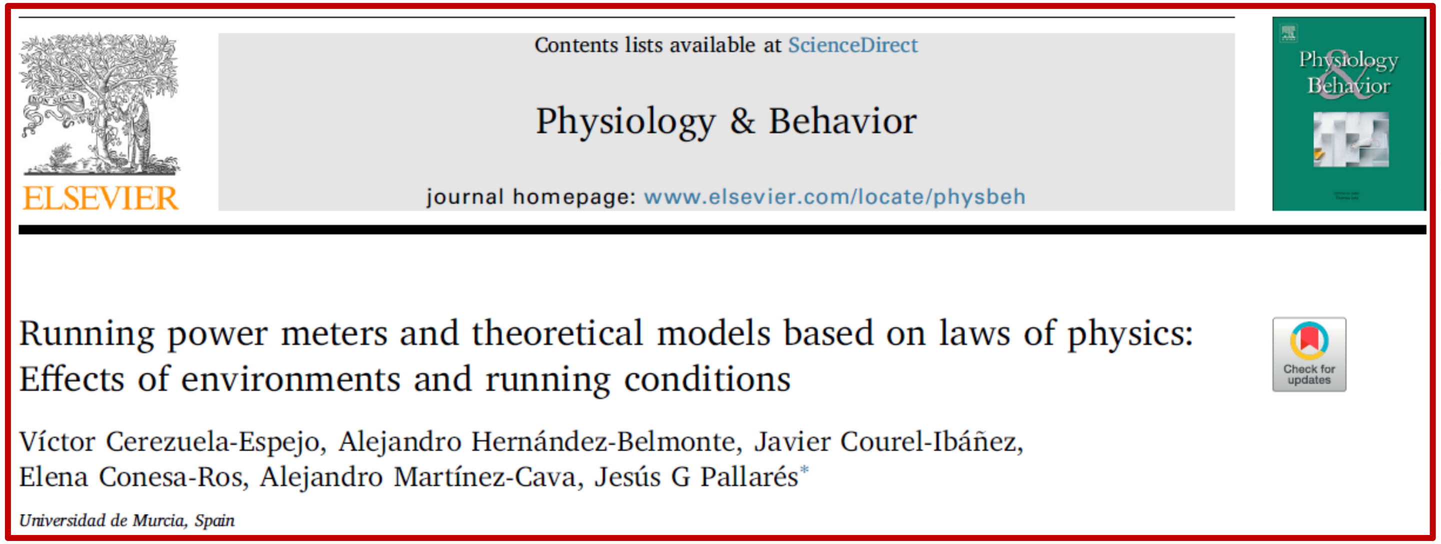
Resultados

Table I. Test-retest repeatability of P_W estimated by each technology in indoor sessions.

		Stryd$_{App}$								Stryd$_{Watch}$							
					Bland Altman (W)								Bland Altman (W)				
							LoA								LoA		
INDOOR		SEM (W)	CV (%)	ICC	Bias (Mean)	Bias (SD)	Lower limit		Upper limit	SEM (W)	CV (%)	ICC	Bias (Mean)	Bias (SD)	Lower limit		Upper limit
Speed (km/h)	9	3.7	1.9	0.998	−1.2	4.6	−10.3	to	7.8	5.2	2.8	0.992	−1.6	8.1	−17.4	to	14.2
	10	3.3	1.5							5.7	2.7						
	11	2.9	1.2							6.3	2.8						
	12	2.7	1.0							5.8	2.3						
	13	3.0	1.1							7.4	2.8						
	14	3.6	1.2							5.3	1.9						
	15	4.8	1.5							2.8	0.9						
Body weight (kg)	0	3.3	1.5	0.991	−0.8	4.2	−9.1	to	7.5	5.7	2.7	0.980	−2.2	6.5	−14.9	to	10.6
	+2.5	2.3	1.0							5.3	2.4						
	+5.0	3.3	1.4							3.0	1.3						
Slope (%)	−6°	1.7	1.1	0.999	−0.5	3.2	−6.8	to	5.9	1.7	0.8	0.988	−0.9	4.6	−10.0	to	8.1
	−3°	2.3	1.3							2.2	1.0						
	+1°	3.3	1.5							5.7	2.7						
	+3°	2.4	1.0							1.8	0.9						
	+6°	1.3	0.5							3.5	1.7						
		Garmin$_{RP}$								RunScribe							
Speed (km/h)	9	57.6	15.7	0.290	−7.0	96.7	−182.6	to	196.5	68.8	16.3	0.709	−19.1	87.8	−191.1	to	152.9
	10	57.0	14.6							64.5	14.1						
	11	66.5	16.2							54.4	11.0						
	12	72.8	17.6							50.3	9.5						
	13	73.0	16.6							45.1	8.15						
	14	70.5	15.5							73.6	12.6						
	15	82.7	18.0							86.9	13.7						
Body weight (kg)	0	57.0	14.6	0.495	17.2	65.9	−112.0	to	146.5	64.5	14.1	0.678	12.8	65.3	−115.3	to	140.8
	+2.5	36.5	9.4							33.5	7.4						
	+5.0	47.0	11.8							30.1	6.9						
Slope (%)	−6°	52.1	13.0	0.121	5.4	79.1	−149.5	to	160.4	75.7	18.1	0.589	16.9	86.8	−153.3	to	187.0
	−3°	53.5	13.2							69.6	16.0						
	+1°	57.0	14.6							64.5	14.1						
	+3°	50.5	12.3							49.9	10.5						
	+6°	63.7	15.5							42.2	8.5						

W: watts; SEM: standard error of measurement; CV: SEM expressed as a coefficient of variation; ICC: intraclass correlation coefficient, model (1,k); LoA: limits of agreement.

Mejor fiabilidad test-retest para todas las condiciones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Running power meters and theoretical models based on laws of physics: Effects of environments and running conditions

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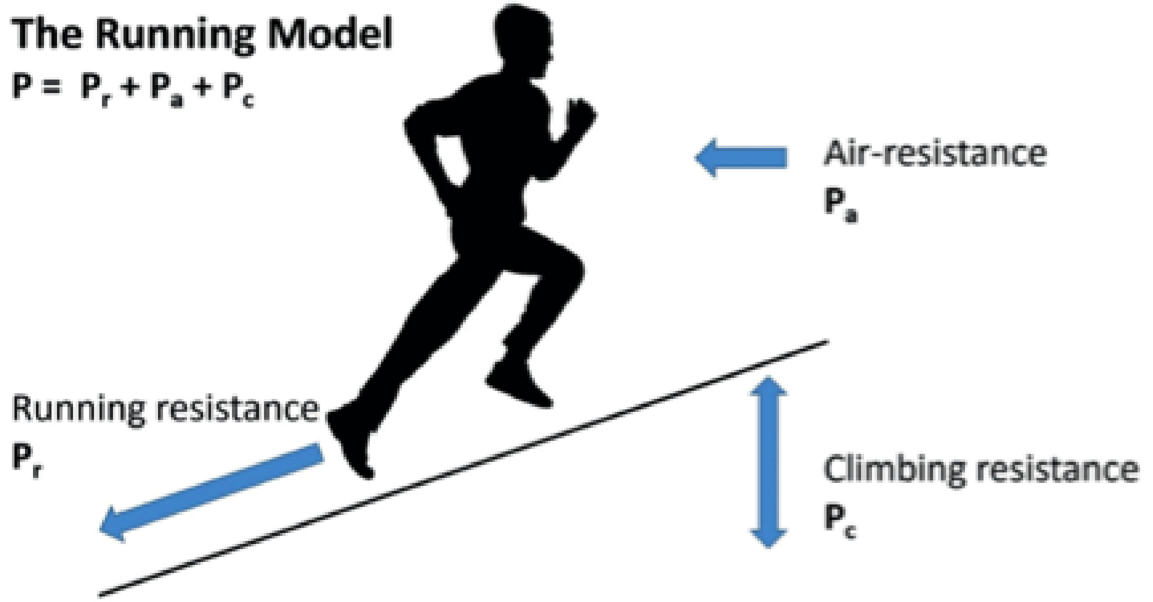

$$TP_{W1} = cmv + 0.5pc_dA(v + v_w)^2v + (i/100)mgvn$$

P_r: Running resistance

cmv

P_a: Air resistance

$0.5pc_dA(v + v_w)^2v$

P_c: Climbing resistance

$(i/100)mgvn$

c = energy cost of running (0.98 kJ/kg/km)
m = body weight (kg)
v = speed (m/s)

p = density of the air (1.205 kg/m³)
c_dA = air resistance (0.24 m²)
v_w = wind speed (m/s)

i = slope (%)
g = gravity force (9.81 m/s²)
n = hill factor (45.6 + 1.1622i)

$$TP_{W2} = (0.5\rho(C_d A_f)v^2 + (155.4s^5 - 30.4s^4 - 43.3s^3 + 46.3s^2 + 19.5s + 3.6)\eta m + (0.5(v^2 - v_0^2)/d))v$$

C_{Kin}

$(0.5(v^2 - v_0^2)/d$

v = speed (m/s)
v_0 = initial speed (m/s)
d = distance

C_{Aero}

$0.5\rho C_d A_f v^2$

ρ = density of the air (1.2 kg/m^3)
C_d = coefficient of aerodynamism (0.9)
A_f = frontal area $(0.2025 \cdot 0.266 h^{0.725} m^{0.425})$
h = height (m)

C_{Slope}

$155.4s^5 - 30.4s^4 - 43.3s^3 + 46.3s^2 + 19.5s + 3.6$

s = slope (%)

Other factors

ηm

η = efficiency factor $(0.25 + 0.054v) \cdot (1 - 0.5v/8.33)$
m = body weight (kg)

$$TP_{w1} = cmv + 0.5pc_dA(v + v_w)^2v + (i/100)mgvn$$

Agreement between running power (P_W) estimated by each technology and the theoretical model of Dijk and Megen (TP_{W1}), in different environments (indoor and outdoor) and running conditions (increasing speed, body weight, and slope).

Running condition	Indoor				Outdoor				
	$Stryd_{App}$	$Stryd_{Watch}$	$Garmin_{RP}$	RunScribe	$Stryd_{App}$	$Stryd_{Watch}$	$Garmin_{RP}$	RunScribe	$Polar_V$
Speed									
Bias ± SD	3 ± 7	−7 ± 7	170 ± 40	258 ± 77	−1 ± 13	−2 ± 12	130 ± 48	224 ± 68	86 ± 28
SEM	5	7	124	190	9	9	98	165	64
SDC	14	20	342	528	26	24	272	459	177
r	0.991	0.990	0.718	0.433	0.967	0.972	0.752	0.463	0.931
Body weight									
Bias ± SD	5 ± 6	−4 ± 6	181 ± 38	248 ± 74	6 ± 7	−1 ± 8	123 ± 41	231 ± 82	70 ± 16
SEM	5	5	131	183	6	6	92	173	50
SDC	15	14	363	506	18	17	254	480	140
r	0.977	0.977	0.675	0.030	0.966	0.948	0.313	0.060	0.935
Slope									
Bias ± SD	4 ± 15	−1 ± 42	198 ± 57	257 ± 81					
SEM	11	29	145	190					
SDC	30	81	403	527					
r	0.947	0.425	0.263	0.230					

Errors are presented in watts (W); SEM: standard error of measurement; SDC: smallest detectable change (sensitivity). *r*: Pearson's correlation coefficient.

$$TP_{W2} = (0.5\rho(C_d A_f)v^2 + (155.4s^5 - 30.4s^4 - 43.3s^3 + 46.3s^2 + 19.5s + 3.6)\eta m + (0.5(v^2 - v_0^2)/d))v$$

Agreement between running power (P_W) estimated by each technology and the theoretical model of Skiba and co-workers (TP_{W2}), in different environments (indoor and outdoor) and running conditions (increasing speed, body weight, and slope).

Running condition	Indoor $Stryd_{App}$	$Stryd_{Watch}$	$Garmin_{RP}$	RunScribe	Outdoor $Stryd_{App}$	$Stryd_{Watch}$	$Garmin_{RP}$	RunScribe	$Polar_V$
Speed									
Bias ± SD	−70 ± 28	−80 ± 29	97 ± 54	185 ± 80	−64 ± 29	−66 ± 29	67 ± 50	161 ± 73	22 ± 26
SEM	53	60	78	143	49	50	59	125	24
SDC	148	166	217	395	137	140	164	346	68
r	0.988	0.984	0.695	0.479	0.966	0.971	0.765	0.508	0.932
Body weight									
Bias ± SD	−47 ± 10	−57 ± 10	129 ± 37	185 ± 67	−39 ± 10	−43 ± 10	86 ± 46	183 ± 78	25 ± 14
SEM	34	41	95	139	29	31	69	140	21
SDC	94	113	263	385	80	87	191	389	55
r	0.977	0.977	0.675	0.070	0.944	0.933	0.347	0.013	0.934
Slope									
Bias ± SD	−45 ± 23	−49 ± 59	148 ± 71	208 ± 87					
SEM	35	54	116	159					
SDC	99	150	323	441					
r	0.962	0.376	0.214	0.238					

Errors are presented in watts (W); SEM: standard error of measurement; SDC: smallest detectable change (sensitivity). *r*: Pearson's correlation coefficient.

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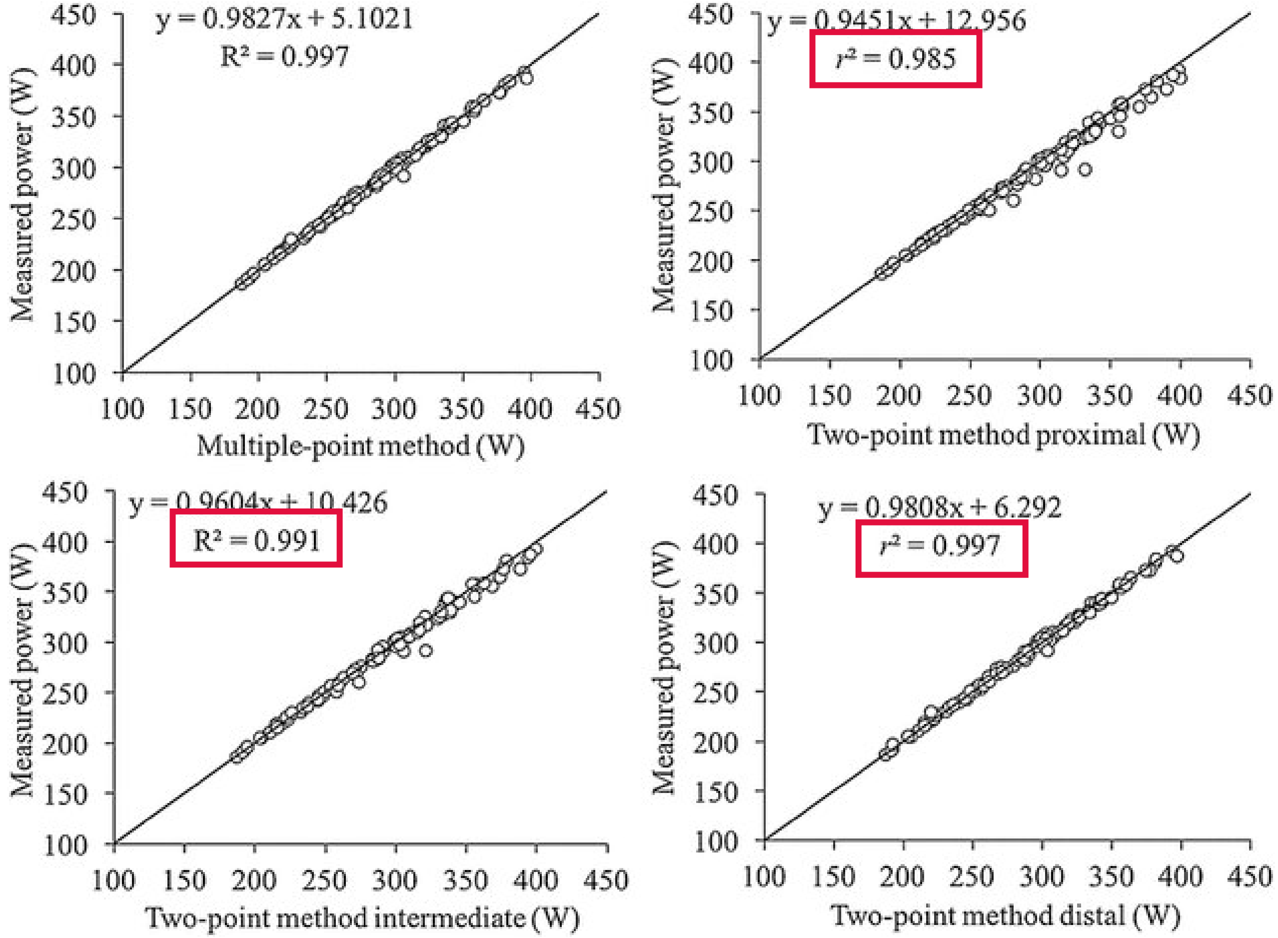
Volume 68, February 2019, Pages 238-243
Full length article

Prediction of power output at different running velocities through the two-point method with the Stryd™ power meter

Felipe García-Pinillos [a], Pedro Á. Latorre-Román [b], Luis E. Roche-Seruendo [c], Amador García-Ramos [d, e]



- Determinar relación potencia-velocidad
- Determinar validez 'two point method' para estimar potencia a diferentes velocidades

- P-V determinada usando el método de múltiples puntos y método de dos puntos
- La relación P-V sigue un modelo lineal cuando corremos a velocidades submáximas
- El método de dos puntos es fiable para evaluar la potencia en carrera usando dos velocidades distantes (i.e.; 10-17km/h

Orthopedics & Biomechanics
Thieme

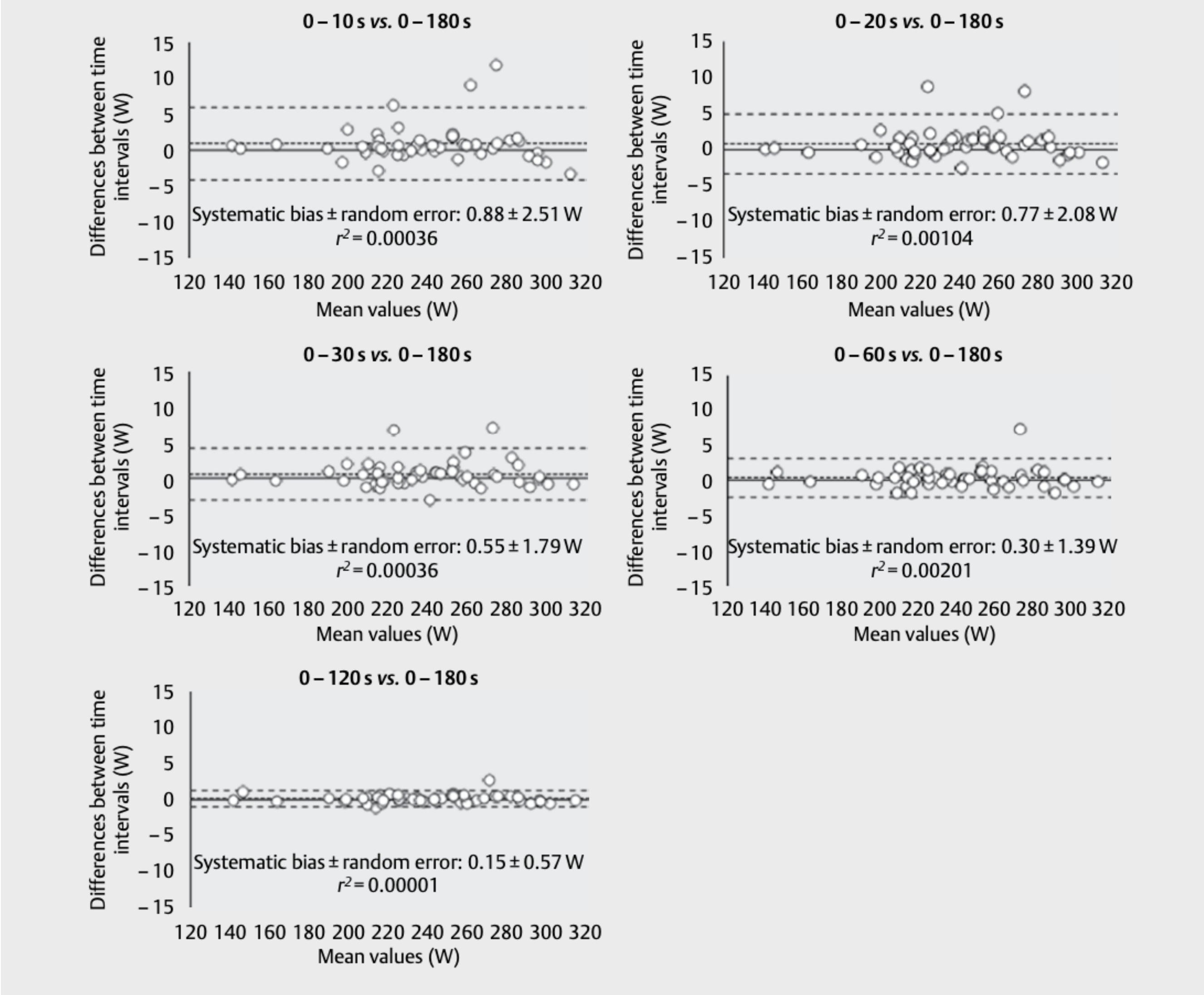
How Does Power During Running Change when Measured at Different Time Intervals?

Authors
Felipe García-Pinillos[1], Víctor M. Soto-Hermoso[2], Pedro Á. Latorre-Román[3], Juan A. Párraga-Montilla[4], Luis E. Roche-Seruendo[5]

- Comprobar los cambios en potencia media en diferentes intervalos de tiempo

- Test incremental de velocidad
- Velocidad inicial de 8 km·h^{-1}
- +1 km·h^{-1} / min
- 3’ recogida de datos

- La potencia permanece constante cuando la velocidad es constante
- A mayor intervalo de tiempo, menor error



Potencia en Carrera

Sistemas para medir la Potencia en Carrera

- **Potencia**
- Potencia vertical
- Ritmo
- Cadencia
- Tiempo de contacto
- Rigidez de la pierna (LSS)
- Oscilación vertical
- Resistencia del aire

PET

- Step Rate
- Stride Length
- Step Length
- Contact Time
- Flight Time
- Contact Ratio
- Flight Ratio
- Stride Angle

Cinemática

- Vertical Speed
- Footstrike Type
- Pronation Excursion
- Max Pronation Velocity
- Pronation Excursion (MP->TO)
- Swing Excursion
- Yaw Excursion
- Yaw Excursion (MP->TO)
- Yaw Excursion (Swing)
- Stance Excursion (FS->MP)
- Stance Excursion (MP->TO)

Fases de la marcha

- Time (FS->MPV)
- Time (MPV->MP)
- Time (MP->TO)
- Time (TO->Min Swing)
- Time (Min Swing->Max Swing)
- Time (Max Swing->FS)

Cinética

- **Potencia**
- Leg Spring Stiffness
- Vertical Spring Stiffness
- Shock
- Impact Gs
- Impact Gs (Amplitude)
- Peak Vertical GRF
- Vertical GRF Rate
- Braking Gs
- Braking Gs (Amplitude)
- Horizontal GRF Rate
- Medio Lateral Gs
- Swing Force Rate
- Total Force Rate

Institution of MECHANICAL ENGINEERS
Journal of SPORTS ENGINEERING AND TECHNOLOGY

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1–6

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SAGE

Absolute reliability and agreement between Stryd and RunScribe systems for the assessment of running power

Antonio Cartón-Llorente[1], Luis E Roche-Seruendo[1], Diego Jaén-Carrillo[1], Noel Marcen-Cinca[1] and Felipe García-Pinillos[2,3]

Protocolo de una sesión

- Tapiz rodante al 0%
- $V_0 = 8\ km \cdot h^{-1} + 1 km \cdot h^{-1}$ / min hasta velocidad confortable
- 8’ acomodación + 3’ de recogida de datos

- Determinar fiabilidad absoluta (intrasujeto)
- Evaluar nivel de acuerdo Stryd-RS para medir potencia

10k < 50’

Table 1. Descriptive characteristics of the participants (mean, ±SD; *n*, %).

Variables		
Sex	Male	44 (89.8%)
	Female	5 (10.2%)
Age (years)		26.16 (8.35)
Height (m)		1.74 (0.07)
Body mass (kg)		70.9 (9.5)
Velocity (km/h)		11.7 (1.3)

Table 2. Coefficient of variation (CV) and standard error of the mean (SEM) of power data from the Stryd™ and RunScribe™ systems.

Device	CV (%)	SEM (W)
Stryd™	0.32 ± 0.29	0.3 ± 0.2
RunScribe™	1.68 ± 1.49	2.6 ± 2.5

FIABILIDAD ABSOLUTA

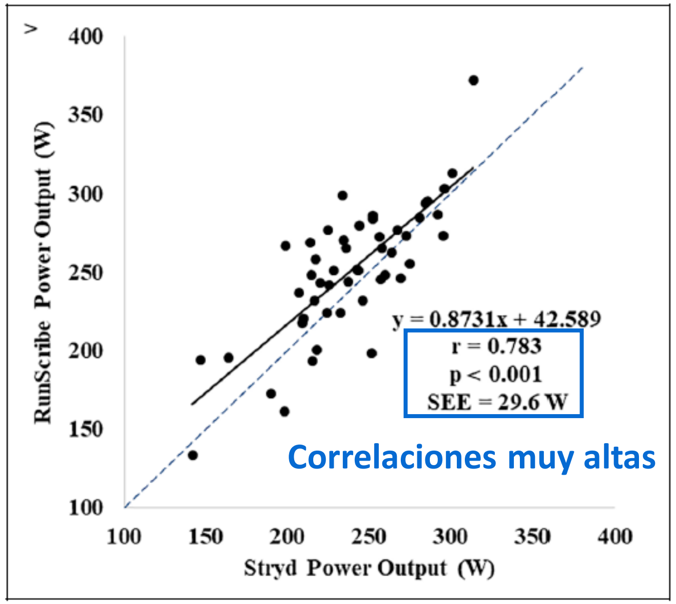

Figure 2. Pearson's correlation analysis between RunScribe and Stryd's power output data achieved during a 3-min treadmill running protocol.
SEE: standard error of estimate.
Circles indicate individual data of the crossing point between average values for each device.

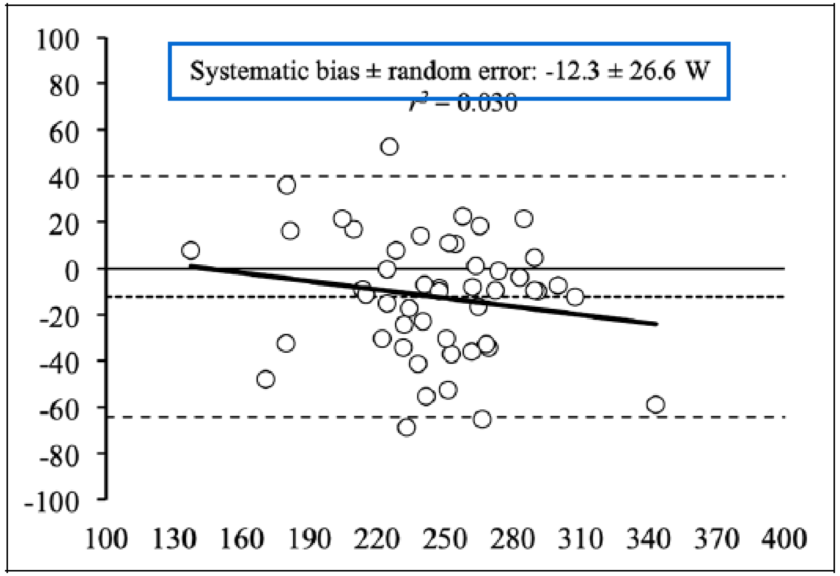

Figure 3. Bland-Altman plots for the measurement of power output during running at a self-selected comfortable speed for the Stryd™ and RunScribe™ systems.
The plot includes the mean difference (dotted line) and 95% limits of agreement (dashed lined), along with the regression line (solid line).

Límites de acuerdo
39.8 – 64.3 W

Table 3. Descriptive values and comparative analysis of power output during running from the Stryd™ and RunScribe™ systems.

	Mean (SD)		*t*-test	Correlation	ICC (2, k)
	Stryd™	RunScribe™	*p*-value	*r* (*p*-value)	95% CI
Power output (W)	238.9 ± 37.7	251.2 ± 42.0	0.002	0.783 (< 0.001)	0.855 (0.707–0.924)

ICC: intraclass correlation coefficient; 95% CI: 95% confidence interval.

Original Article

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1–6

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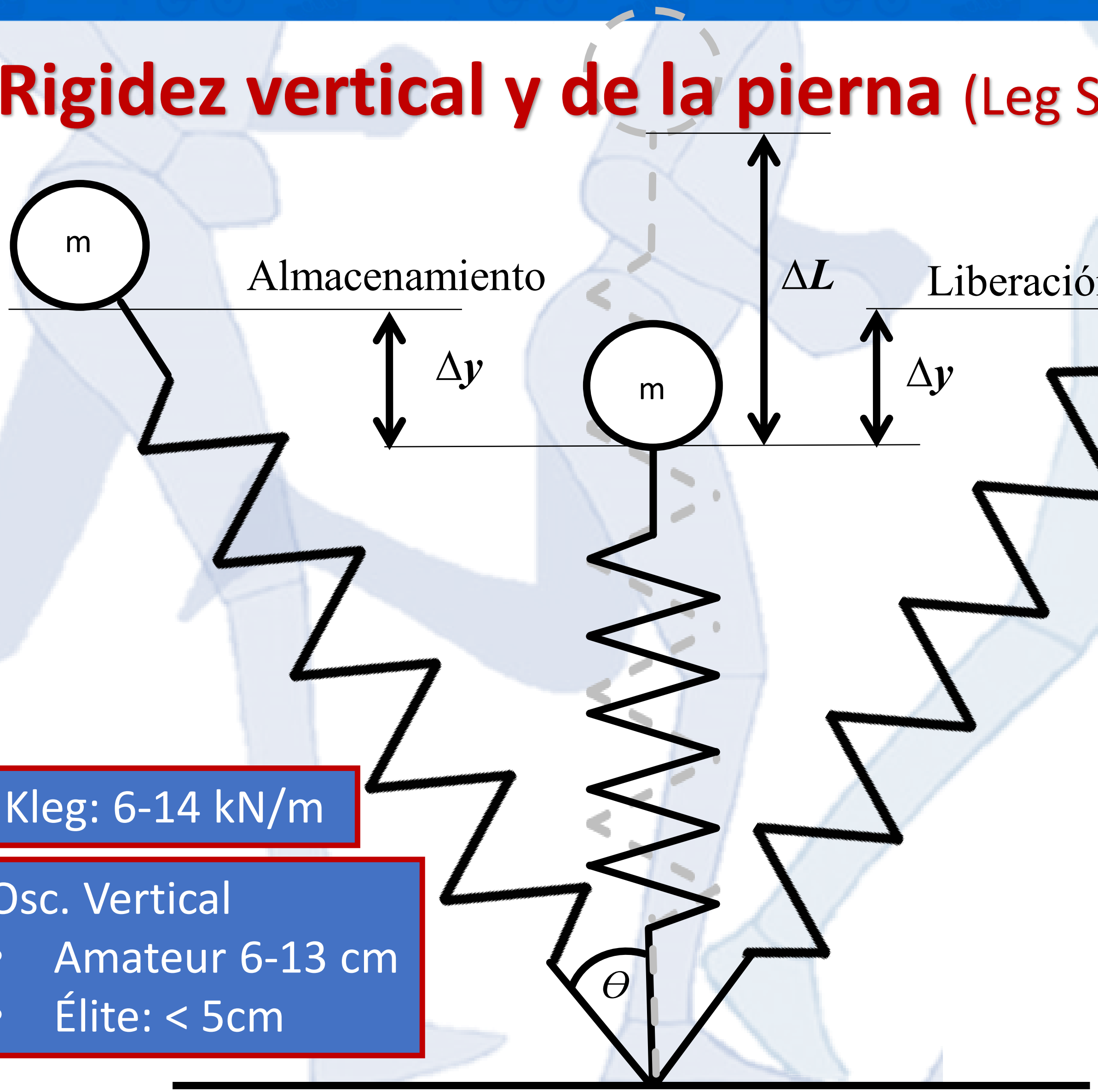
Absolute reliability and agreement between Stryd and RunScribe systems for the assessment of running power

Antonio Cartón-Llorente[1], Luis E Roche-Seruendo[1], Diego Jaén-Carrillo[1], Noel Marcen-Cinca[1] and Felipe García-Pinillos[2,3]

Ambos sistemas ofrecen datos fiables de potencia en carrera

No se recomienda usar ambos sistemas de manera aleatoria y/o intercambiar los datos de potencia que ofrecen

Rigidez vertical y de la pierna (Leg Spring Stiffness y Oscilación Vertical)



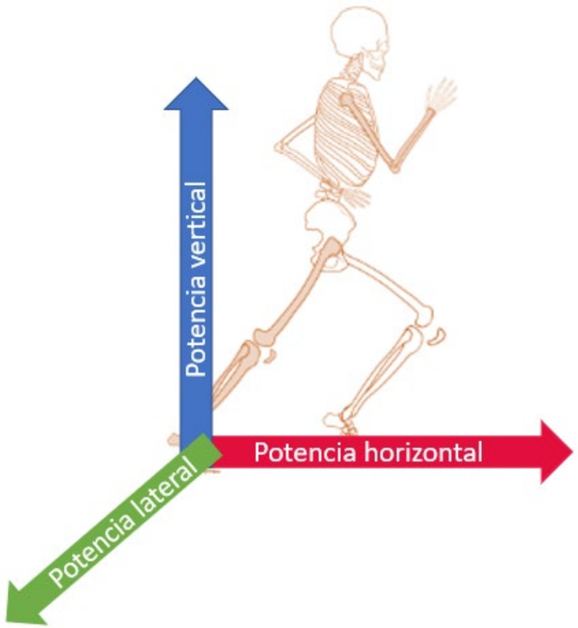
Kleg: 6-14 kN/m

Osc. Vertical
- Amateur 6-13 cm
- Élite: < 5cm

(Blickhan, 1989; Blickhan & Full, 1993; Farley, Glasheen, & McMahon, 1993b; McMahon & Cheng, 1990b)

Entrenamiento neuromuscular	Entrenamiento pliométrico	Entrenamiento musculatura pie
Aumento rigidez activa y pasiva HRT: musc. agonista LLE: ratio desarrollo F	Mejora acumulación y liberación energía elástica CT < 0.2 s.	Fortalecer foot core y aumentar stiffness del arco
Squats, peso muerto, levantamientos olímpicos y derivados	Saltos a la comba	Short foot Towel toe curl Barefoot running
2 – 3 sesiones a la semana		

Form Power



Power-Form Power= Potencia horizontal

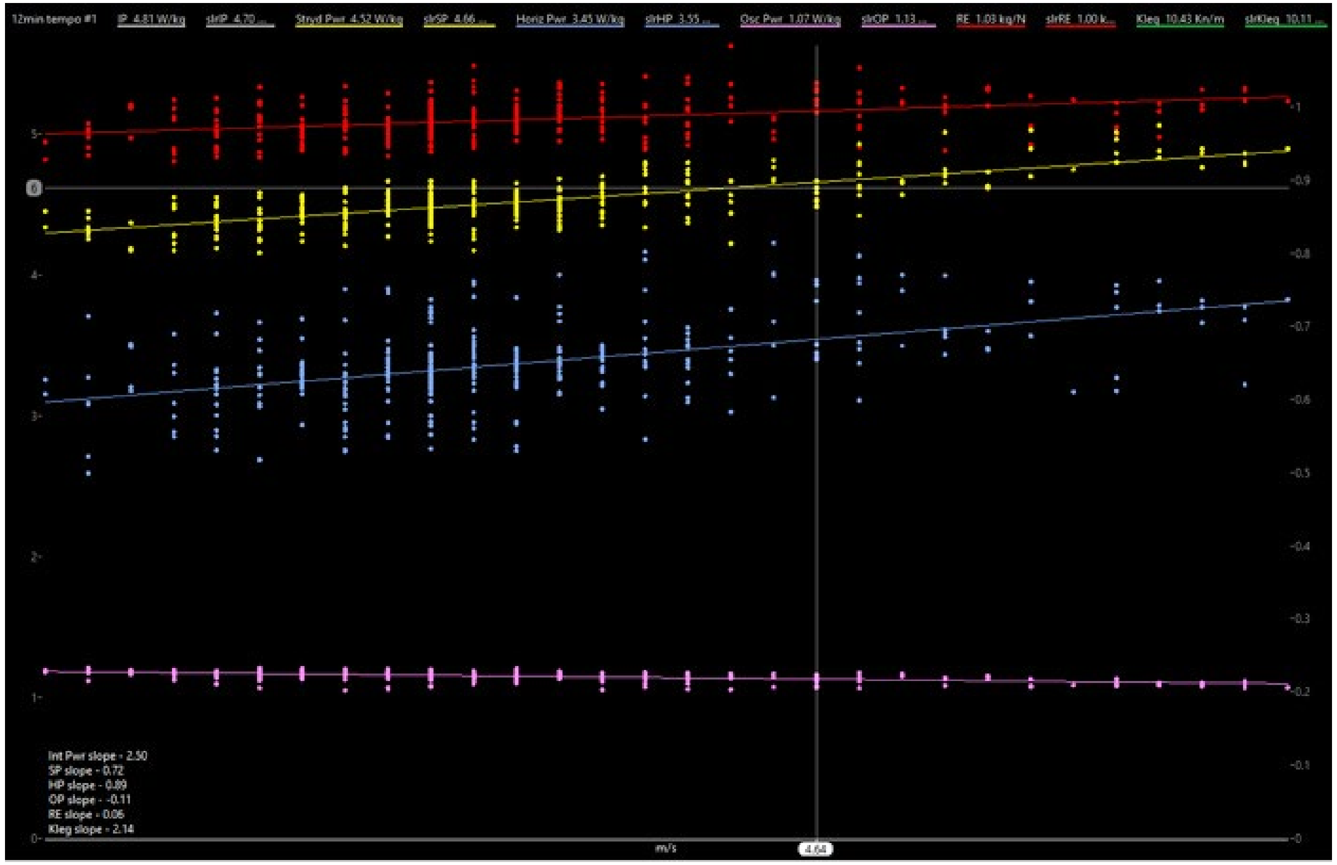
Form Power Ratio

(FORM/Power)x100 = FORM POWER RATIO (FPR)

(77/290) x 100 = 26,5%

Outstanding / likely elite	**< 20%**
Good	**< 25%**
Average	**25-30%**
Below average	**> 30%**

Running Effectiveness



RE: ratio de velocidad en relación a la potencia

RE= velocidad/potencia

A **más RE**, mayor efectividad a la hora de convertir la potencia producida en velocidad y en **avance.**

RE = <0.99 por debajo de la media
RE = 0.99 a 1.01 en la media
RE = >1.01 buena
RE = >1.05 world class runners

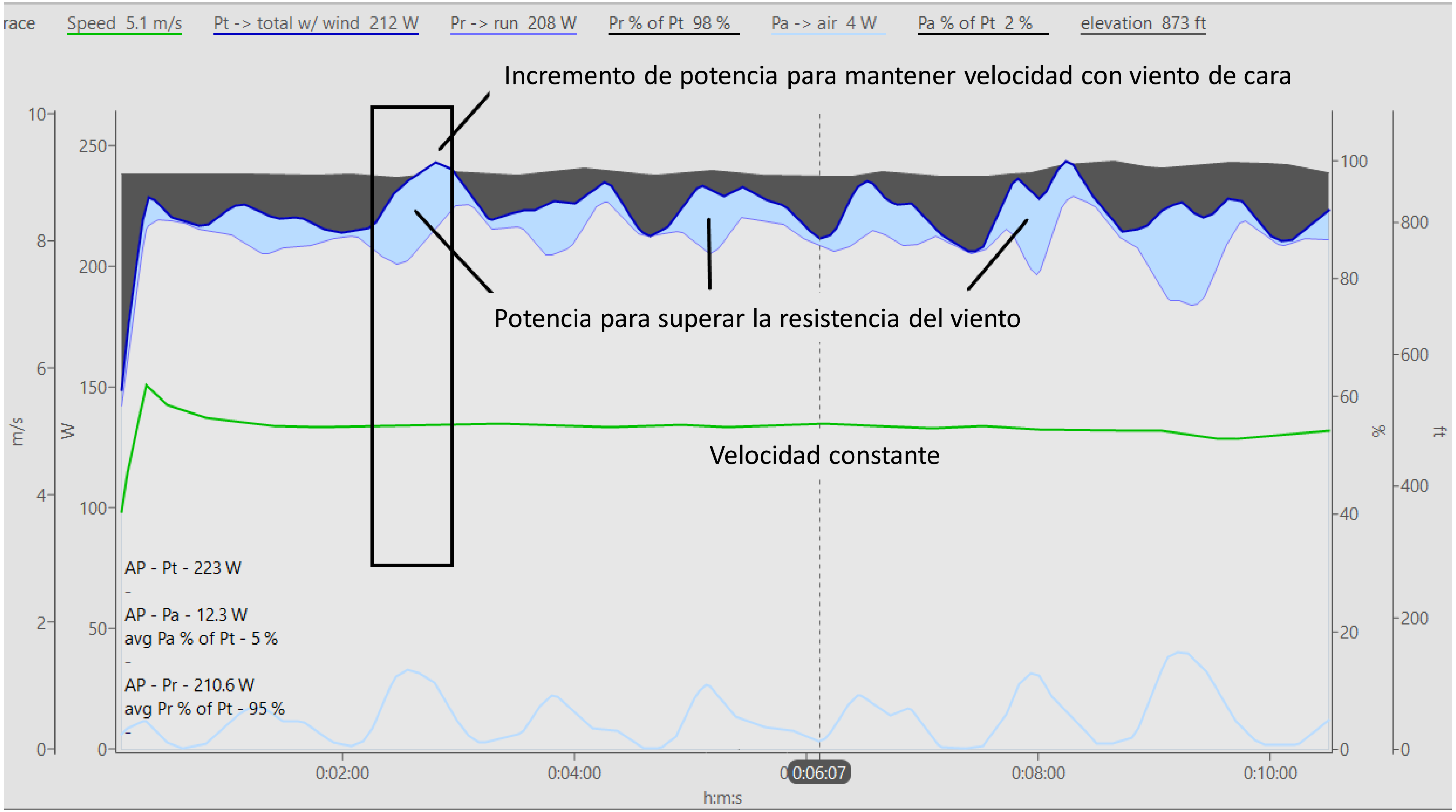
Relación con HP y FP

Resistencia al aire

https://storage.googleapis.com/stryd_static_assets/white_papers/wind-white-paper-8-17.pdf

$$F_A = \frac{1}{2}\rho C_d A v^2$$

ρ: densidad del aire
C_d: coeficiente de arrastre
A: área de sección transversal que enfrenta al aire
v: velocidad



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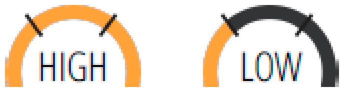
TRIATLETA ÉLITE

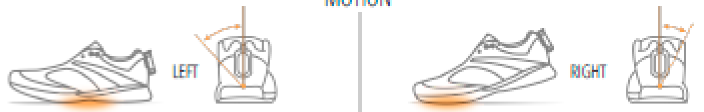
Thursday, 16 Jul 2020 - 12:16 PM

COMMUNITY COMPARISON

EFFICIENCY SHOCK



MOTION



MID FOOTSTRIKE — HIGH PRONATION AVG VELOCITY — FORE FOOTSTRIKE — AVG PRONATION LOW VELOCITY

RUN SUMMARY

SYMMETRY L R — LOW IMBALANCE

0.44	01:27	96	167	3:19	1.2k
KM	ELAPSED TIME	TOTAL STEPS	STEPS / MIN	PACE	TOTAL SHOCK (Gs)

01:27 moving time — 01:27 running time — 00:00 walking time — 00:00 stationary time

PACE (min/km)	3:05 min/km			

EFFICIENCY METRICS

		L		R
STEP RATE (s/min)	167 s/min			
STRIDE LENGTH (m)	3.88 m			
CONTACT TIME (ms)	228 ms	230	L R	229
FLIGHT RATIO (%)	37 %	36	L R	38
POWER (W)	270 W			

SHOCK METRICS

		L		R
SHOCK (G)	12.3 G	11.9	L R	13.2
IMPACT GS (G)	7.2 G	7.3	L R	6.6
BRAKING GS (G)	9.9 G	9.3	L R	11.4

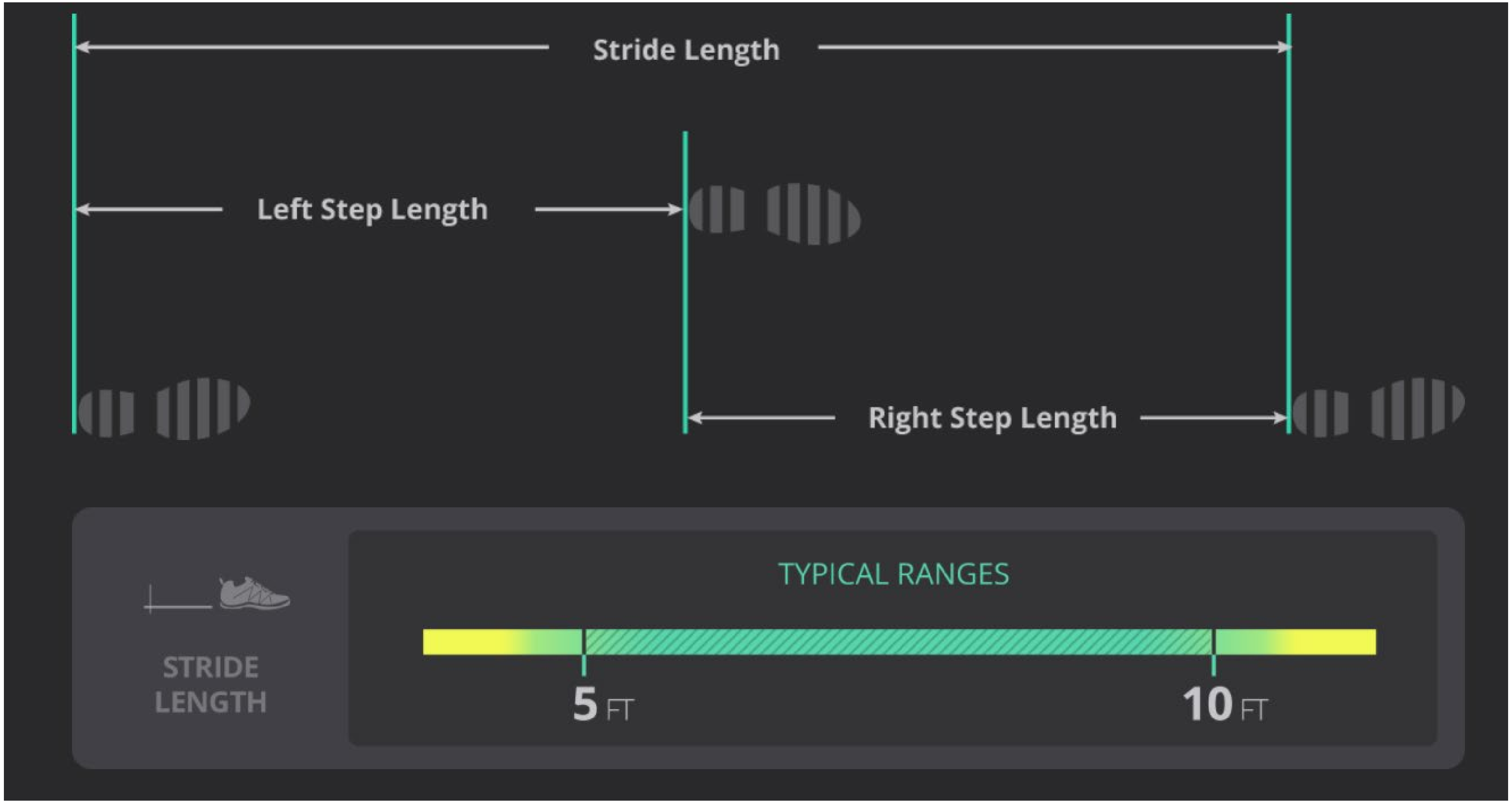
MOTION METRICS

		L		R
FOOTSTRIKE TYPE	10.9	9.8	L R	14.9
PRONATION EXCURSION (°)	-20.1 °	-21.2	L R	-16.0
MAX PRONATION VELOCITY (°/s)	627 °/s	646	L R	539

DERIVED METRICS

		L		R
PEAK VERTICAL GRF (F(Bw))	4.3 F(Bw)	4.3	L R	4.4
CONTACT RATIO (%)	63 %	64	L R	62
FLIGHT TIME (ms)	132 ms	130	L R	138
STRIDE ANGLE (°)	4.6 °	2.2	L R	3.1
LEG SPRING STIFFNESS (kN/m)	8.4 kN/m	7.1	L R	10.0
VERTICAL SPRING STIFFNESS (kN/m)	23.4 kN/m	22.0	L R	22.7
VERTICAL GRF RATE (N/kg/s)	43.1 N/kg/s	42.7	L R	42.8

Longitud de zancada (SL)



Step Length: 1.94 m

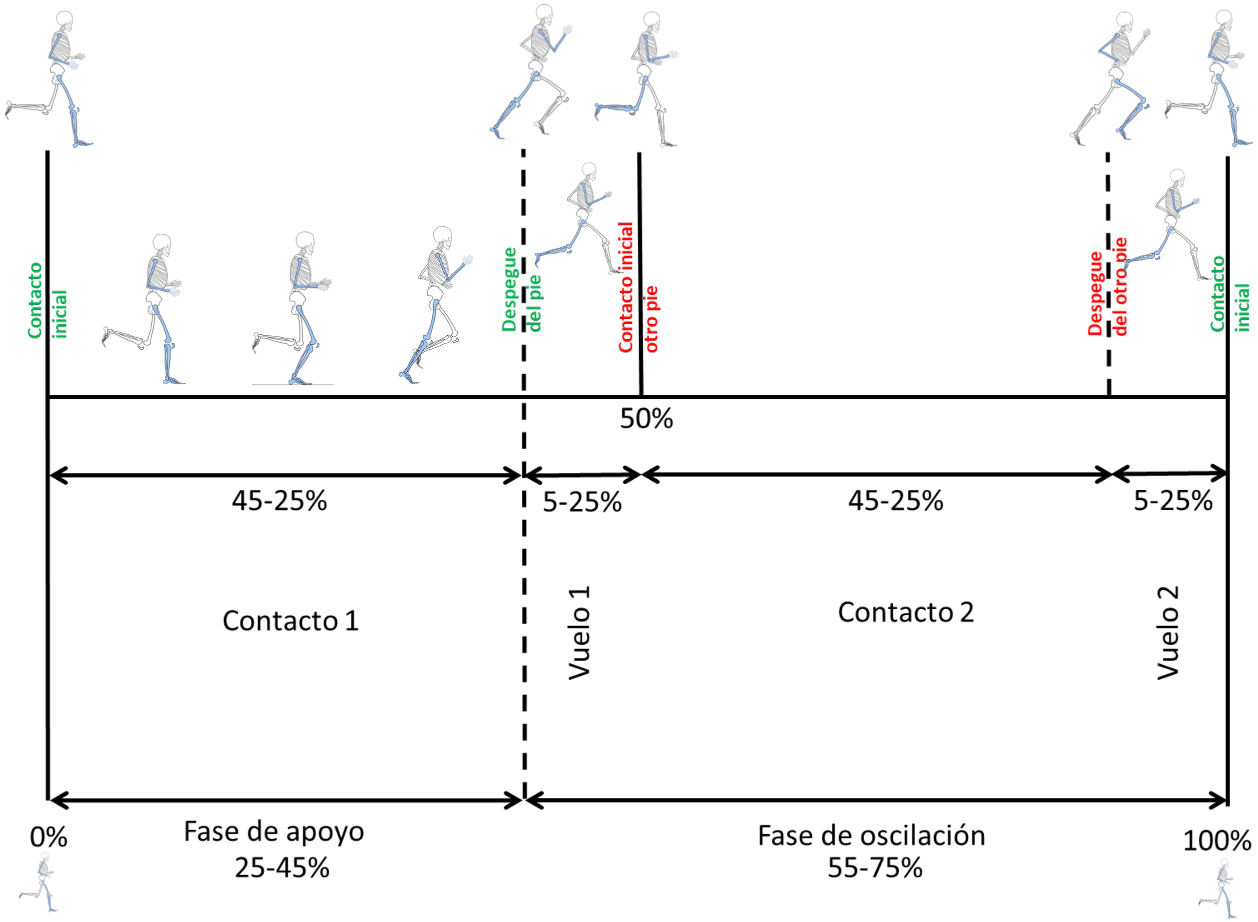
SL = StepLength x 2

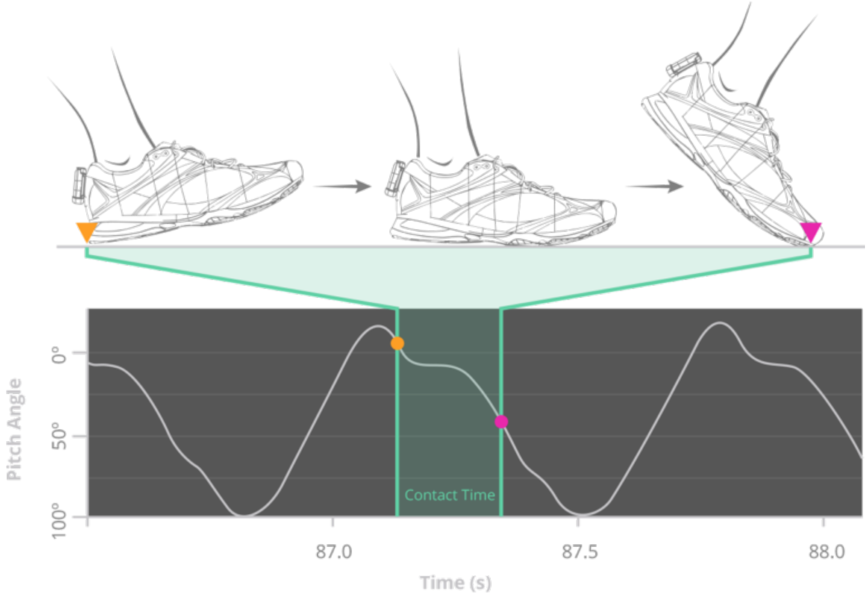
SL = 1.94 x 2

SL = 3.88 m

Tiempo de Contacto y Tiempo de Vuelo

CONTACT TIME (ms)	228 ms	230	L	R	229
FLIGHT RATIO (%)	37 %	36	L	R	38

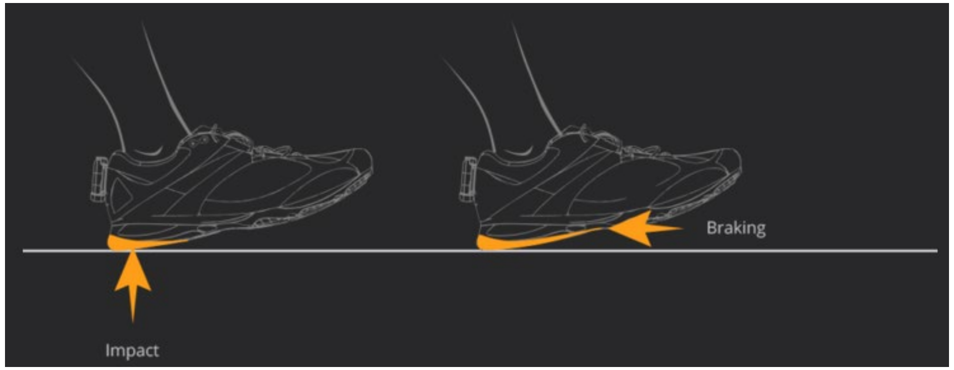


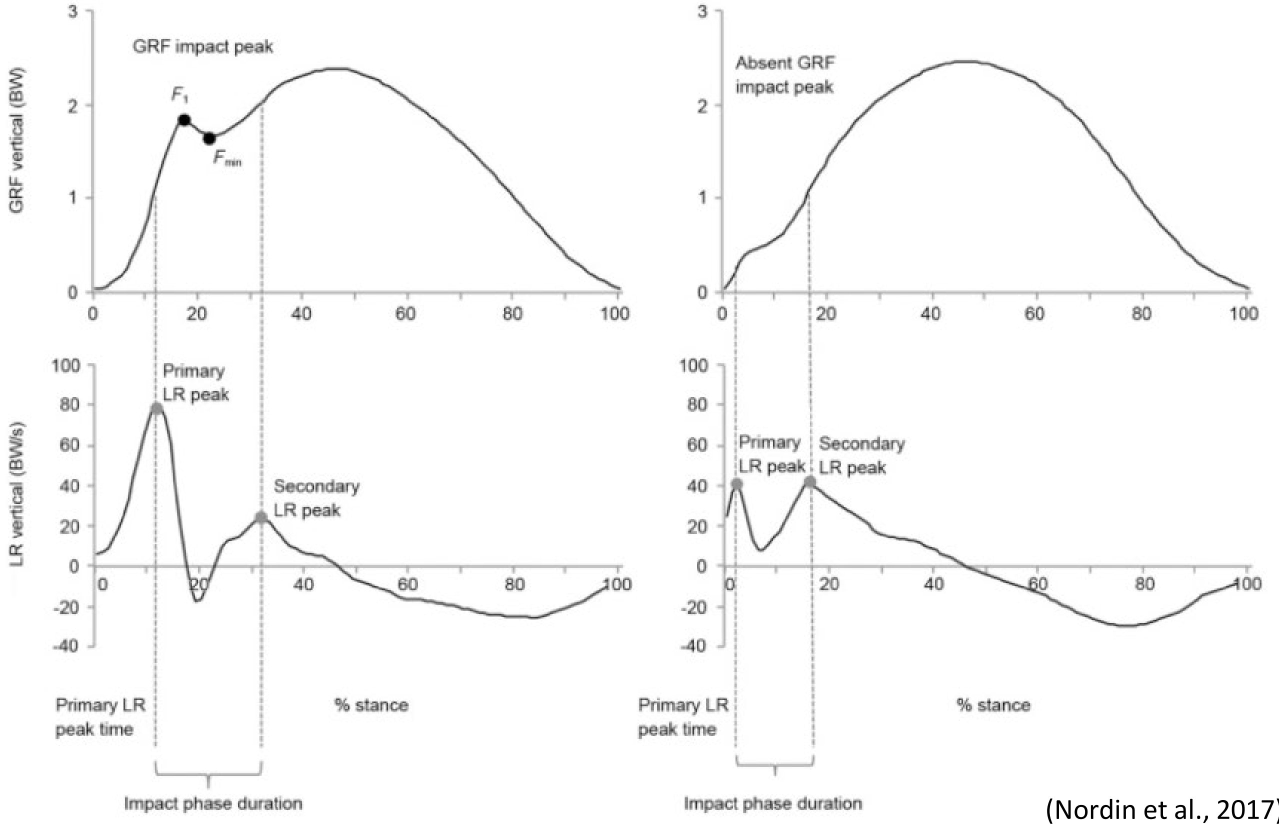


MÉTRICAS DE IMPACTO (shock metrics)

SHOCK METRICS

SHOCK (G)	12.3 G	11.9	L R	13.2
IMPACT GS (G)	7.2 G	7.3	L R	6.6
BRAKING GS (G)	9.9 G	9.3	L R	11.4





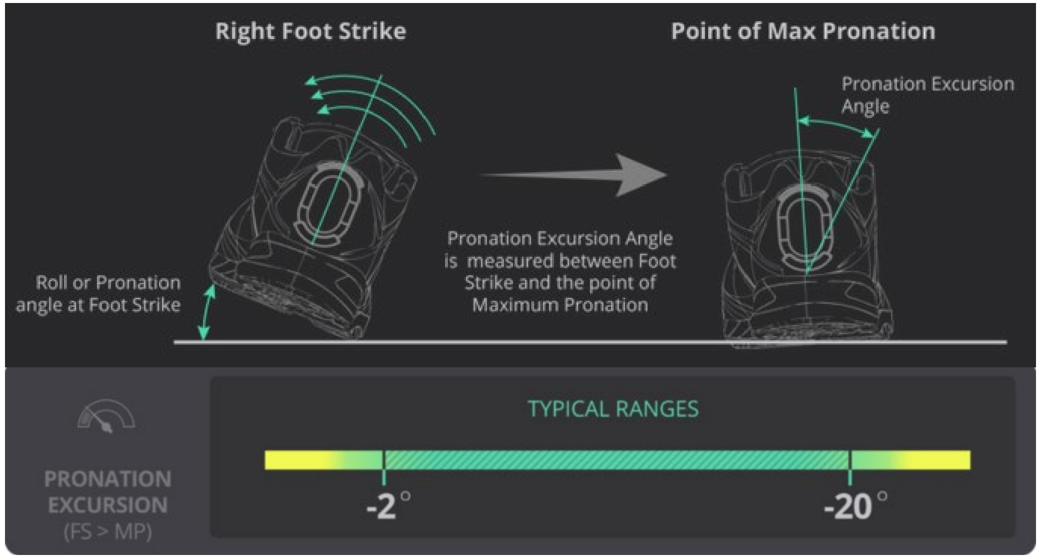
(Nordin et al., 2017)

MÉTRICAS DE MOVIMIENTO (Motion metrics)

MOTION METRICS

FOOTSTRIKE TYPE	10.9	9.8	L R	14.9
PRONATION EXCURSION (°)	-20.1 °	-21.2	L R	-16.0
MAX PRONATION VELOCITY (°/s)	627 °/s	646	L R	539

Pronación



FSP

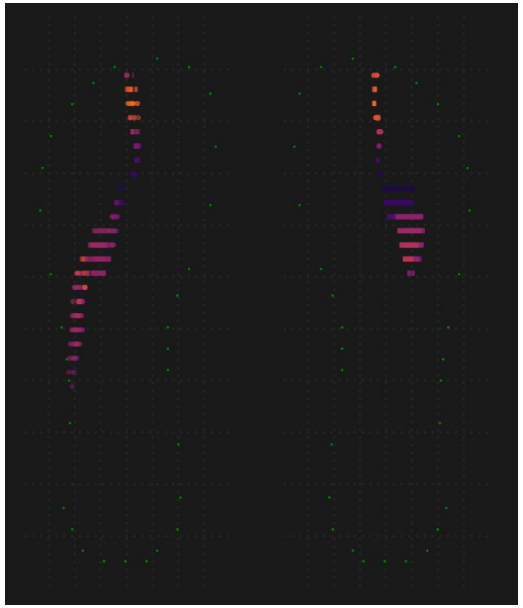
Velocidad de máxima pronación

MÉTRICAS DERIVADAS (Derived metrics)

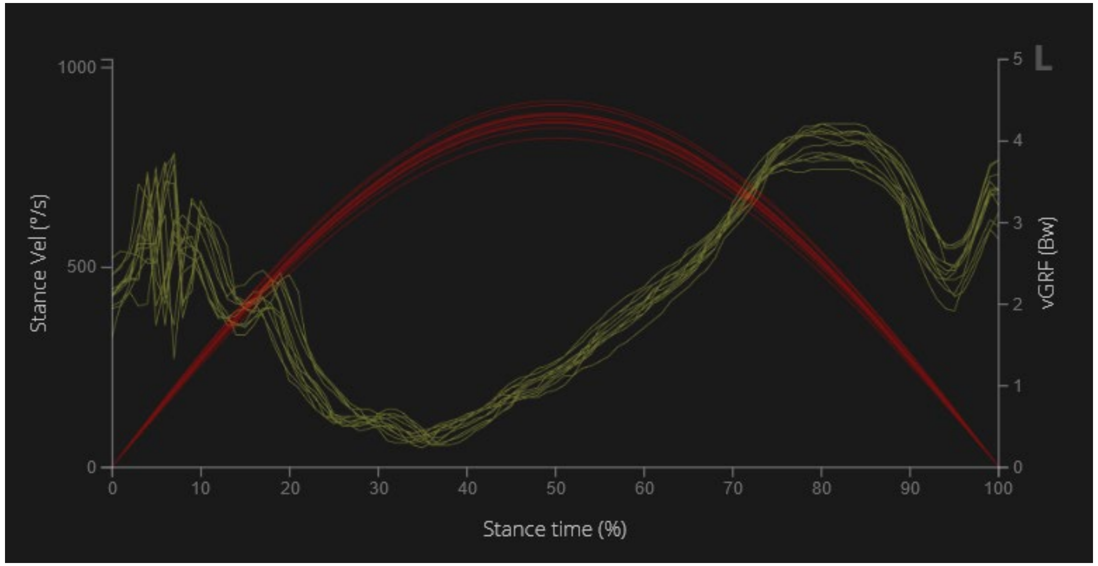
DERIVED METRICS

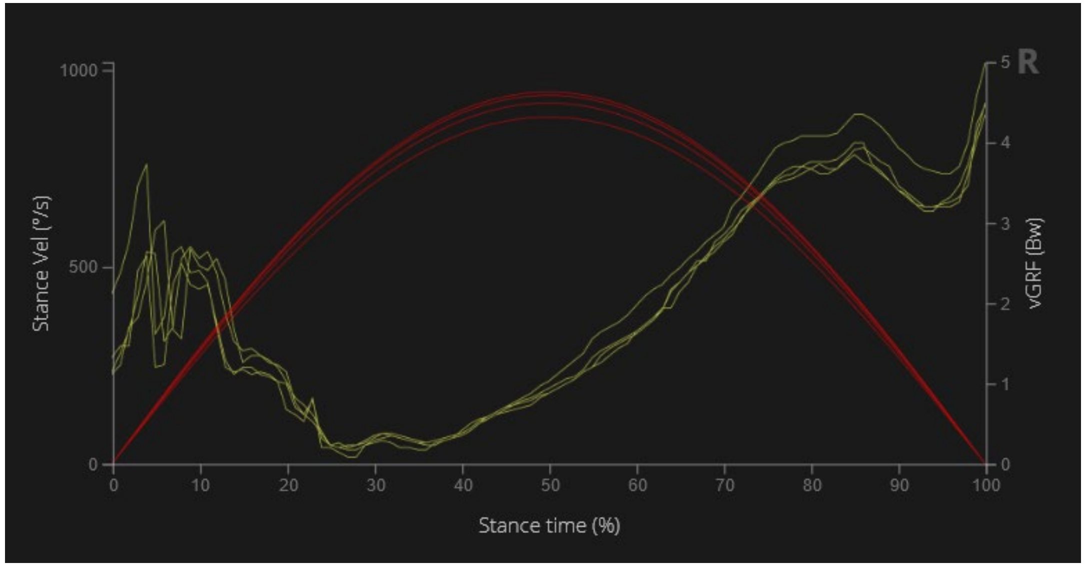
		L	R
PEAK VERTICAL GRF (F(Bw))	4.3 F(Bw)	4.3	4.4
CONTACT RATIO (%)	63 %	64	62
FLIGHT TIME (ms)	132 ms	130	138
STRIDE ANGLE (°)	4.6 °	2.2	3.1
LEG SPRING STIFFNESS (kN/m)	8.4 kN/m	7.1	10.0
VERTICAL SPRING STIFFNESS (kN/m)	23.4 kN/m	22.0	22.7
VERTICAL GRF RATE (N/kg/s)	43.1 N/kg/s	42.7	42.8

Shoe ride



Velocidad apoyo / vGRF





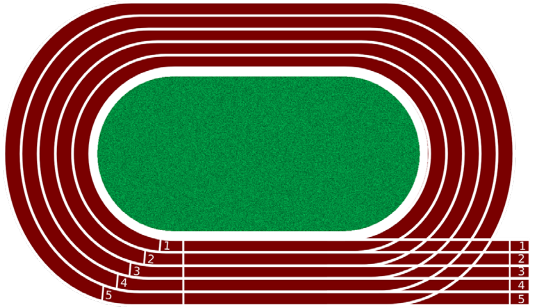
Potencia en Carrera

Aplicación Práctica

1. HALLAR CP / FTP

3-6 VUELTAS

- Calentamiento 5’ + 2-3x100m (80%)
- 800m en la pista cómodos “easy pace”
- 5’ rec
- 2400m (6 vueltas) all-out
- 30’ rec caminando o trotando
- 1200m (3 vueltas) all-out
- Vuelta a la calma



3’-9’ VUELTAS

- Calentamiento 10’’ + 5x100m (80%)
- Completar max distancia en 9’
- 30’ rec caminando o trotando
- Completar max distancia en 3’
- Vuelta a la calma

TEST 30’

- Calentamiento 15’
- 30’ All-Out
- Vuelta a la calma
- rFTP→media de los últimos 20’

1. HALLAR FTP

sensors MDPI

Article

Estimating Functional Threshold Power in Endurance Running from Shorter Time Trials Using a 6-Axis Inertial Measurement Sensor

Antonio Cartón-Llorente [1], Felipe García-Pinillos [2,3], Jorge Royo-Borruel [1], Alberto Rubio-Peirotén [1], Diego Jaén-Carrillo [1,*] and Luis E. Roche-Seruendo [1]

- Analizar el nivel de acuerdo entre los valores de MPO obtenidos en 3 time trials diferentes (10, 20 y 30 min) comparados uno de 60 min
- edad: 34.0 ±7.5; altura: 1.76 ± 0.04 m; body mass: 71.1 ± 5.8 kg; BMI: 22.9 ± 1.5 kg/m2

10k < 40’

Protocolo de 4 sesiones

- 4 Time trials (10-20-30-60 min) intentando cubrir la máxima distancia posible.
  - 1 semana de separación entre TTs.
- Medir BM antes de cada TT para ajustar potencia
- Protocolo 8’ (4’ self-selected + 4’ velocidad TT) para evitar acomodación al tapiz
- HR, RPE y MPO durante toda la prueba

Table 2. Acute response (mean, SD) to the different running time trials.

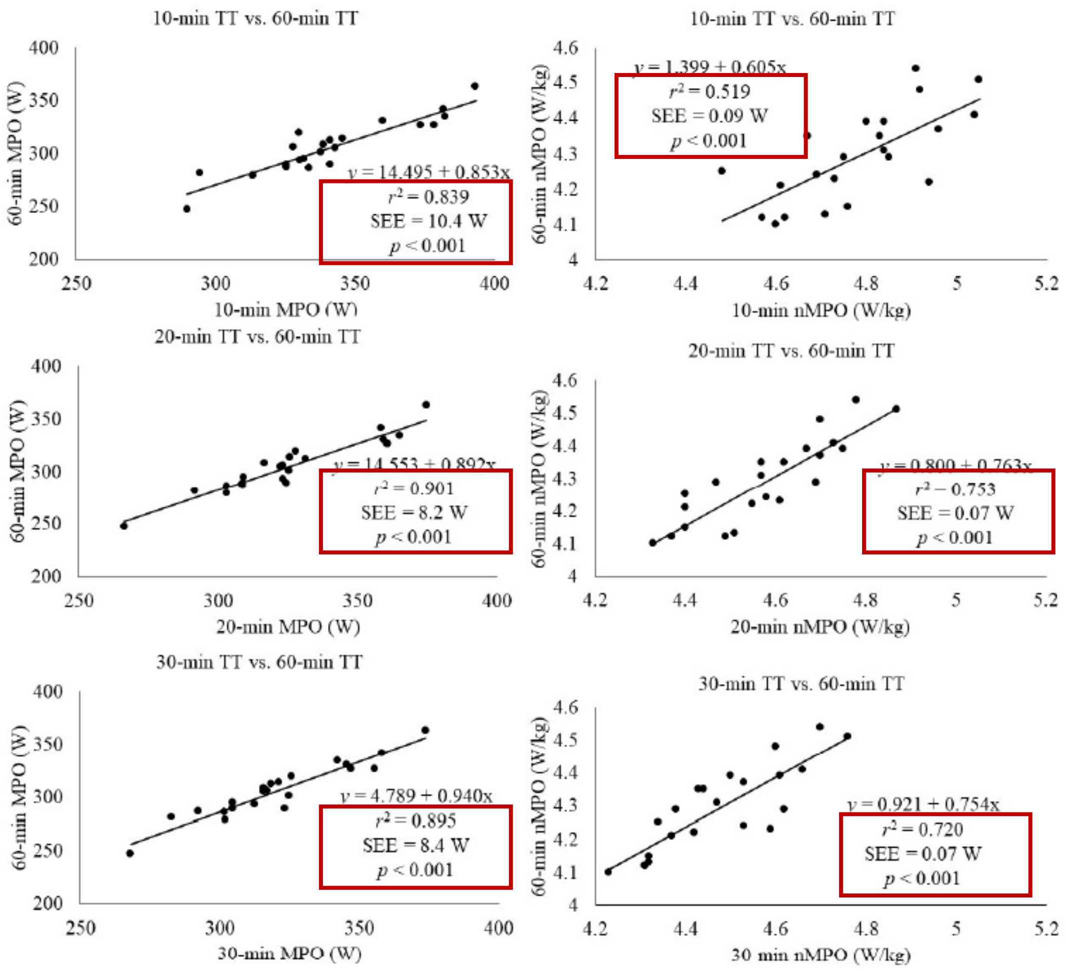
	10-min Trial	20-min Trial	30-min Trial	60-min Trial	Main Effect of Test *p*-Value
Running speed (km/h^{-1})	17.16 (0.65) [b,c,d]	16.33 (0.53) [a,c,d]	15.88 (0.50) [a,b,d]	15.12 (0.56) [a,b,c]	<0.001
Mean power output (W)	341.73 (27.19) [b,c,d]	326.90 (26.97) [a,c,d]	320.63 (25.51) [a,b,d]	306.15 (25.33) [a,b,c]	<0.001
Normalized mean power output (W/kg^{-1})	4.78 (0.15) [b,c,d]	4.58 (0.15) [a,c,d]	4.47 (0.15) [a,b,d]	4.29 (0.13) [a,b,c]	<0.001
RPE (6–20)	19.27 (0.83) [c]	18.95 (0.84)	18.64 (0.73) [a,d]	19.27 (0.88) [c]	0.011

[a] indicates significant differences regarding 10-min trial after post-hoc testing; [b] indicates significant differences regarding 20-min trial after post-hoc testing; [c] indicates significant differences regarding 30-min trial after post-hoc testing; [d] indicates significant differences regarding 60-min trial after post-hoc testing.

Table 3. Level of agreement between power output obtained during different running based-time trials regarding the reference duration (60-min time trial).

		Mean Power (W)	Normalized Mean Power (W/kg)
10-min vs. 60-min	Correlation (r-coefficient)	0.916 ***	0.720 ***
	ICC (95% CI)	0.647 (−0.084–0.909)	0.188 (−0.046–0.566)
	ICF% (CI)	89.6 (88.2–90.9)	89.8 (88.8–90.7)
20-min vs. 60-min	Correlation (r-coefficient)	0.949 ***	0.868 ***
	ICC (95% CI)	0.839 (−0.120–0.964)	0.432 (−0.061–0.808)
	ICF% (CI)	93.6 (92.5–94.7)	93.7 (93.1–94.4)
30-min vs. 60-min	Correlation (r-coefficient)	0.946 ***	0.859 ***
	ICC (95% CI)	0.899 (−0.089–0.976)	0.625 (−0.152–0.895)
	ICF% (CI)	95.5 (94.3–96.6)	95.9 (95.2–96.6)

*** $p < 0.001$; ICC: intra class correlation coefficient; ICF%: individual correction factor (%); CI: confidence interval.



10-TT: FTP = $PO_{10'}$ x 0.9

20-TT: FTP = $PO_{20'}$ x 0.94

30-TT: FTP = $PO_{30'}$ x 0.96

2. DEFINIR ZONAS DE ENTRENAMIENTO

STRYD

Zone 1 Easy — 65 - 80% CP
256 - 315 W

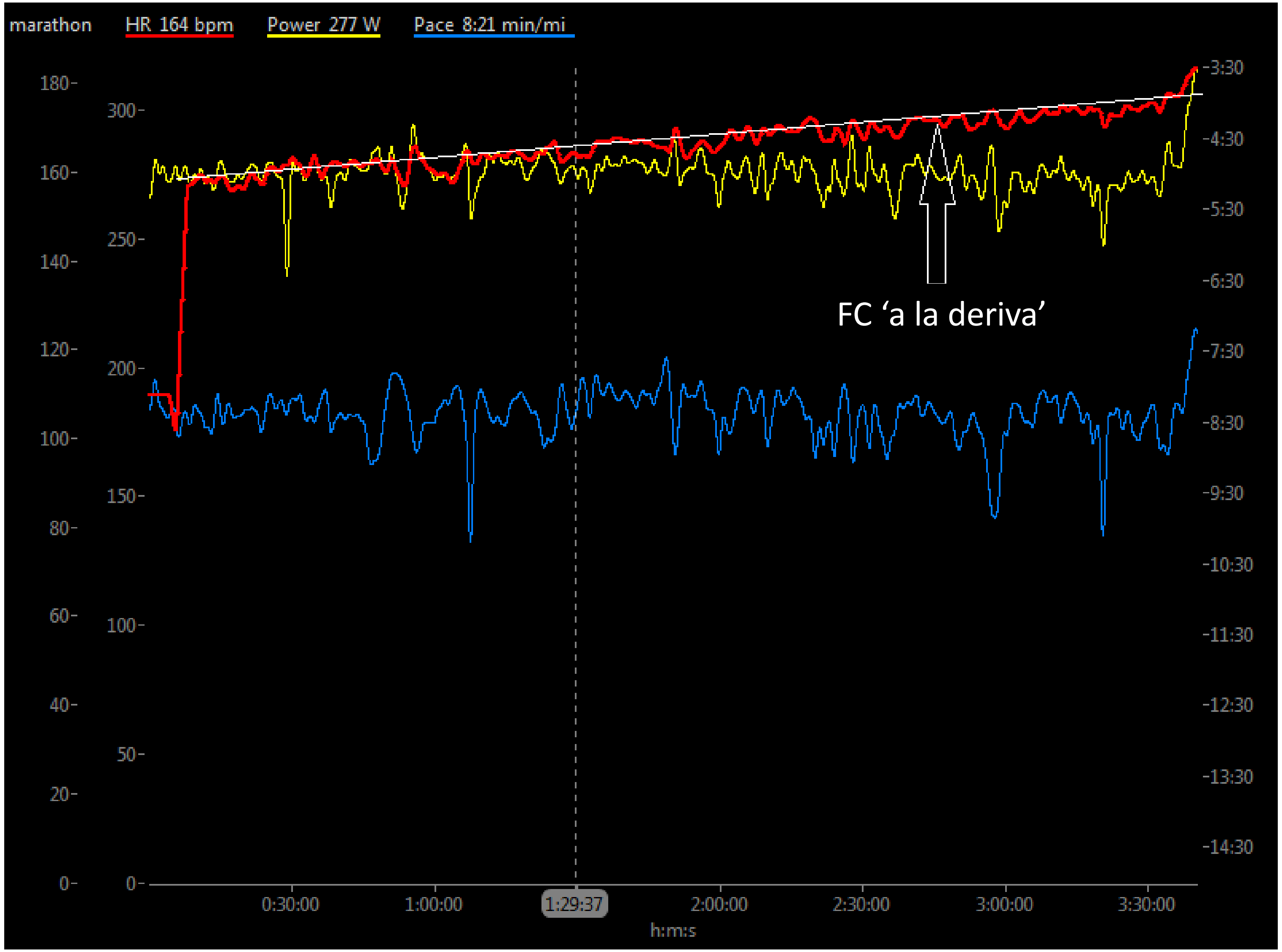
Zone 2 Moderate — 80 - 90% CP
315 - 354 W

Zone 3 Threshold — 90 - 100% CP
354 - 393 W

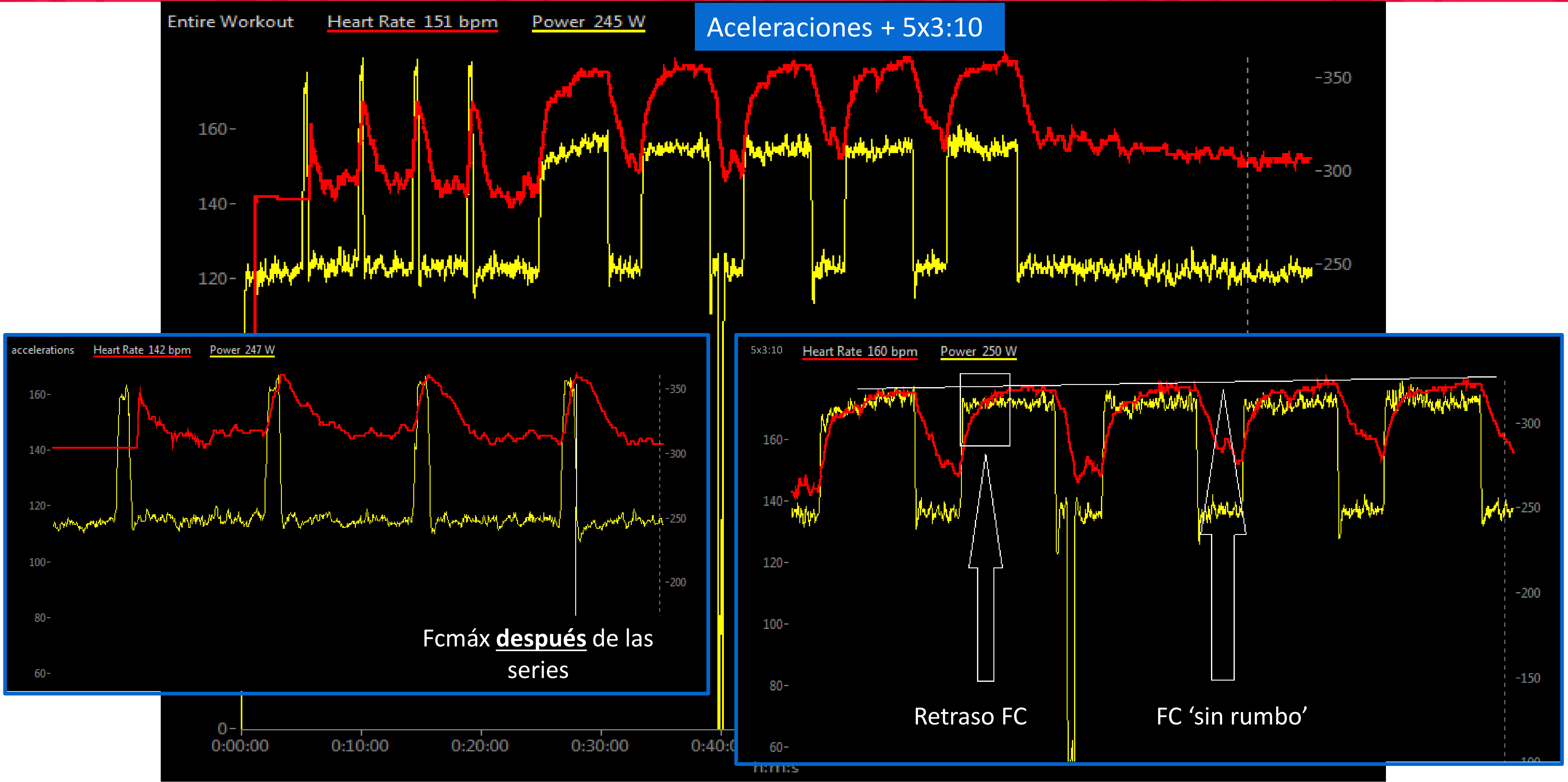
Zone 4 Interval — 100 - 115% CP
393 - 452 W

Zone 5 Repetition — 115 - 300% CP
452+ W

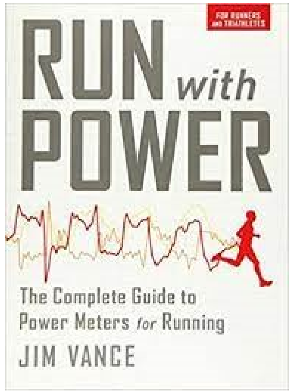
	Stryd Power Zones	Karvonen HR
Zone 1	65-80%	50% - 60%
Zone 2	80-90%	60% - 70%
Zone 3	90-100%	70% - 80%
Zone 4	100-115%	80% - 90%
Zone 5	115-130%	90% - 100%



Aceleraciones + 5x3:10



2. DEFINIR ZONAS DE ENTRENAMIENTO



Palladino Power Project

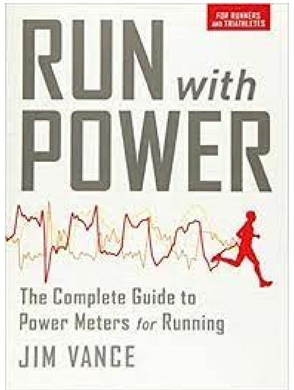
Zonas	Intensidad de entrenamiento	% del rFTPw	Tiempo
1	Andar/recuperación	<81	+3 horas
2	Resistencia	81-88	2-3 horas
3	Tempo	89-95	1-3 horas
4	Umbral	96-105	1 hora
5	Alta intensidad	105-115	20-45 minutos
6	VO_2	116-128	2-18 minutos
7	Capacidad anaeróbica Pico de potencia	>129	<2 minutos

ZONE 1		Easy Running		
	1A	Post Interval Recovery	Easy recovery between intervals and cool-down	65-75% of FTP / CP
	1B	EZ Warm-Up	Easy warm-up component before intervals or racing	75-80% of FTP / CP
	1C	EZ Aerobic Runnig	Easy Aerobic Runs	
ZONE 2		Endurance Long Run	Typically, average power for long runs / overdistance (or sustained runs with higher intensity mixed in) Otherwise a grey zone for more standard lengthen aerobic runs.	>80% to <88% of FTP / CP
ZONE 3		Threshold Stimulus		
	3A	Extensive Threshold Stimulus	Sweet spot running. Tempo runs. Generally, sustained effort runs executed at the lower percentages of FTP, or, long (>=15 minute) intervals at the higher percentages of FTP within this zone.	88 to <95% of FTP / CP
	3B	Intensive Threshold Stimulus	Threshold work. Longer intervals and occasionally, sustained effort running.	95-101% of FTP / CP
ZONE 4		Supra Threshold	Suprathreshold work. Generally intervals.	>101% to <106% of FTP / CP
ZONE 5		Maximal Aerobic Power Stimulus	Max aerobic work. Typically intervals (or occasional 'time' trials).	106% to 116% of FTP / CP
ZONE 6		Anaerobic Power Stimulus	Anaerobic work. Short intervals or short time trials	>116% to 150% of FTP / CP
ZONE 7		Sprint / Maximal Power	Maximal Power. Sprints.	>150% of FTP / CP

https://www.facebook.com/groups/PalladinoPowerProject

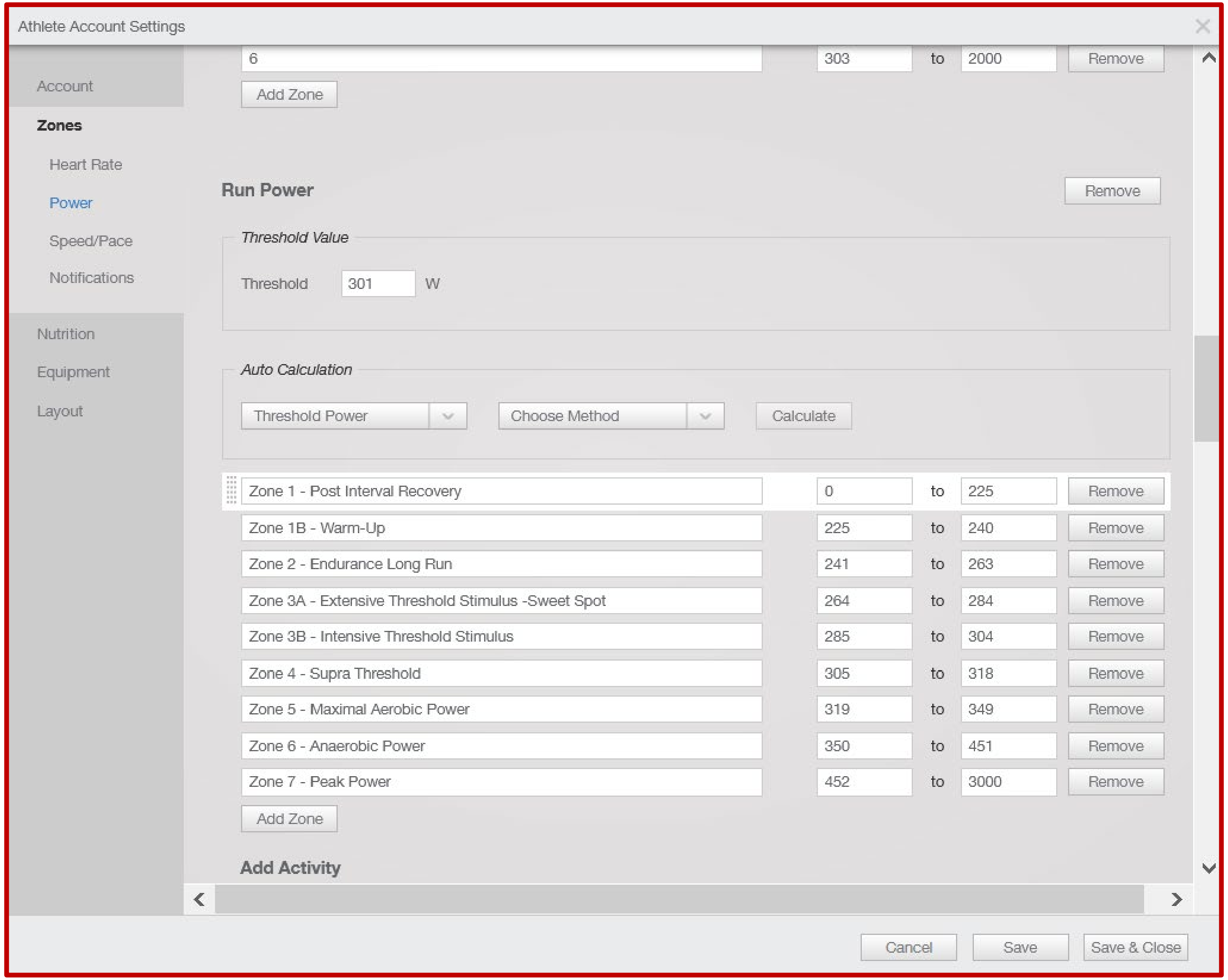
2. DEFINIR ZONAS DE ENTRENAMIENTO

Adaptaciones generadas en zonas 1-7



Adaptación	1	2	3	4	5	6	7
Incremento de volumen plasmático	*	*	**	***	****	*	*
Incremento de enzimas mitocondriales musculares	*	**	***	****	***	**	*
Incremento de umbral de lactato	*	**	***	****	***	**	*
Incremento de almacenamiento de glucógeno muscular	*	**	****	***	**	**	*
Hipertrofia de fibras musculares lentas	*	*	**	**	***	*	
Incremento de capilarización muscular	*	**	***	**	***	**	
Conversión de fibras rápidas IIb → IIa	*	**	***	***	**	*	*
Aumento del volumen sistólico / gasto cardíaco máximo	*	*	**	***	****	**	*
Incremento de VO_2máx	*	*	**	***	***	****	*
Incremento de almacenamiento de fosfatos de alta energía (ATP/PCr)						*	**
Incremento de la capacidad anaeróbica (TOLA)					*	**	***
Hipertrofia de fibras rápidas						*	***
Incremento de la potencia neuromuscular						*	***

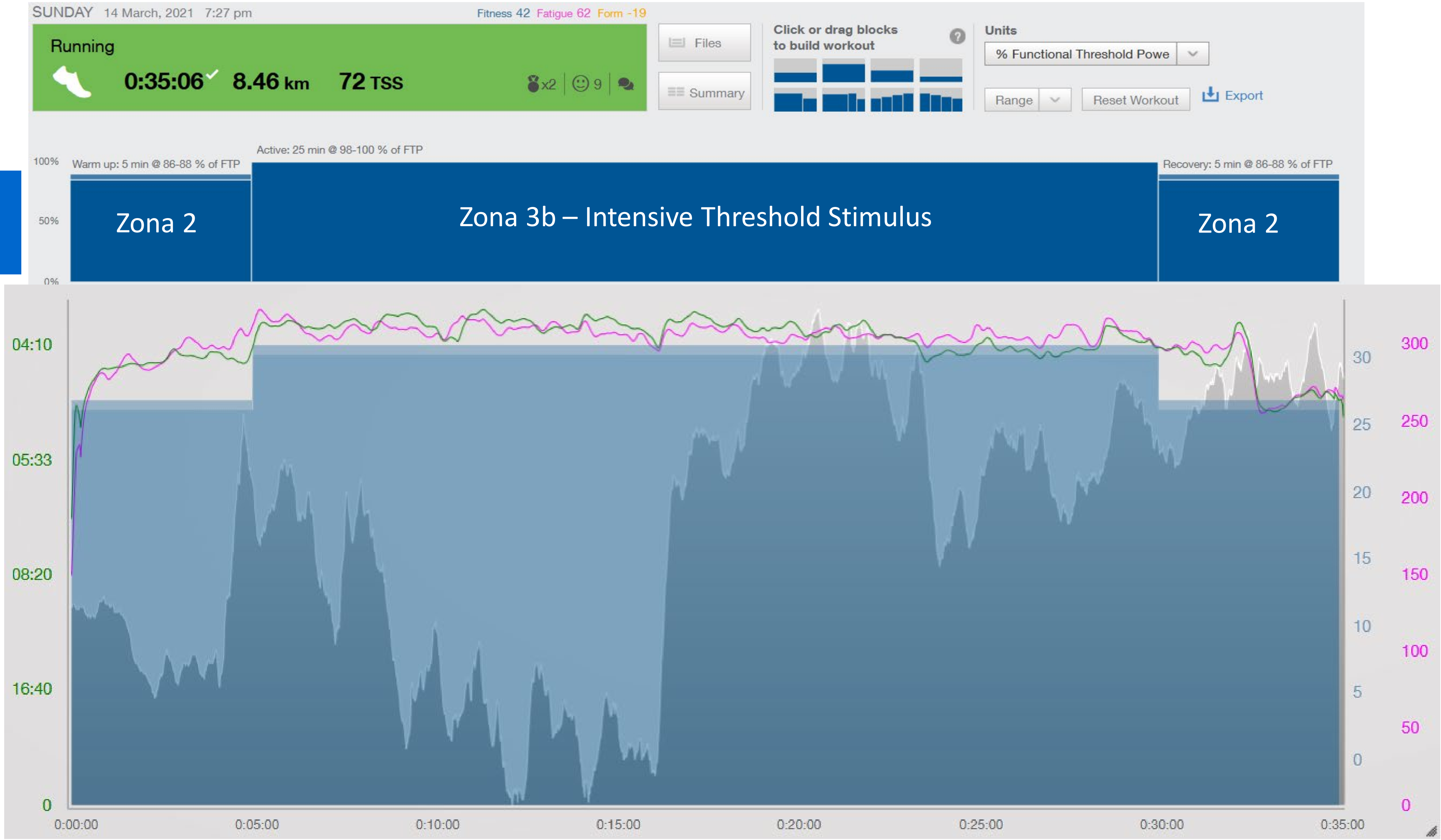
2. DEFINIR ZONAS DE ENTRENAMIENTO



3. EJEMPLOS

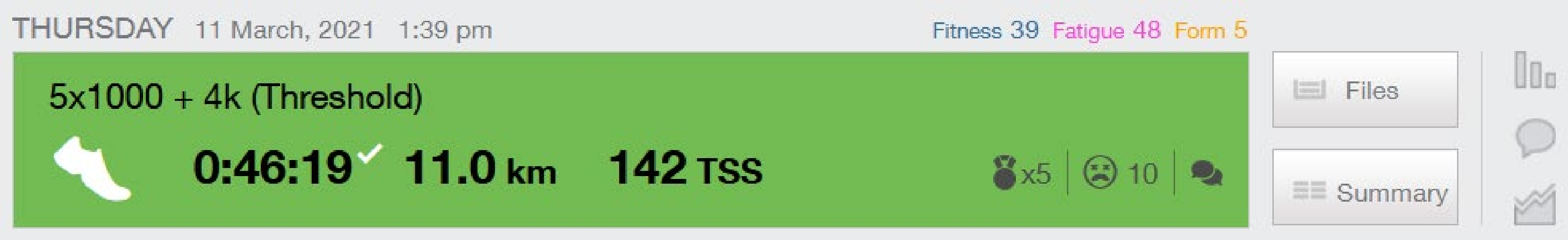
TP

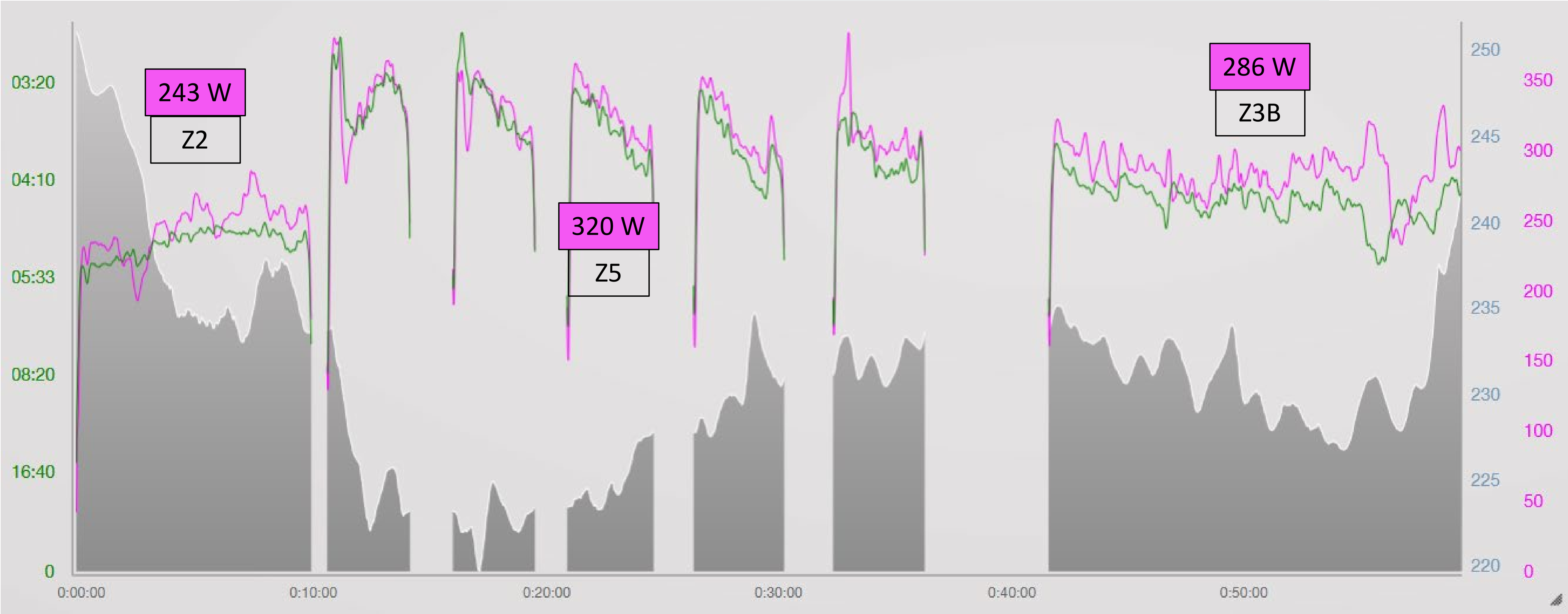
Entrenamiento estructurado



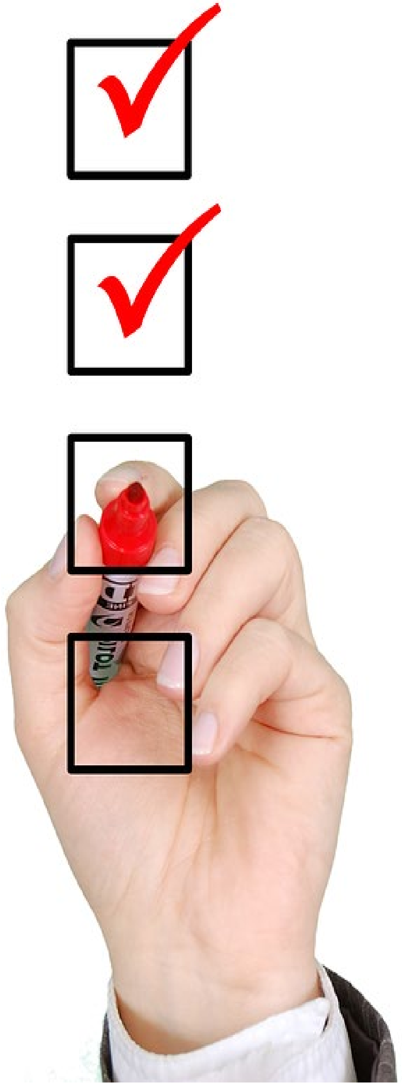
3. EJEMPLOS

Series + Threshold





TAKE-HOME MESSAGE



1. La potencia en carrera muestra una correlación muy alta con VO_2.
2. Los potenciómetros de carrera son fiables, **pero no se recomienda intercambiar sus datos**.
3. La potencia no se ve comprometida por el viento u otras inclemencias meteorológicas.
4. La potencia ofrece un método de cuantificación de la carga y monitorización del esfuerzo que es superior al ritmo o a la FC.
5. Es posible realizar la cuantificación interna (FC y RPE) y externa (potencia y ritmo) del esfuerzo de cada atleta el entrenador lo estima oportuno.

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Gracias

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