The use of velocity-based resistance training in cyclists. New perspectives on strength training in cyclists

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WHO WE ARE?

- Research Group in Training
- European University of Madrid (Universidad Europea de Madrid - UEM)
- Faculty of Sports Sciences

WHO WE ARE?

WHO WE ARE. Multidisciplinary team






WHO WE ARE. Brief curriculum vitae

Dra. Lidia Brea. Graduate in Sports Science. Specialist in exercise and physical activity for health improvement.

Dra. Almudena Montalvo. Graduada en Ciencias del Deporte y Fisioterapia y Máster en Alto Rº en Deportes Cíclicos. Especialista en fisioterapia deportiva y traumatológica.

Jaime Gil. Graduate in Sports Science and Master in High Rº of the COE. Specialist in strength and resistance training and in new methodologies applied to sports training.

Dr. Pedro L. Valenzuela. Graduate in Sports Science. Master in Integrative Physiology. Specialist in Exercise Physiology and Sports Performance Analysis.

Carlos Revuelta. Graduate in Sports Science. Specialist in training and performance in athletics. PhD candidate in Cycling Performance

Dr. David Barranco. Graduate in Sports Science. Specialist in training, coaching and performance analysis in cycling.

WHO WE ARE. We have the best help

Dr. Alejandro Lucía.

Degree in Medicine.

Professor of Human and Exercise Physiology at the UEM.

What science tells us about this…

Strength training improves 5-min all-out performance following 185 min of cycling

Running head: *"Strength training and cycling performance"*

Bent R. Rønnestad[1], Ernst A. Hansen[2], and Truls Raastad[2]

[1]Lillehammer University College, Lillehammer, Norway

[2]Norwegian School of Sport Sciences, Oslo, Norway

Maximal Strength Training Improves Cycling Economy in Competitive Cyclists

Arnstein Sunde,[1] Øyvind Støren,[1,2] Marius Bjerkaas,[1] Morten H. Larsen,[1] Jan Hoff,[2,3] and Jan Helgerud[2,4]

[1]Department of Sport and Outdoor Life Studies, Telemark University College, Bø, Norway; [2]Department of Circulation and Medical Imaging, Faculty of Medicine, Norwegian University of Science and Technology, Trondheim, Norway; [3]Department of Physical Medicine and Rehabilitation, St. Olavs University Hospital, Trondheim, Norway; and [4]Hokksund Medical Rehabilitation Centre, Hokksund, Norway

Maximal Leg-Strength Training Improves Cycling Economy in Previously Untrained Men

DANIELLE J. LOVELESS, CLARE L. WEBER, LUKE J. HASELER, and DONALD A. SCHNEIDER

School of Physiotherapy and Exercise Science, Gold Coast Campus, Griffith University, Queensland, AUSTRALIA

In-season strength maintenance training increases well-trained cyclists' performance

Running head: *"Strength maintenance training in cyclists"*

Bent R. Rønnestad[1], Ernst Albin Hansen[2], and Truls Raastad[2]

[1]Lillehammer University College, Lillehammer, Norway

[2]Norwegian School of Sport Sciences, Oslo, Norway

Scand J Med Sci Sports 2015: 25: e89–e98
doi: 10.1111/sms.12257

SCANDINAVIAN JOURNAL OF MEDICINE & SCIENCE IN SPORTS

Strength training improves performance and pedaling characteristics in elite cyclists

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The Effect of Maximal- & Explosive-Strength Training on Performance Indicators in Cyclists

Submission type: Original Investigation

Kris Beattie[1], Brian P. Carson[1], Mark Lyons[1] and Ian C. Kenny[1]
[1]Department of Physical Education and Sport Sciences, University of Limerick, Ireland.

doi: 10.1111/sms.12468

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SCANDINAVIAN JOURNAL OF MEDICINE & SCIENCE IN SPORTS

Strength training improves cycling performance, fractional utilization of VO_{2max} and cycling economy in female cyclists

O. Vikmoen[1]*, S. Ellefsen[1]*, Ø. Trøen[1], I. Hollan[2]*, M. Hanestadhaugen[3]*, T. Raastad[4], B. R. Rønnestad[1]*

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Accepted for publication 10 March 2015

Heavy strength training improves running and cycling performance following prolonged submaximal work in well-trained female athletes

Olav Vikmoen[1], Bent R. Rønnestad[1], Stian Ellefsen[1] & Truls Raastad[2]

1 Section for Sport Sciences, Lillehammer University College, Lillehammer, Norway
2 Deparment of Physical Performance, Norwegian School of Sport Sciences, Oslo, Norway

10 weeks of heavy strength training improves performance-related measurements in elite cyclists

Bent R. Rønnestad, Joar Hansen and Håvard Nygaard

Section for Sport Science, Lillehammer University College, Lillehammer, Norway

Optimizing strength training for running and cycling endurance performance – a review

Running head: *"Strength training and endurance performance"*

Bent R. Rønnestad[1], Iñigo Mujika[2,3]

[1] Lillehammer University College, Section for Sport Science, Lillehammer, Norway

[2] Department of Physiology, Faculty of Medicine and Odontology, University of the Basque Country, Leioa, Basque Country

[3] School of Kinesiology and Health Research Center, Faculty of Medicine, Finis Terrae University, Santiago, Chile.

Bent Rønnestad

Rønnestad's Classic Work...

Table 1 Strength training program for the cyclists who performed heavy strength training.

	Preparatory period						Competition period
	Week 1-3		Week 4-6		Week 7-12		Week 13-25
	1. Bout	2. Bout	1. Bout	2. Bout	1. Bout	2. Bout	1. Bout
Half squat	3x10RM	3x6RM	3x8RM	3x5RM	3x6RM	3x4RM	2x5 reps @80-85% of 1RM
One-legged leg press	3x10RM	3x6RM	3x8RM	3x5RM	3x6RM	3x4RM	2x5 reps @80-85% of 1RM
One-legged hip flexion	3x10RM	3x6RM	3x8RM	3x5RM	3x6RM	3x4RM	1x6RM
Ankle plantar flexion	3x10RM	3x6RM	3x8RM	3x5RM	3x6RM	3x4RM	1x6RM

Rønnestad BR, Hansen EA, Raastad T. ***In-season strength maintenance training increases well-trained cyclists' performance***. Eur J Appl Physiol. 2010 Dec;110(6):1269-82.

NEW PERSPECTIVES IN STRENGTH TRAINING… VBRT (velocity based resistance training)

VBRT
(velocity based resistance training)

Guerriero A, Varalda C, Piacentini MF. The role of velocity based training in the strength periodization for modern athletes. *J Funct Morphol Kinesiol*. 2018;3(4). doi:10.3390/jfmk3040055

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NEW PERSPECTIVES IN STRENGTH TRAINING… VBRT (velocity based resistance training)

VBRT
(velocity based resistance training)

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Rauch J, Loturco I, Cheesman N, et al. Similar Strength and Power Adaptations between Two Different Velocity-Based Training Regimens in Collegiate Female Volleyball Players. *Sports*. 2018;6(4):163. doi:10.3390/sports6040163

Loturco I, Nakamura F, Kobal R, et al. Traditional Periodization versus Optimum Training Load Applied to Soccer Players: Effects on Neuromuscular Abilities. *Int J Sports Med*. 2016;37(13):1051-1059. doi:10.1055/s-0042-107249

STATE OF THE ART…

Traditional Versus Optimum Power Load Training in Professional Cyclists: A Randomized Controlled Trial

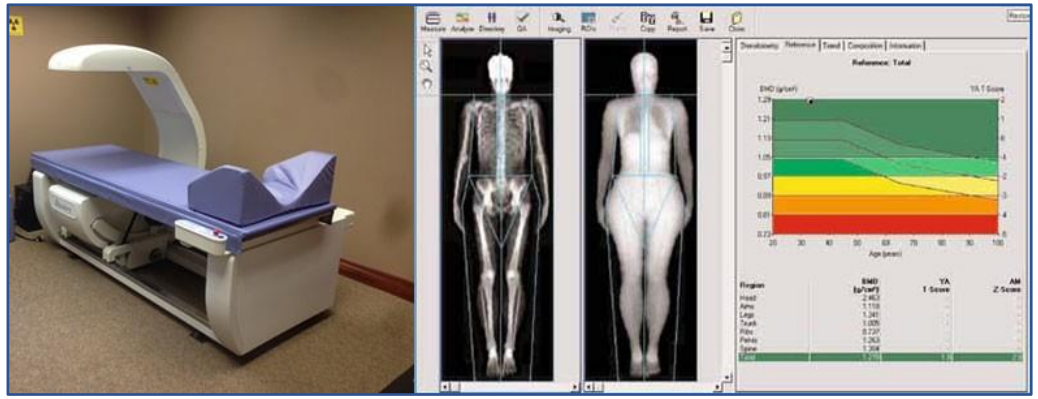
Jaime Gil-Cabrera, Pedro L. Valenzuela, Lidia B. Alejo, Eduardo Talavera, Almudena Montalvo-Pérez, Alejandro Lucia, and David Barranco-Gil

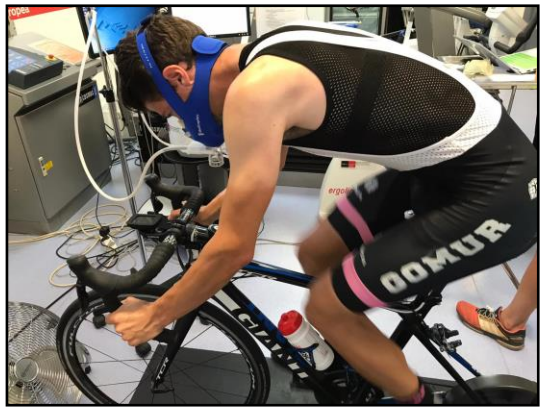
Traditional Versus Velocity-Based Resistance Training in Competitive Female Cyclists: A Randomized Controlled Trial

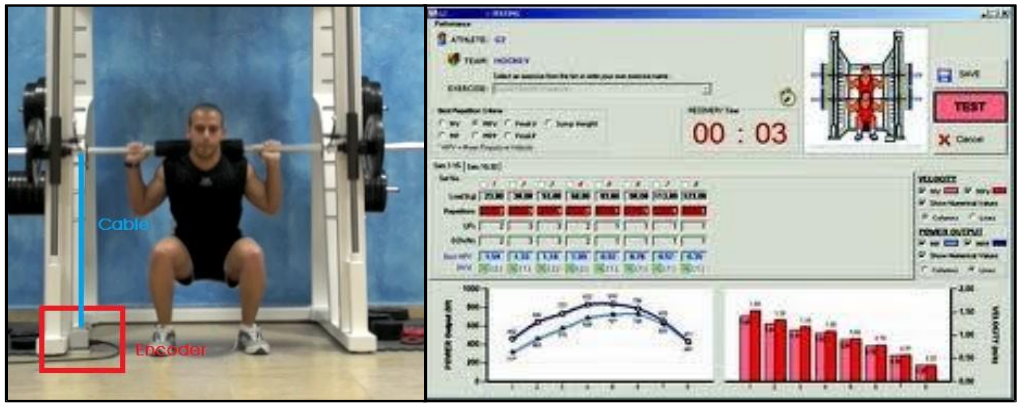
Almudena Montalvo-Pérez[1], Lidia B. Alejo[1,2], Pedro L. Valenzuela[3,4], Jaime Gil-Cabrera[1], Eduardo Talavera[1], Alejandro Luia[1,2] and David Barranco-Gil[1]**

[1] Faculty of Sport Sciences, Universidad Europea de Madrid, Madrid, Spain, [2] Instituto de Investigación Hospital 12 de Octubre (imas12), Madrid, Spain, [3] Department of Systems Biology, University of Alcalá, Madrid, Spain, [4] Department of Sport and Health, Spanish Agency for Health Protection in Sport (AEPSAD), Madrid, Spain

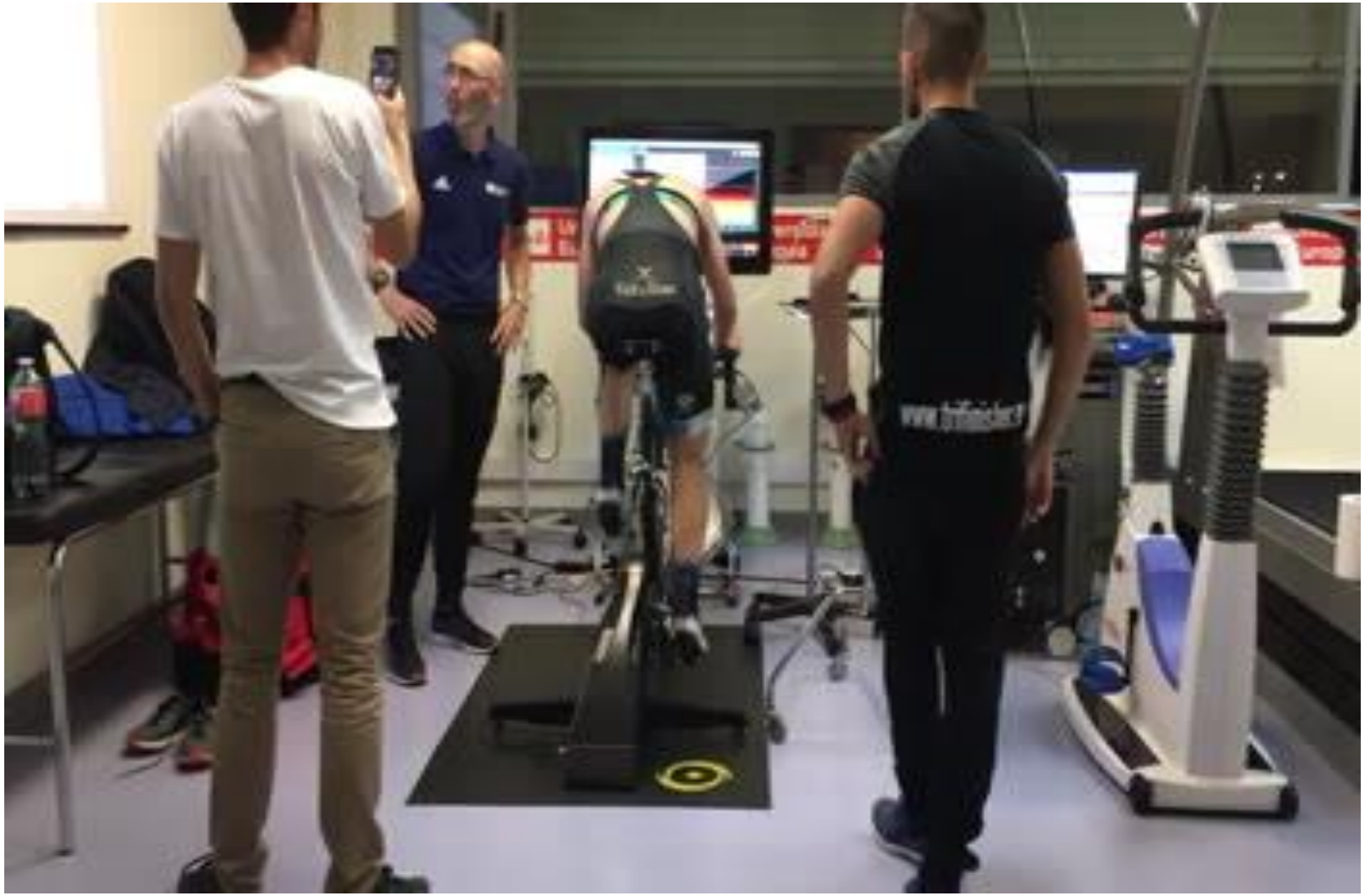
PRE-POST ASSESSMENTS







PRE-POST ASSESSMENTS



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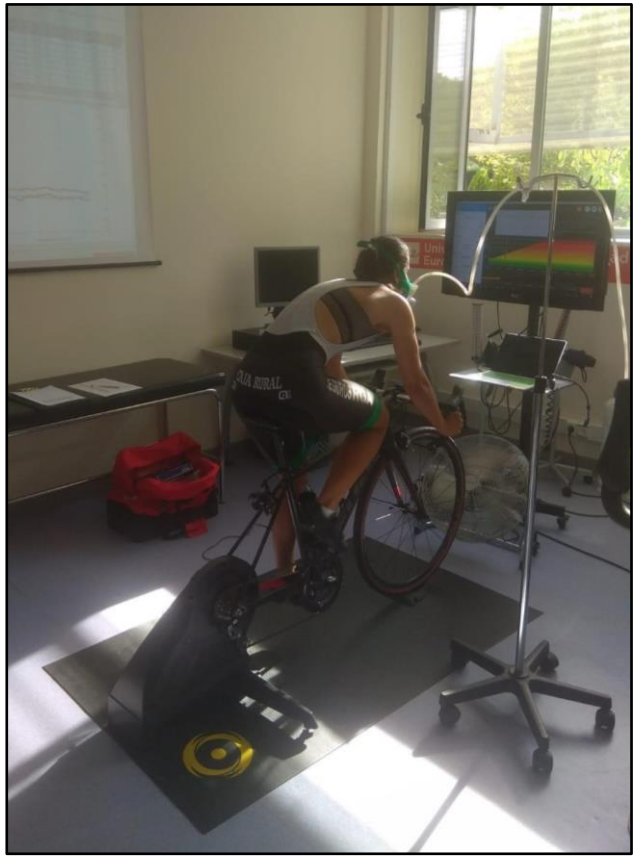
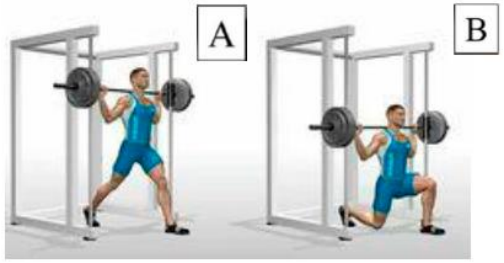


PRE-POST ASSESSMENTS

- Exercises are started with 20 kilograms
- Increasing the load by 10 kg per set
- Until detecting the maximum PO load
- Once identified, “repetitions test” at that load until loss of 10% of speed in the set

1. Split Squat en *Multipower (Smith Machine)*
   a. Posición inicial
   b. Posición final



2. Sentadilla en *Multipower (Smith Machine)*
   a. Posición inicial
   b. Posición final

3. Empujes de cadera o *Hip Thrust* en *Multipower (Smith Machine)*
   a. Posición inicial
   b. Posición final

PRE-POST ASSESSMENTS

T-FORCE System :: Tablas Resumen de Datos (Series y Repeticiones)

Análisis de la Ejecución

EQUIPO: Estudio Fuerza Chicos

ATLETA: Pablo Garcia

EJECUCIÓN: Sentadilla Completa (multipower) 20/12/19 19:01:46

Criterio exportar MEJOR REPETICIÓN

○ VM ◉ VMP ○ VMax
○ PM ○ PMP ○ PMax
○ FMP ○ FMax
○ Despl. EXC Max ○ Despl. CON Max

Exportar a EXCEL

Cancelar

Tipo de Tabla

◉ Datos principales
○ Datos cada ms

Criterio MEJOR REPETICIÓN

○ VM ◉ VMP ○ VMax
○ PM ○ PMP ○ PMax
* VMP = Velocidad Media Propulsiva

Exportar fases

◉ SUBIDAS
○ BAJADAS

Mostrar de cada serie...

◉ Sólo la mejor repetición
○ Todas las repeticiones

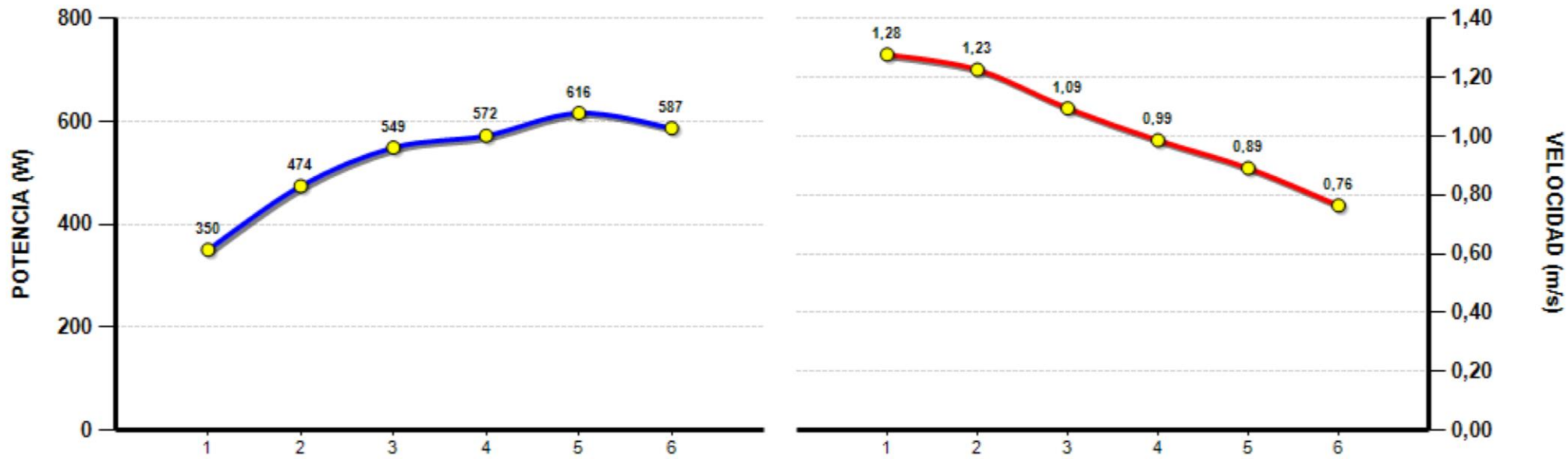
Series 1-15 | Series 16-30 | Velocidad y Potencia | Repeticiones y Velocidad (Series) | Repeticiones y Velocidad (Todas) | Desplazamiento | Velocidad-Tiempo | Zonas Velocidad

POTENCIA

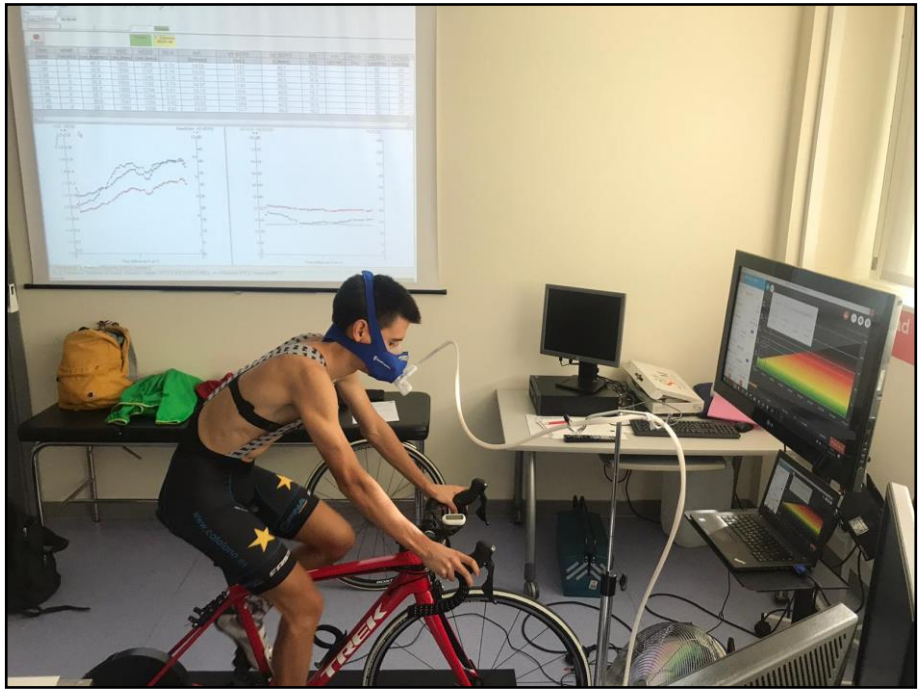
☐ PM ☑ PMP ☐ PMax
○ Columnas ◉ Líneas ☑ Valores

VELOCIDAD

☐ VM ☑ VMP ☐ VMax
○ Columnas ◉ Líneas ☑ Valores



SAMPLE

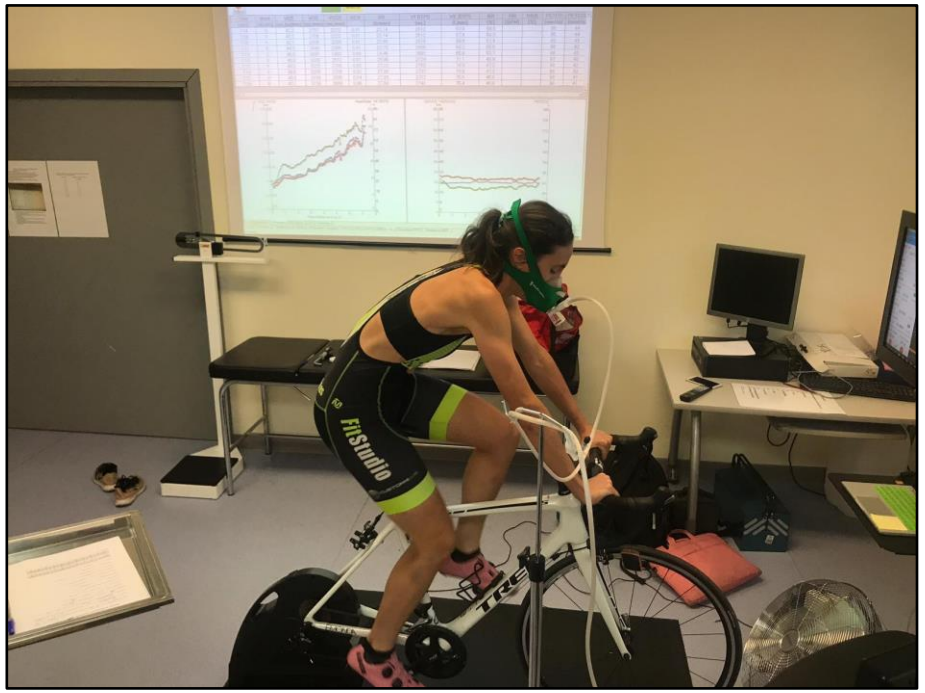


22 men / 19±1 age

VO_{2max}: 75,5±6,0 ml· kg^{-1}· min^{-1}

TRT (n=11)

VBRT (n=11)



17 women / 25±7 age

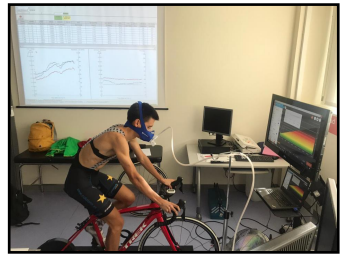
VO_{2max}: 55,0±5,8 ml· kg^{-1}· min^{-1}

TRT (n=8)

VBRT (n=9)

Traditional Versus Optimum Power Load Training in Professional Cyclists: A Randomized Controlled Trial

Jaime Gil-Cabrera, Pedro L. Valenzuela, Lidia B. Alejo, Eduardo Talavera, Almudena Montalvo-Pérez, Alejandro Lucia, and David Barranco-Gil



- 2 weeks of familiarization
- 2 sessions per week
- 48 hours recovery between sessions
- Same time of the day
- All sessions supervised
- Attend 90% of sessions
- RE-TEST WEEK 4

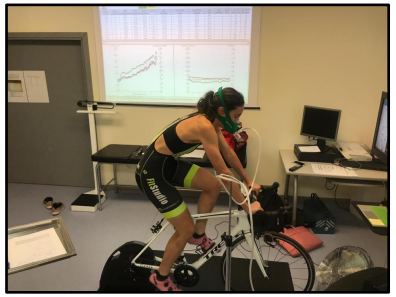
Table 1 Characteristics of the Traditional and Velocity-Based Resistance Training Interventions

		Weeks 1–3		Weeks 4–6		Weeks 7–8	
Intervention	**Variable**	**Day 1**	**Day 2**	**Day 1**	**Day 2**	**Day 1**	**Day 2**
TRT	Exercises	Squat, hip thrust, and lunge					
	Training, sets × reps	3 × 10	3 × 6	3 × 8	3 × 5	3 × 6	3 × 4
	Load, %RM	75%	85%	80%	87%	85%	90%
	Rest, s	120					
OPT	Exercises	Squat, hip thrust, and lunge					
	Training, sets × reps	3 × maximum number of repetitions at >90% OPL (8 [3] reps)					
	Load, %RM	OPL (65% [10%])					
	Rest, s	120					

Abbreviations: OPL, optimum power load; OPT, optimum power load training; reps, repetitions; RM, repetition maximum; TRT, traditional resistance training.

Traditional Versus Velocity-Based Resistance Training in Competitive Female Cyclists: A Randomized Controlled Trial

Almudena Montalvo-Pérez[1], Lidia B. Alejo[1,2], Pedro L. Valenzuela[3,4], Jaime Gil-Cabrera[1], Eduardo Talavera[1], Alejandro Luia[1,2] and David Barranco-Gil[1]**



- 2 weeks of familiarization
- 2 sessions per week
- 48 hours recovery between sessions
- Same time of the day
- All sessions supervised
- Attend 90% of sessions
- **NO RE-TEST**

TABLE 1 | Characteristics of the traditional (TRT) and velocity-based resistance training (VBRT) interventions.

Intervention	Variable	Weeks 1–2		Weeks 3–6	
		Day 1	Day 2	Day 1	Day 2
		Exercises: squat, hip thrust, and split squat			
TRT	Training (sets × repetitions)	3 × 8	3 × 5	3 × 6	3 × 4
	Load (% of 1RM)	80%	87%	85%	90%
	Rest between sets (s)	120			
VBRT	Training (sets × repetitions)	3 × maximum number or repetitions at > 90% of OPL (8 ± 3 repetitions)			
	Load (% of 1RM)	OPL (65 ± 10%)			
	Rest between sets (s)	120			

OPL, optimum power load; RM, repetition maximum.

Traditional Versus Optimum Power Load Training in Professional Cyclists: A Randomized Controlled Trial

Jaime Gil-Cabrera, Pedro L. Valenzuela, Lidia B. Alejo, Eduardo Talavera, Almudena Montalvo-Pérez, Alejandro Lucia, and David Barranco-Gil

Table 2 Body-Composition Outcomes

End point	Group	Baseline	Postintervention	Within-group *P*	Time *P*	Group × time *P*	Effect size (η_p^2)
Body mass, kg	TRT	64.1 (6.1)	64.7 (5.8)	.130	.404	.489	.027
	OPT	62.9 (6.0)	62.9 (5.7)	.944			
Fat mass, kg	TRT	11.7 (3.3)	11.1 (3.1)	**.041**	**.005**	.668	.010
	OPT	11.2 (2.6)	10.7 (3.0)	.086			
Muscle mass, kg	TRT	48.8 (3.6)	50.8 (3.9)	**.003**	**<.001**	.453	.032
	OPT	48.2 (4.0)	49.8 (4.3)	**.008**			
BMD, g/cm^2	TRT	1.15 (0.09)	1.14 (0.07)	.203	.331	.290	.062
	OPT	1.09 (0.09)	1.17 (0.22)	.889			
BMC, g	TRT	2.37 (0.29)	2.38 (0.28)	.929	.228	.603	.015
	OPT	2.22 (0.24)	2.24 (0.23)	.213			

Abbreviations: BMC, bone mineral content; BMD, bone mineral density; OPT, optimum power load training; TRT, traditional resistance training. Note: Data are presented as mean (SD). Significant *P* values are presented in bold.

Table 3 Strength-Related Outcomes

End point	Group	Baseline	Postintervention	Within-group *P*	Time *P*	Group × time *P*	Effect size (η_p^2)
Squat 1RM, kg	TRT	74 (13)	92 (14)	**.005**	**<.001**	.227	.080
	OPT	69 (11)	94 (10)	**.008**			
Squat MPP, W	TRT	475 (84)	584 (98)	**.008**	**<.001**	.370	.045
	OPT	436 (104)	584 (109)	**.008**			
Hip thrust 1RM, kg	TRT	89 (14)	144 (24)	**.003**	**<.001**	.093	.149
	OPT	91 (24)	124 (28)	**.008**			
Hip thrust MPP, W	TRT	421 (67)	694 (122)	**.003**	**<.001**	.275	.066
	OPT	381 (133)	585 (143)	**.015**			
Lunge 1RM, kg	TRT	60 (14)	83 (8)	**.003**	**<.001**	.144	.115
	OPT	54 (11)	84 (14)	**.008**			
Lunge MPP, W	TRT	388 (70)	500 (93)	**.003**	**<.001**	**.032**	.232
	OPT	298 (69)	500 (126)	**.008**			

Abbreviations: 1RM, 1-repetition maximum; MPP, mean propulsive power; OPT, optimum power load training; TRT, traditional resistance training. Note: Data are presented as mean (SD). Significant *P* values are presented in bold.

Table 4 Endurance-Related Outcomes

End point	Group	Baseline	Postintervention	Within-group *P*	Time *P*	Group × time *P*	Effect size (η_p^2)
PPO, W	TRT	387 (30)	396 (30)	.130	**.022**	.902	.001
	OPT	393 (38)	403 (28)	.260			
PPO, W/kg	TRT	6.06 (0.59)	6.14 (0.54)	.286	.054	.443	.033
	OPT	6.28 (0.57)	6.46 (0.53)	.110			
VT, W	TRT	238 (20)	239 (18)	.959	.376	.556	.020
	OPT	240 (24)	246 (28)	.259			
VT, W/kg	TRT	3.75 (0.50)	3.72 (0.37)	.505	.655	.413	.038
	OPT	3.84 (0.39)	3.92 (0.34)	.343			
RCP, W	TRT	327 (23)	338 (21)	.056	**.009**	.601	.015
	OPT	337 (32)	352 (24)	.066			
RCP, W/kg	TRT	5.13 (0.51)	5.25 (0.53)	.154	**.036**	.423	.036
	OPT	5.37 (0.45)	5.62 (0.49)	.173			
VO_2peak, mL/kg/min	TRT	74.5 (6.0)	72.8 (6.4)	.328	.859	.161	.106
	OPT	76.8 (6.0)	78.0 (7.2)	.236			
8-min TT, W	TRT	304 (30)	318 (24)	**.026**	**.001**	.651	.012
	OPT	322 (31)	333 (31)	**.015**			
8-min TT, W/kg	TRT	4.75 (0.44)	4.91 (0.46)	.056	**.015**	.979	.000
	OPT	5.14 (0.43)	5.30 (0.39)	.066			
8-min TT, %VO_2peak	TRT	90.4 (1.8)	91.8 (4.4)	.328	.859	.405	.039
	OPT	92.0 (5.0)	91.1 (4.7)	.767			

Abbreviations: OPT, optimum power load training; PPO, peak power output; RCP, respiratory compensation point; TRT, traditional resistance training; TT, time trial; VO_2peak, peak oxygen uptake; VT, ventilatory threshold. Note: Data are presented as mean (SD). Significant *P* values are presented in bold.

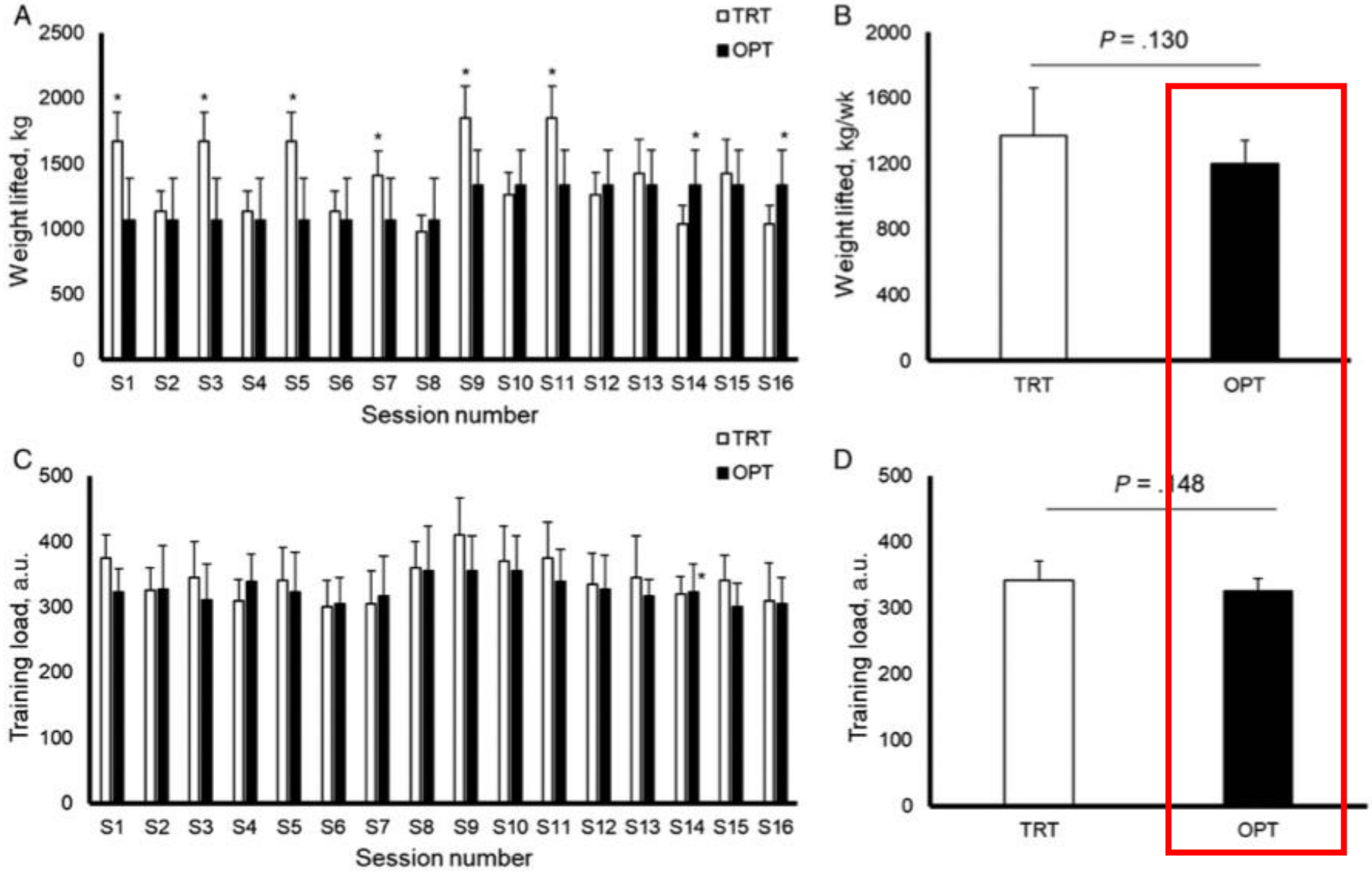


Figure 2 — Weight lifted (computed as load [in kilograms] multiplied by the number of repetitions) during each training session (A) and average of all sessions (B) and training load (computed as session length [in minutes] multiplied by rating of perceived exertion [assessed on a 1–10 Borg scale]) during each training session (C) and average of all sessions (D). OPT indicates optimum power load training; TRT, traditional resistance training. Significant differences between conditions: *P < .001.

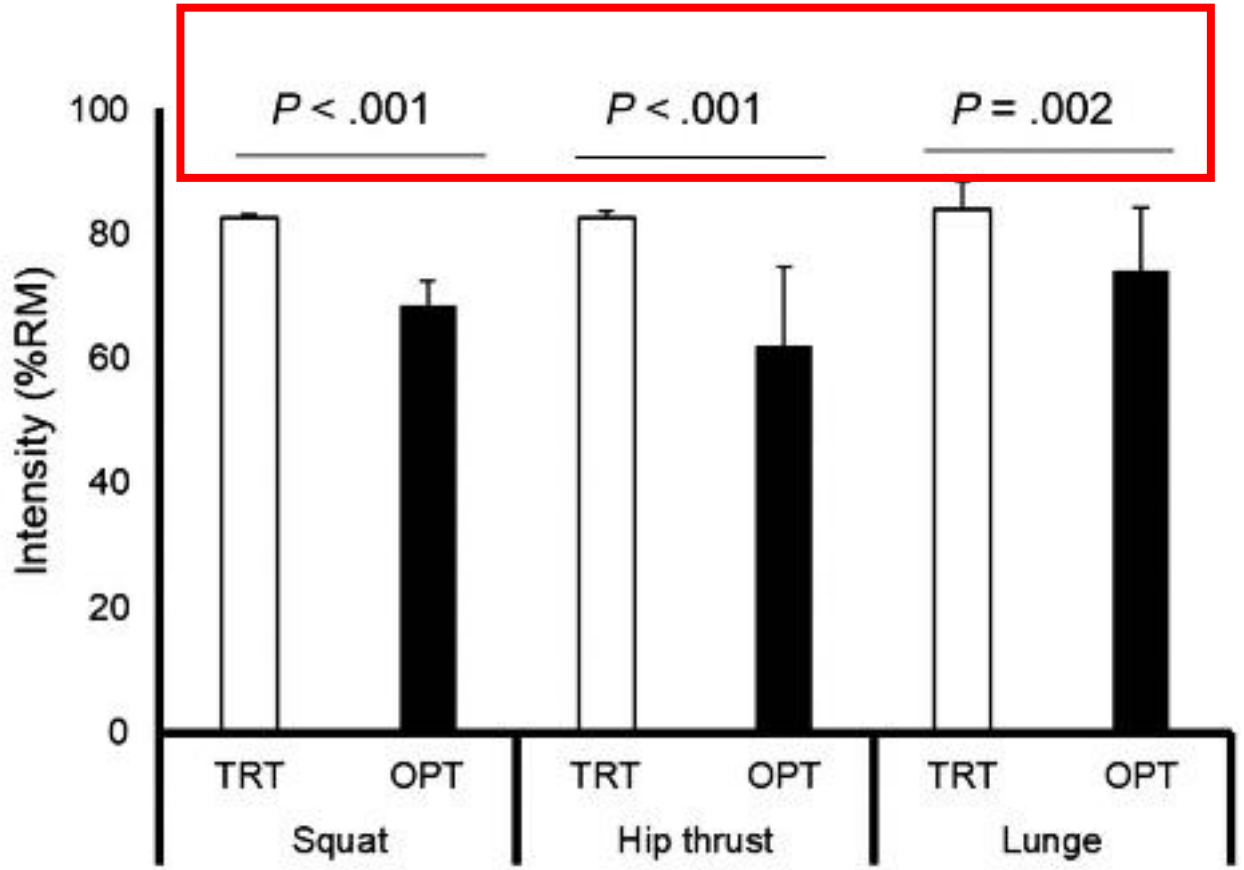


Figure 1 — Average relative intensity (expressed as percentage of 1RM) during all training sessions for the 3 exercises performed. OPT indicates optimum power load training; RM, repetition maximum; TRT, traditional resistance training.

CONCLUSIONS

- **Both** groups:
  - **Improvements in body composition**
  - **Improvements in strength-power values**
  - **Improved RCP values**
  - **TT-8 min (4-5% better)**
  - **Similar TL** (weight and RPE)
- **Group VBRT** (**lower % of work intensity**)

Traditional Versus Velocity-Based Resistance Training in Competitive Female Cyclists: A Randomized Controlled Trial

Almudena Montalvo-Pérez[1], Lidia B. Alejo[1,2], Pedro L. Valenzuela[3,4], Jaime Gil-Cabrera[1], Eduardo Talavera[1], Alejandro Luia[1,2] and David Barranco-Gil[1]**

TABLE 2 | Results of body composition.

Outcome	Group	Baseline	Effect size for between-group differences at baseline (Hedges' *g*)	Post-intervention	Within-group comparison (baseline vs. post-intervention) *p* value	Time effect, *p* value	Group by time interaction effect, *p* value	Effect size for between-group differences in intervention effects (η_p^2)
Body mass (kg)	TRT	58.3 ± 6.1	0.073	59.4 ± 7.0	0.079	**0.019**	0.920	0.001
	VBRT	57.8 ± 6.9		58.8 ± 6.6	0.084			
Fat mass (kg)	TRT	16.6 ± 4.4	0.355	17.1 ± 4.0	0.198	0.612	0.170	0.122
	VBRT	15.3 ± 2.4		15.0 ± 2.6	0.511			
Muscle mass (kg)	TRT	39.5 ± 4.8	0.151	40.0 ± 6.1	0.398	0.058	0.446	0.039
	VBRT	40.3 ± 5.2		41.5 ± 5.4	0.057			
BMD (g cm^{-2})	TRT	1.15 ± 0.10	0.368	1.14 ± 0.10	0.345	0.838	0.245	0.089
	VBRT	1.18 ± 0.05		1.18 ± 0.05	0.477			
BMC (g)	TRT	2.24 ± 0.41	0.078	2.24 ± 0.39	0.849	0.751	0.968	0.000
	VBRT	2.27 ± 0.32		2.27 ± 0.30	0.794			

Data are mean ± SD and significant p values are in bold. BMC, bone mineral content; BMD, bone mineral density; TRT, traditional resistance training; VBRT, velocity-based resistance training.

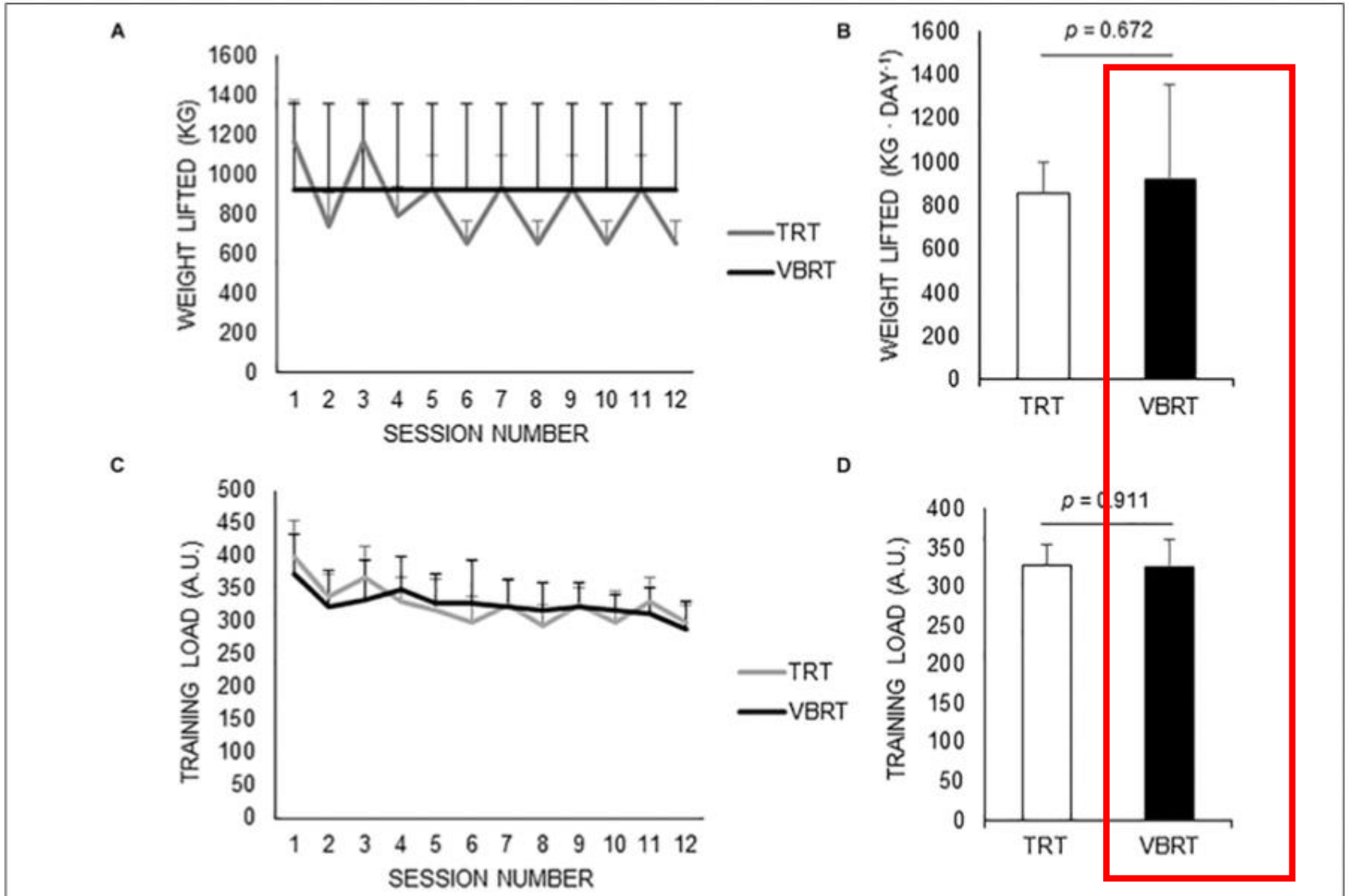


FIGURE 1 | Training loads by group. Total weight lifted in kg **(A)** or in kg·day^{-1} **(B)** during the traditional (TRT) or velocity-based resistance training (VBRT) sessions. Total internal training loads [in arbitrary units (A.U.)] by group across TRT/VBRT sessions **(C)** and during outdoor cycling sessions **(D)**. TRT, traditional resistance training; VBRT, velocity-based resistance training.

TABLE 3 | Results of muscle strength/power-related outcomes.

Outcome	Group	Baseline	Effect size for between-group differences at baseline (Hedges' *g*)	Post-intervention	Within-group comparison (baseline vs. post-intervention) *p* value	Time effect, *p* value	Group by time interaction effect, *p* value	Effect size for between-group differences in intervention effects (η_p^2)
Squat 1RM (kg)	TRT	48 ± 13	0.373	65 ± 6	**0.001**	**<0.001**	0.990	0.000
	VBRT	54 ± 17		70 ± 12	**<0.001**			
Squat MMP (W)	TRT	285 ± 98	0.553	362 ± 71	**0.002**	**<0.001**	0.499	0.031
	VBRT	345 ± 107		442 ± 81	**<0.001**			
Squat MMP [W/lower body muscle mass (kg)]	TRT	20 ± 5	0.701	27 ± 5	**0.001**	**<0.001**	0.846	0.003
	VBRT	25 ± 8		31 ± 6	**<0.001**			
Hip thrust 1RM (kg)	TRT	62 ± 19	0.109	84 ± 15	**<0.001**	**<0.001**	**0.015**	0.336
	VBRT	60 ± 16		99 ± 9†	**<0.001**			
Hip thrust MMP (W)	TRT	278 ± 98	0.054	363 ± 71	**0.003**	**<0.001**	**0.015**	0.335
	VBRT	283 ± 78		459 ± 71†	**<0.001**			
Hip thrust MMP [W/lower body muscle mass (kg)]	TRT	20 ± 4	0.000	27 ± 4	**0.001**	**<0.001**	**0.042**	0.247
	VBRT	20 ± 6		32 ± 3†	**<0.001**			
Split squat 1RM (kg)	TRT	43 ± 10	0.000	59 ± 11	**0.001**	**<0.001**	0.386	0.050
	VBRT	43 ± 9		64 ± 13	**<0.001**			
Split squat MMP (W)	TRT	228 ± 74	0.503	328 ± 82	**0.007**	**<0.001**	0.590	0.020
	VBRT	264 ± 62		386 ± 95	**<0.001**			
Split squat MMP [W/lower body muscle mass (kg)]	TRT	17 ± 5	0.463	24 ± 4	**0.001**	**<0.001**	0.809	0.004
	VBRT	20 ± 7		27 ± 8	**<0.001**			

Data are mean ± SD and significant p values are in bold. Symbols: †p < 0.05 vs. TRT at the same time point. 1RM, one-repetition maximum; MMP, maximum mean power output; TRT, traditional resistance training; VBRT, velocity-based resistance training.

TABLE 4 | Results of endurance performance-related outcomes.

Outcome	Group	Baseline	Effect size for between-group differences at baseline (Hedges' *g*)	Post-intervention	Within-group comparison (baseline vs. post-intervention) *p* value	Time effect, *p* value	Group by time interaction effect, *p* value	Effect size for between-group differences in intervention effects (η_p^2)
PPO								
W	TRT	288 ± 47	0.071	296 ± 52	0.138	**0.046**	0.913	0.001
	VBRT	291 ± 33		298 ± 36	0.154			
W/total body mass (kg)	TRT	4.8 ± 0.5	0.468	4.9 ± 0.6	0.122	0.177	0.347	0.059
	VBRT	5.0 ± 0.3		5.0 ± 0.4	0.751			
W/lower-body muscle mass (kg)	TRT	21.0 ± 1.1	0.111	21.7 ± 1.5	0.152	0.120	0.592	0.020
	VBRT	20.8 ± 2.1		21.2 ± 1.8	0.434			
8-min TT performance (average PO)								
W	TRT	224 ± 43	0.241	230 ± 40	0.099	**0.003**	0.361	0.056
	VBRT	215 ± 27		225 ± 26	**0.006**			
W/total body mass (kg)	TRT	3.7 ± 0.5	0.561	3.8 ± 0.5	0.686	0.134	0.340	0.061
	VBRT	3.3 ± 0.8		3.5 ± 0.8	0.080			
W/lower-body muscle mass (kg)	TRT	13.0 ± 0.8	0.388	16.9 ± 1.1	**< 0.001**	**<0.001**	0.238	0.091
	VBRT	12.5 ± 1.5		16.0 ± 1.5	**< 0.001**			

CONCLUSIONS

- **Both** groups:
  - **Improvements in body composition**
  - **Improvements in strength-power values**
  - **Better** values **PPO**
  - **TT-8 min (4-5% better)**
  - **Similar TL** (weight and RPE)

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Human Kinetics
ORIGINAL INVESTIGATION

On- Versus Off-Bike Power Training in Professional Cyclists: A Randomized Controlled Trial

Pedro L. Valenzuela, Jaime Gil-Cabrera, Eduardo Talavera, Lidia B. Alejo, Almudena Montalvo-Pérez, Cecilia Rincón-Castanedo, Iván Rodríguez-Hernández, Alejandro Lucia, and David Barranco-Gil

STATE OF THE ART…

Article Title: Effects of Cycling Training at Imposed Low Cadences - A Systematic Review

Authors: Ernst A. Hansen[1] and Bent R. Rønnestad[2]

Affiliations: [1]Research Interest Group of Physical Activity and Human Performance, SMI®, Department of Health Science and Technology, Aalborg University, Denmark. [2]Section for Sport Science, Lillehammer University College, Lillehammer, Norway.

Journal: *International Journal of Sports Physiology and Performance*

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Authors: Ernst A. Hansen[1] and Bent R. Rønnestad[2]

- Studies show no difference between low and high cadences.
- There is no clear performance improvement effect of low cadence or even indicate a superior effect of CFC training.

Currently there is no definitive and solid evidence to prescribe training at low cadences (below 60 rpm).

STATE OF THE ART…

Comparison of Short-Sprint and Heavy Strength Training on Cycling Performance

Morten Kristoffersen[1,2], Øyvind Sandbakk[2], Bent R. Rønnestad[3] and Hilde Gundersen[1]*

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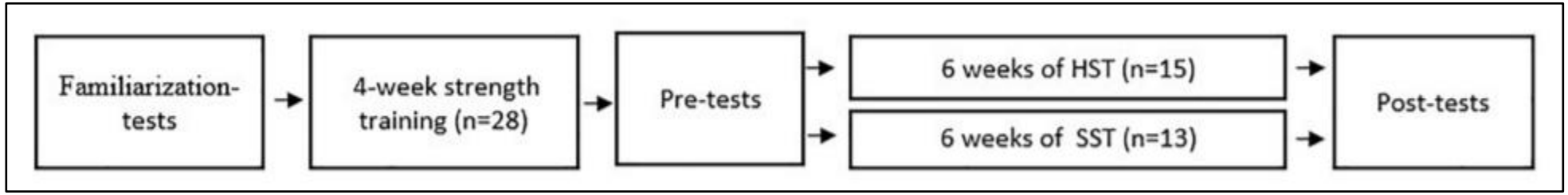
STATE OF THE ART…



	Week 1-3		Week 4-6	
	1. Bout	2. Bout	1. Bout	2. Bout
Half squat	3x8RM	3x5RM	3x6RM	3x4RM
One-legged leg press	3x8RM	3x5RM	3x6RM	3x4RM
One-legged hip flexion	3x8RM	3x5RM	3x6RM	3x4RM
Ankle plantar flexion	3x8RM	3x5RM	3x6RM	3x4RM

15 min Warm Up			
3x4 seated sprints	max. effort	R: 2’ between sprints	R: 5’ between sets
	Week 1-2	Week 3-4	Week 5-6
Session 1	4 seg	7 seg	8 seg
Session 2	6 seg	5 seg	6 seg

Comparison of Short-Sprint and Heavy Strength Training on Cycling Performance

Morten Kristoffersen[1,2], Øyvind Sandbakk[2], Bent R. Rønnestad[3] and Hilde Gundersen[1]*

- Group sprints ^ average and peak PO in all sprint tests.
- Resistance training group ^ increase in squat RFD values.
- No differences were found in $VO2_{max}$, PO at a threshold of [La-] 4 mmol-L^{-1} and Gross Efficiency.

On- Versus Off-Bike Power Training in Professional Cyclists: A Randomized Controlled Trial

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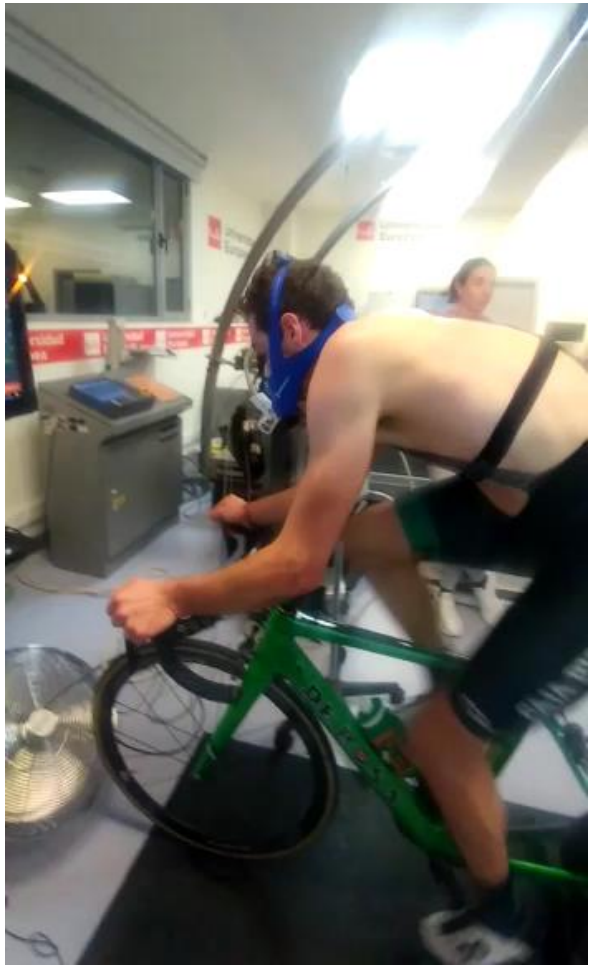

On- Versus Off-Bike Power Training in Professional Cyclists: A Randomized Controlled Trial

Pedro L. Valenzuela, Jaime Gil-Cabrera, Eduardo Talavera, Lidia B. Alejo, Almudena Montalvo-Pérez, Cecilia Rincón-Castanedo, Iván Rodríguez-Hernández, Alejandro Lucia, and David Barranco-Gil

Table 1 Characteristics of the 2 Muscle Power Training Interventions

Intervention	Variable	Description
CPT	Duration	7 wk
	Frequency	2 sessions/wk
	Exercises	Cycling sprints
	Training (sets × repetitions)	3 × 4
	Intensity	"All-out" with the highest possible gear
	Rest, s	120 between sprints/300 between sets
RPT	Duration	7 wk
	Frequency	2 sessions/wk
	Exercises	Squat, hip thrust, and lunge
	Training (sets × repetitions)	3 × maximum number of repetitions at >90% of OPL
	Intensity	OPL
	Rest, s	120

Abbreviations: 1RM, 1-repetition maximum; CPT, cycling power training; OPL, optimum power load; RPT, resistance power training.

Table 2 Results of Body Composition Outcomes

Outcome	Group	Baseline	Postintervention	Within group *P* value	Time *P* value	Group × time *P* value	Effect size η_p^2
Body mass, kg	CPT	66.2 (8.0)	65.6 (6.8)	.237	**.023**	.547	.023
	RPT	62.1 (8.2)	61.0 (7.6)	.059			
Fat mass, kg	CPT	10.7 (1.0)	10.7 (1.3)	.889	.069	.076	.184
	RPT	9.5 (1.8)	9.0 (1.6)	**.017**			
Muscle mass, kg	CPT	51.7 (6.6)	52.1 (5.6)	.575	.911	.487	.031
	RPT	49.1 (5.8)	48.8 (6.2)	.721			
BMD, $g \cdot cm^{-2}$	CPT	1.11 (0.09)	1.10 (0.09)	.207	.421	.329	.060
	RPT	1.07 (0.08)	1.15 (0.22)	.203			
BMC, g	CPT	2.39 (0.36)	2.41 (0.35)	.068	**.007**	.627	.015
	RPT	2.18 (0.32)	2.22 (0.33)	**.047**			

Abbreviations: BMC, bone mineral content; BMD, bone mineral density; CPT, cycling power training; RPT, resistance power training. Note: Data are presented as mean (SD). Significant ($P < .05$) values are given in bold.

Table 3 Results of Muscle Strength-Related Outcomes

Outcome	Group	Baseline	Postintervention	Within group *P* value	Time *P* value	Group × time *P* value	Effect size η_p^2
Squat 1RM, kg	CPT	86 (10)	86 (18)	.889	.085	.106	.155
	RPT	81 (15)	92 (13)	**.028**			
Squat MPP, watts	CPT	500 (88)	546 (168)	.401	.058	.977	.000
	RPT	499 (91)	544 (106)	**.028**			
Hip thrust 1RM, kg	CPT	103 (13)	115 (34)	.674	.065	.582	.019
	RPT	93 (24)	114 (32)	.202			
Hip thrust MPP, watts	CPT	475 (113)	538 (184)	.161	**.020**	.438	.038
	RPT	411 (81)	531 (149)	.083			
Lunge 1RM, kg	CPT	66 (11)	74 (12)	.249	**.005**	.438	.038
	RPT	64 (16)	76 (11)	**.025**			
Lunge MPP, watts	CPT	363 (104)	444 (128)	.050	**.011**	.638	.014
	RPT	367 (114)	425 (83)	.059			

Abbreviations: 1RM, 1-repetition maximum; CPT, cycling power training; MPP, maximum mean power output; RPT, resistance power training. Note: Data are presented as mean (SD). Significant *P* values are given in bold.

Table 4 Results of Endurance Performance-Related Outcomes

Outcome	Group	Baseline	Postintervention	Within group *P* value	Time *P* value	Group × time *P* value	Effect size η_p^2
VO_2peak, mL·kg^{-1}·min^{-1}	CPT	76.5 (3.3)	78.5 (4.3)	.176	.521	.513	.027
	RPT	79.2 (4.9)	79.2 (7.5)	.959			
PPO, watts	CPT	423 (49)	433 (38)	.310	.299	.734	.007
	RPT	421 (43)	426 (39)	.114			
PPO, watts·kg^{-1}	CPT	6.4 (0.4)	6.6 (0.4)	.091	**.032**	.986	.000
	RPT	6.8 (0.4)	7.0 (0.6)	.074			
VT, watts	CPT	254 (16)	274 (9)	**.018**	**.017**	.789	.005
	RPT	250 (30)	267 (27)	.114			
VT, watts·kg^{-1}	CPT	3.9 (0.4)	4.2 (0.4)	**.018**	**.003**	.911	.001
	RPT	4.1 (0.3)	4.4 (0.5)	.066			
RCP, watts	CPT	371 (39)	390 (28)	.174	**.022**	.907	.001
	RPT	350 (30)	366 (40)	**.028**			
RCP, watts·kg^{-1}	CPT	5.6 (0.3)	6.0 (0.6)	.090	**.004**	.964	.000
	RPT	5.7 (0.5)	6.0 (0.6)	**.013**			
8-min TT (average percentage of VO_2peak)	CPT	90 (3)	91 (6)	.674	.527	.788	.005
	RPT	91 (5)	93 (7)	.799			
8-min TT (average of watts/VO_2 (mL·min^{-1})	CPT	77 (2)	77 (3)	1.000	.427	.590	.019
	RPT	77 (3)	79 (5)	.508			

Abbreviations: CPT, cycling power training; PPO, peak power output; RCP, respiratory compensation threshold; RPT, resistance power training; TT, time trial; VO_2peak, peak oxygen uptake; VT, ventilatory threshold. Note: Data are presented as mean (SD). Significant *P* values are given in bold.

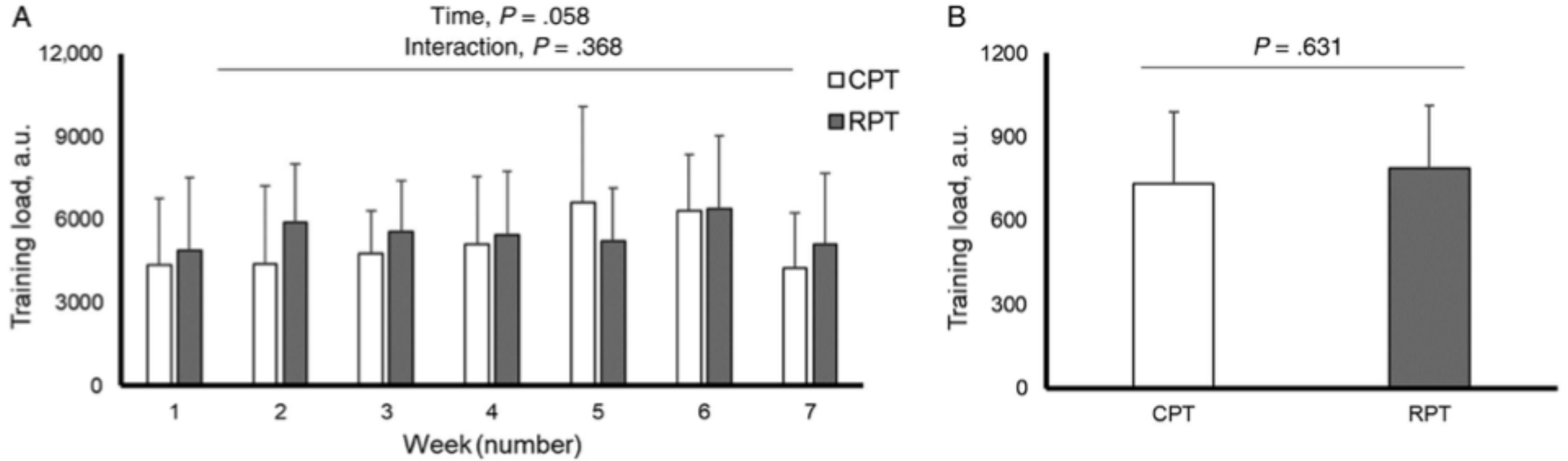

Figure 1 — Weekly (panel A) and daily average (panel B) training load (computed as session length [in minutes] multiplied by rating of perceived exertion [assessed on a 1–10 Borg scale]). CPT indicates cycling power training; RPT, resistance power training.

CONCLUSIONS

- **Improvements in bone mineral content (VIP bone lesions), even more in the resistance training group.**
- **TT-8 min** (**4% better**), in **both groups**
- Significant changes in body composition and physiological markers (pre-post), less significant between groups
- **Both types of training can be included in the program, depending on the athlete's preferences.**

The use of velocity-based resistance training in cyclists. New perspectives on strength training in cyclists

THANK YOU!!

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