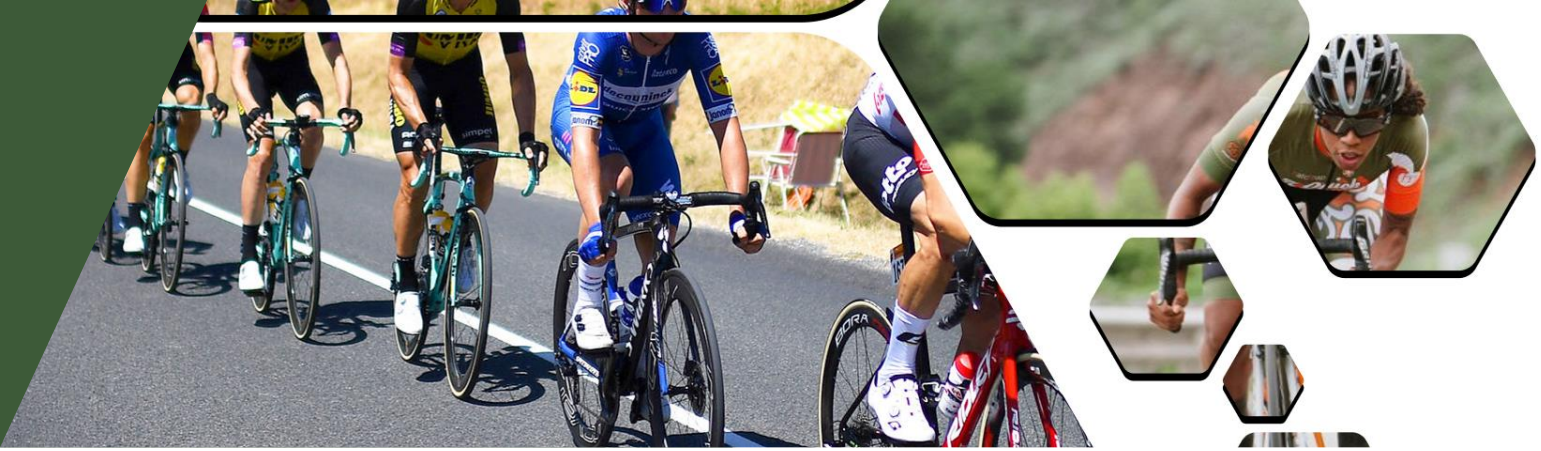


ESCOLA DE EDUCAÇÃO FÍSICA E ESPORTE
UNIVERSIDADE DE SÃO PAULO

LabFab
CONECTANDO A CIÊNCIA DO CICLISMO À SOCIEDADE

Disciplina: Fisiologia do Esporte

Ciclismo de estrada – características anatômicas, fisiológicas e de treinamento de ciclistas de elite

Prof. Dr. Fabiano A. Pinheiro

[2004-2007]

Graduação

UNIP UNIVERSIDADE PAULISTA

[2008-2009]

Especialização

FMU

[2009-2010]

[2011-2014]

Mestrado

USP Universidade de São Paulo

[2012 e 2013]

SSISA SPORTS SCIENCE INSTITUTE OF SOUTH AFRICA

[2014-2016]

Reflexão

[2016-2020]

Doutorado

USP Universidade de São Paulo

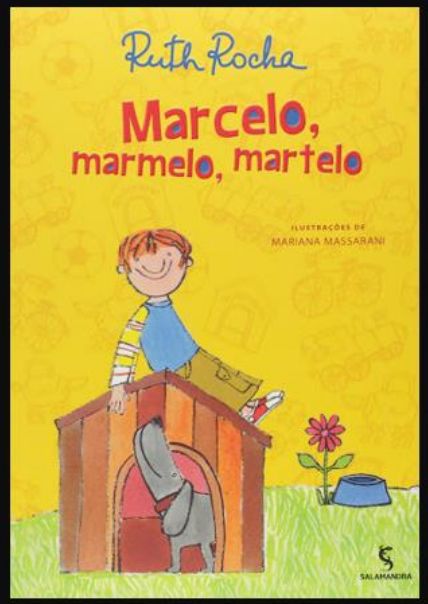
Parceria (Pandemia)

INLAND NORWAY UNIVERSITY OF APPLIED SCIENCES

[2020]

LabFab

• A dúvida não deve ser temida, ela é bem vinda e deve ser discutida (Richard Feynman, 1955).



Oportunidade no mercado de trabalho

Em meio à pandemia de Covid, vendas de bicicleta sobem 34% no semestre

Alívio mental e exercício atraem ciclistas, apesar da alta de preços; serviços de aluguel do equipamento também cresceram

https://www1.folha.uol.com.br/cotidiano

Bicicletas continuam em alta no Brasil: Primeiro semestre de 2021 teve aumento de 34% nas vendas em comparação a 2020

17 de agosto de 2021 | Estudos Econômicos, Lojistas, Notícias

https://aliancabike.org.br/aumento-nas-vendas-em-2021/

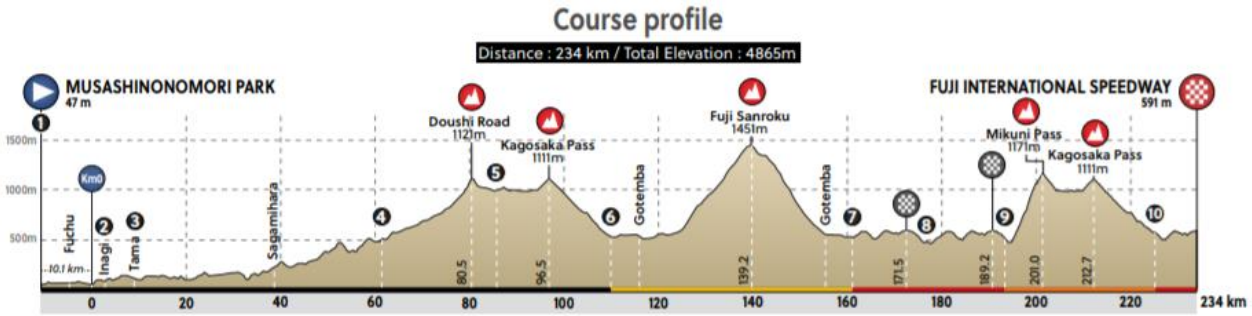
https://aliancabike.org.br/ciclismo-de-estrada-sp/

1817

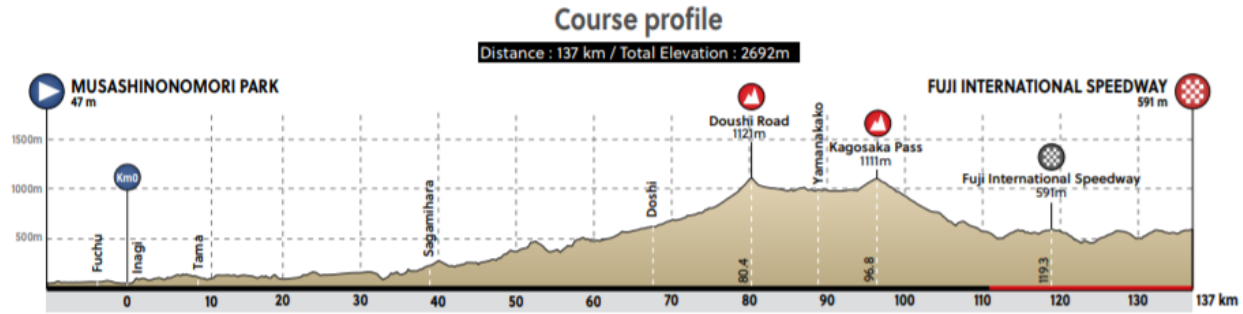
2021

TOKYO 2020

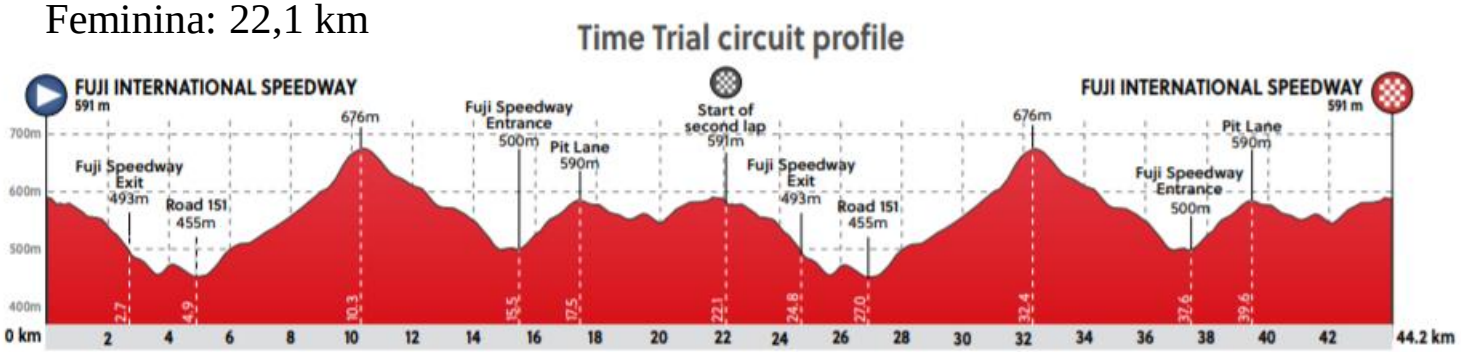
Masculina: 234 km



Feminina: 137 km



Masculina: 44,2
Feminina: 22,1 km



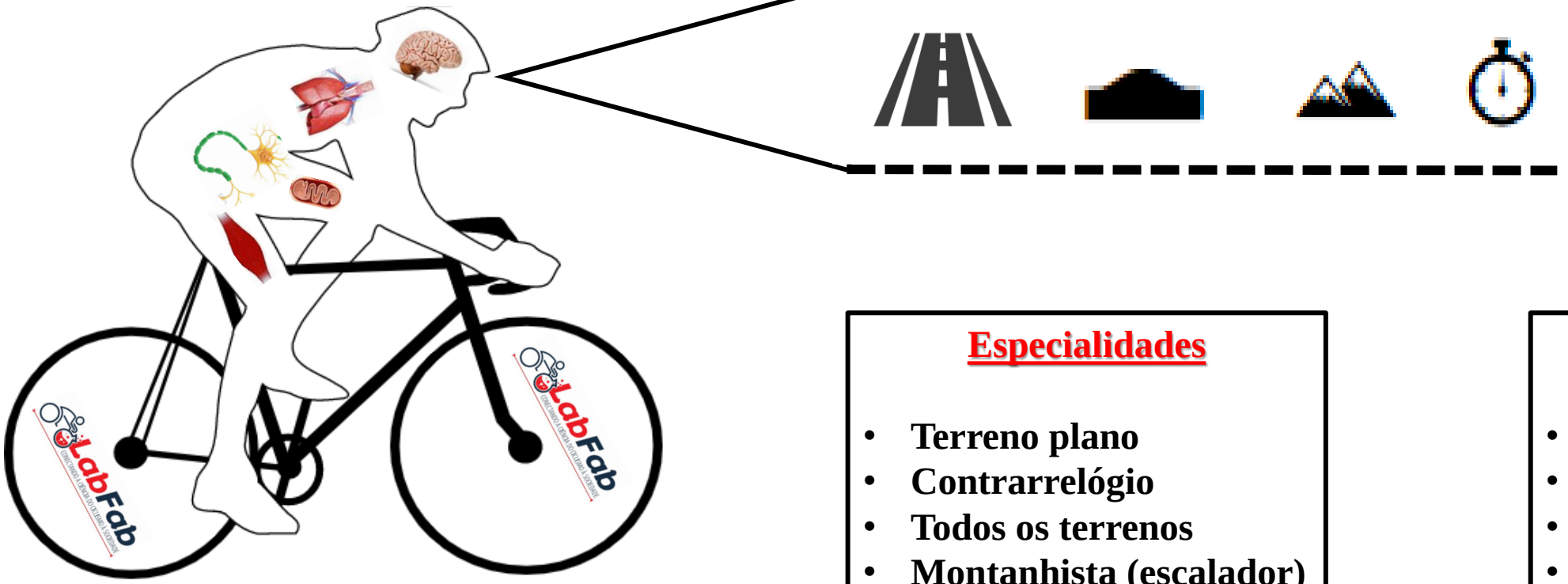
Distância de ~3.228 km

Distância de ~3.417 km

21 etapas
23 dias
2 dias de folga

Distância de ~3.410 km

$\sum$ = 10.055 km



Especialidades

- **Terreno plano**
- **Contrarrelógio**
- **Todos os terrenos**
- **Montanhista (escalador)**
- **Sprinter (sem dados)**

Mujika e Padilla (2001)

Gíria do ciclismo

- **Gregário**
- **Passista**
- **Montanhista**
- **Velocista (sprinter)**

Table III. Physical caracteristics of the specialist rider groups. Values are mean ± SD

Characteristic	Group			
	flat terrain (n = 5)	time trial (n = 4)	all terrain (n = 6)	uphill (n = 9)
Age (y)	27 ± 3	28 ± 5	25 ± 2	25 ± 4
Height (cm)	186 ± 4	181 ± 6	180 ± 2	175 ± 7[a]
BM (kg)	76 ± 3	71 ± 6	68 ± 3[a]	62 ± 4[a,b,c]
BSA (m^2)	2.00 ± 0.06	1.91 ± 0.11	1.87 ± 0.04[a]	1.76 ± 0.10[a,b,c]
FA (m^2)	0.37 ± 0.01	0.35 ± 0.02	0.35 ± 0.01[a]	0.33 ± 0.02[a,b,c]
BSA/BM × 10^{-3}	26.3 ± 0.5	26.8 ± 0.7	27.4 ± 0.5[a]	28.3 ± 0.5[a,b,c]
FA/BM × 10^{-3}	4.9 ± 0.1	5.0 ± 0.1	5.1 ± 0.1[a]	5.2 ± 0.1[a,b]

a Significantly different from flat terrain.

b Significantly different from time trial.

c Significantly different from all terrain.

BM = body mass; **BSA** = body surface area; **FA** = frontal area

Adaptado de Mujika e Padilla (2001)

Equipe australiana de ciclismo feminino de estrada, nível internacional.

Variáveis	Média	Valores Mínimos	Valores Máximos
Idade (anos)	24,5	21	28
Estatura (cm)	168	162	174
Massa Corporal (kg)	57,1	55,4	58,8
Gordura corporal (%)	9,3	7	12

Adaptado de Martin et al. (2001)

Selective training-induced thigh muscles hypertrophy in professional road cyclists

François Hug · Tanguy Marqueste · Yann Le Fur · Patrick J. Cozzone · Laurent Grélot · David Bendahan

Eur J Appl Physiol (2006) 97: 591–597

VS

Table 1 Morphological ~~and physiological~~ characteristics of the professional road cyclists as compared to the sport science students

	Sport science students	Professional road cyclists
Age (year)	24.0±2.8	24.3±3.2
Height (m)	1.77±0.07	1.83±0.03[a]
Body mass (kg)	72.1±7.7	73.4±3.9
BMI (kg m^{-2})	22.8±2.2	22.0±1.3

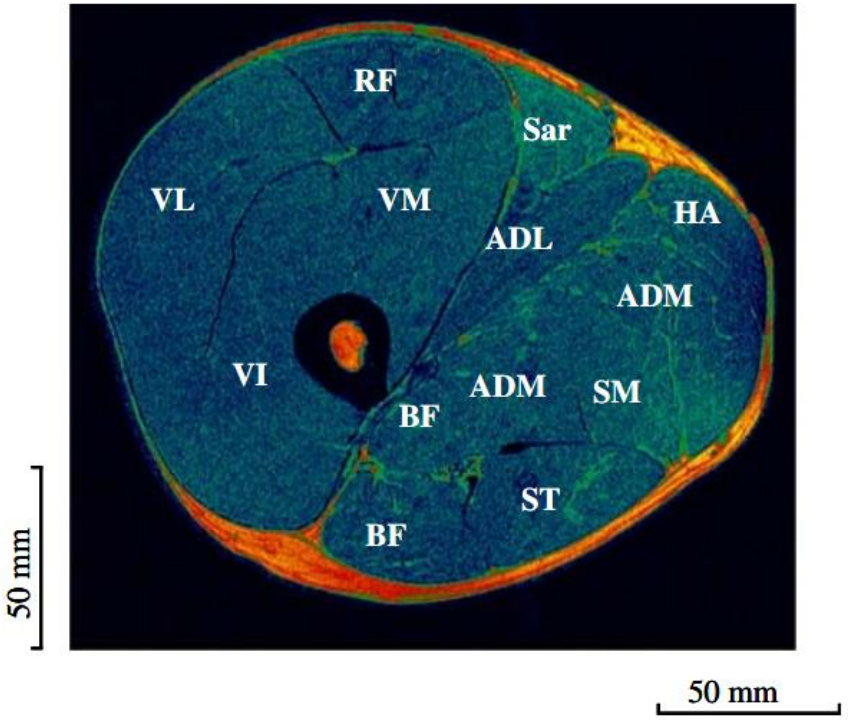
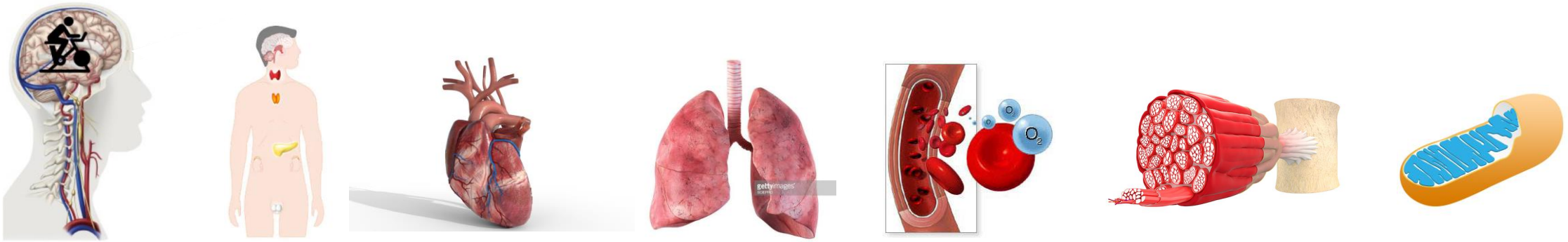


Table 2 Cross sectional area value for each thigh muscle

CSA (mm^2)	Sport science students		Professional road cyclists	
	Mean ± SD	Range	Mean ± SD	Range
Thigh	19,295±3,701	15,158–24,478	20,176±1,869	17,440–23,308
All muscles	14,183±1,856	11,425–16,608	17,114±1,335[a]	15,330–18038
Vastus lateralis	2,829±546	2,216–3,303	3,797±275[a]	3,505–4,312
Rectus femoris	1,017±286	610–1,345	1,257±168	1,138–1,514
Vastus medialis	921±169	562–1,212	968±187	730–1,257
Vastus intermedius	2,901±255	2,682–3,302	2,976±282	2,630–3,512
Sartorius	406 ± 63	290–501	507±88[a]	401–656
Adductor longus	936 ± 397	449–1,472	1,019±188	863–1,446
Adductor magnus	2652 ± 684	1,869–4,003	3,413±589[a]	2,626–4,352
Hip adductor	520 ± 111	362–696	649±198	461–1,083
Biceps femoris	951 ± 102	787–1390	1,372±179[a]	1,128–1,641
Semitendinosus	1036 ± 275	457–1370	1,117±300	689–1,528
Semimembranosus	530 ± 166	299–824	685±149	494–955

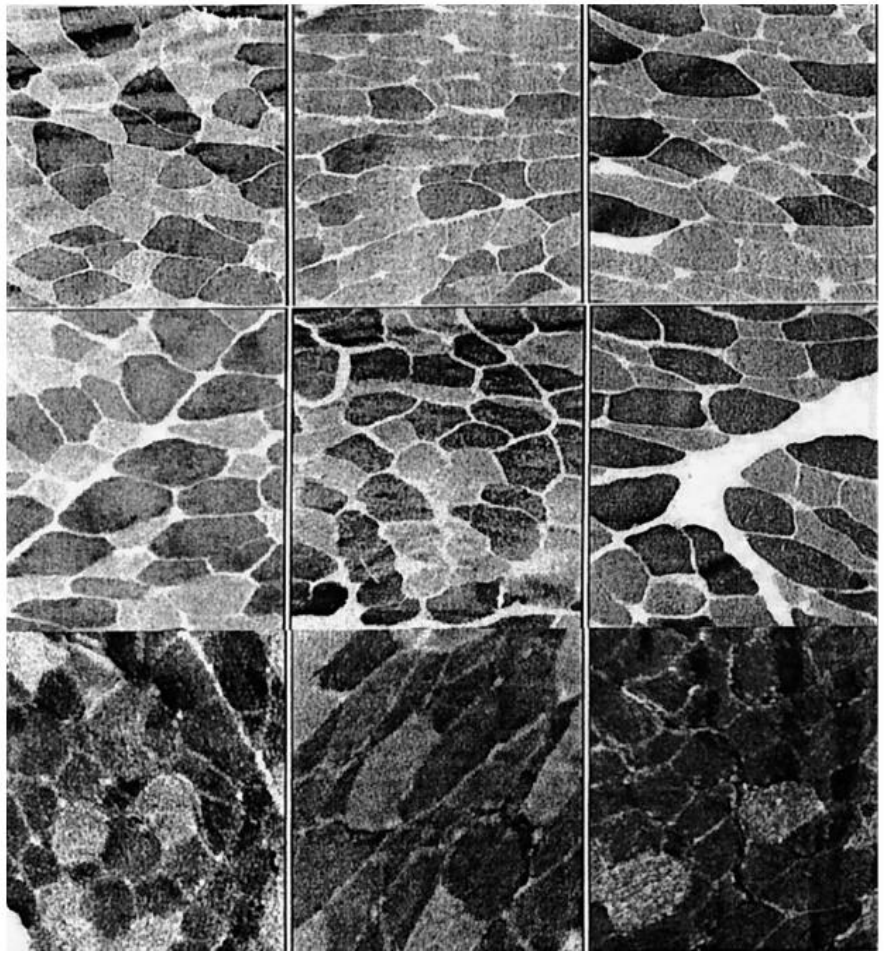
Thigh CSA corresponds to the sum of muscles and fat CSA, and all muscles CSA represents only the muscles CSA

[a] Significant difference between the two populations



Adaptações crônicas do exercício aeróbio

Calverley et al. (2020); Boutcher et al. (2003); Levine, B. (2008); Hopker et al. (2013)



RC21 > NT21
25,5%

RC25 > NT25
34,9%

RC21 < RC25
7,8%

RC21 < NT21
23,5%

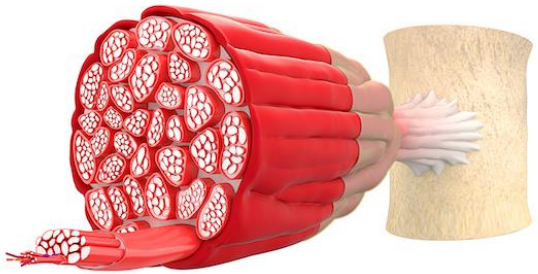
RC25 < NT25
34,7%

RC21 > RC25
13,9%

RC21 < NT21
30,0%

RC25 < NT25
36,3%

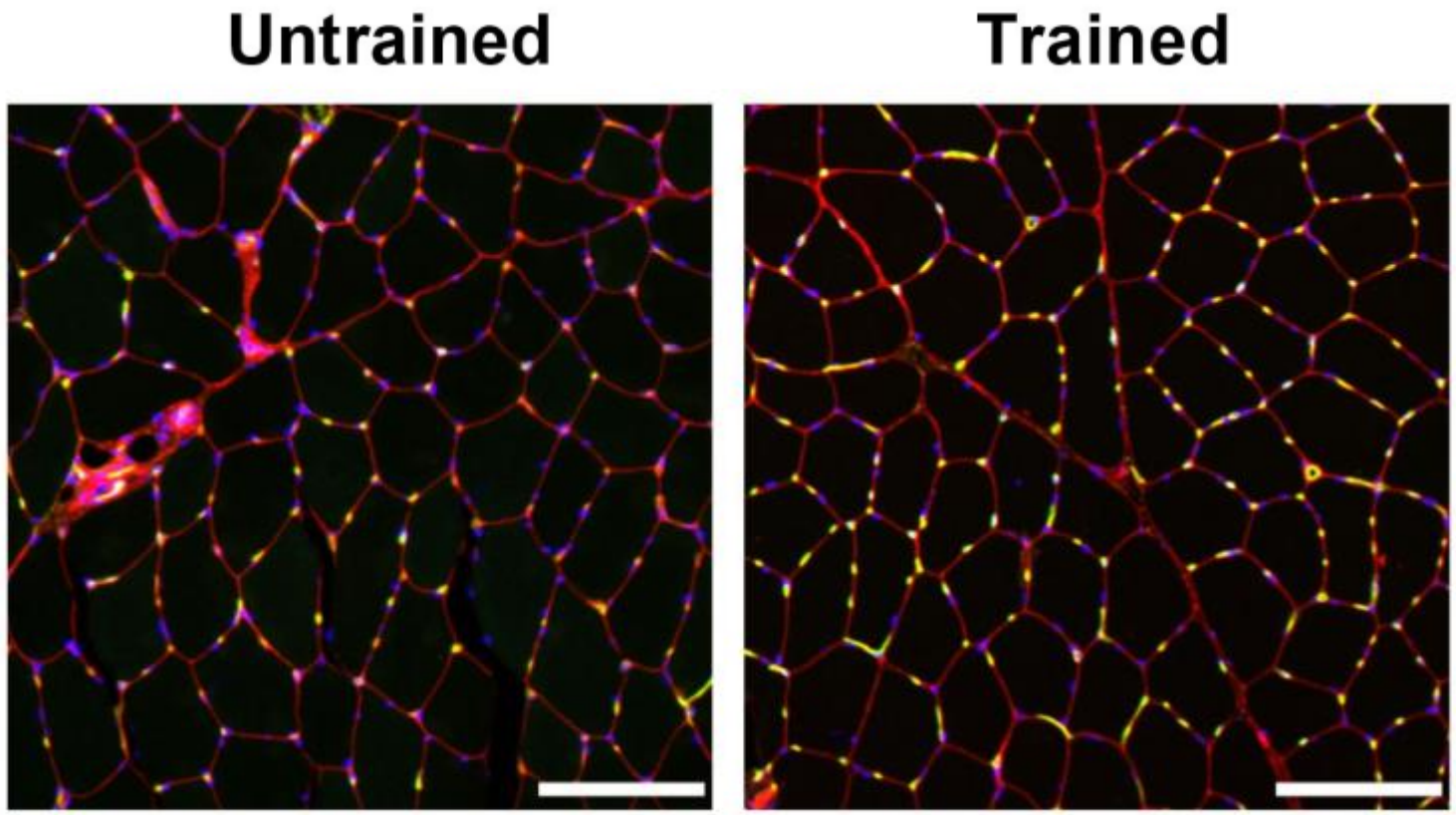
RC21 = RC25
Sem diferença

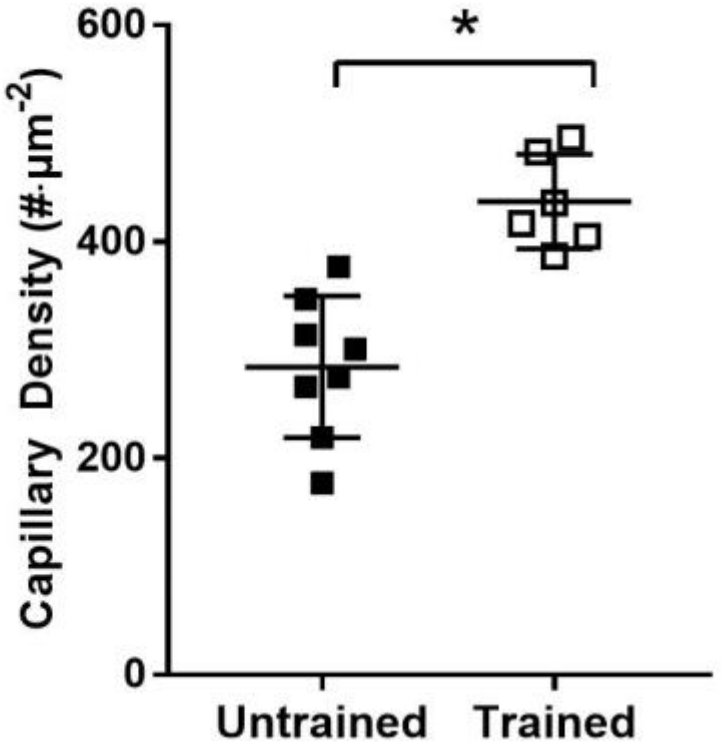


10 Fisicamente Ativos (NT)
NT21
NT25

20 Ciclistas
RC21= 3 anos de competição
RC25= 7 anos de competição

Rodriguez et al. (2002)

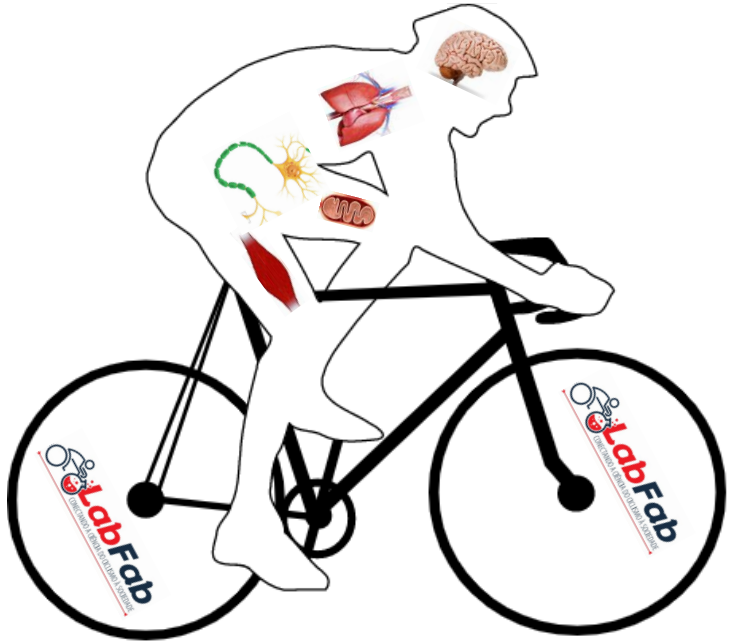




Shaw et al. (2020)

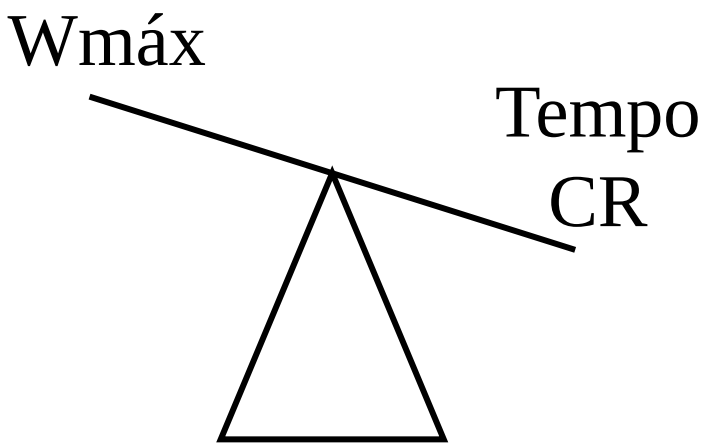
Preditores do desempenho

- Wmáx
- VO_2máx
- 2º LL/LV
- %VO2máx
- Economia (EC)



Potência mecânica máxima (Wmáx)

- máxima potência mecânica alcançada durante um teste incremental máximo



Hawley e Noakes et al. (1992)

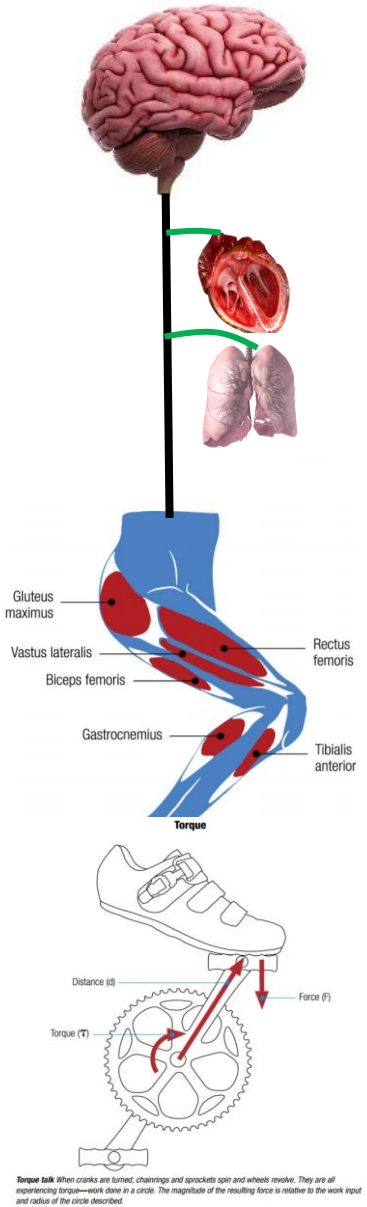
Consumo máximo de oxigênio ($VO_2máx$)

- capacidade máxima que um indivíduo tem de absorver, transportar e utilizar o O_2 para ressíntese da ATP.

- **Potência aeróbia:** quantidade de energia por unidade de tempo

$$\mathbf{VO_2máx = FC \times VS \times dif.\ a\text{-}vO_2}$$

Débito cardíaco máximo



Segundo limiar de lactato/ventilatório (2º LL/LV) (MLSS, Critical power)

- a maior intensidade que pode ser mantida sem o acúmulo considerável do lactato sanguíneo

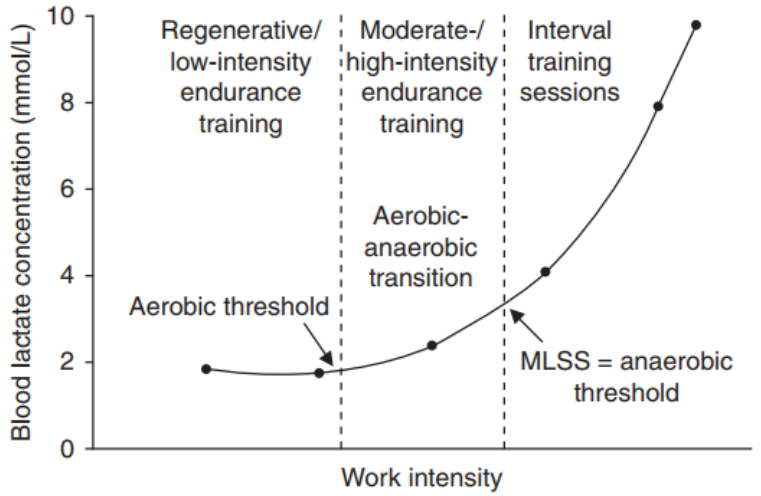
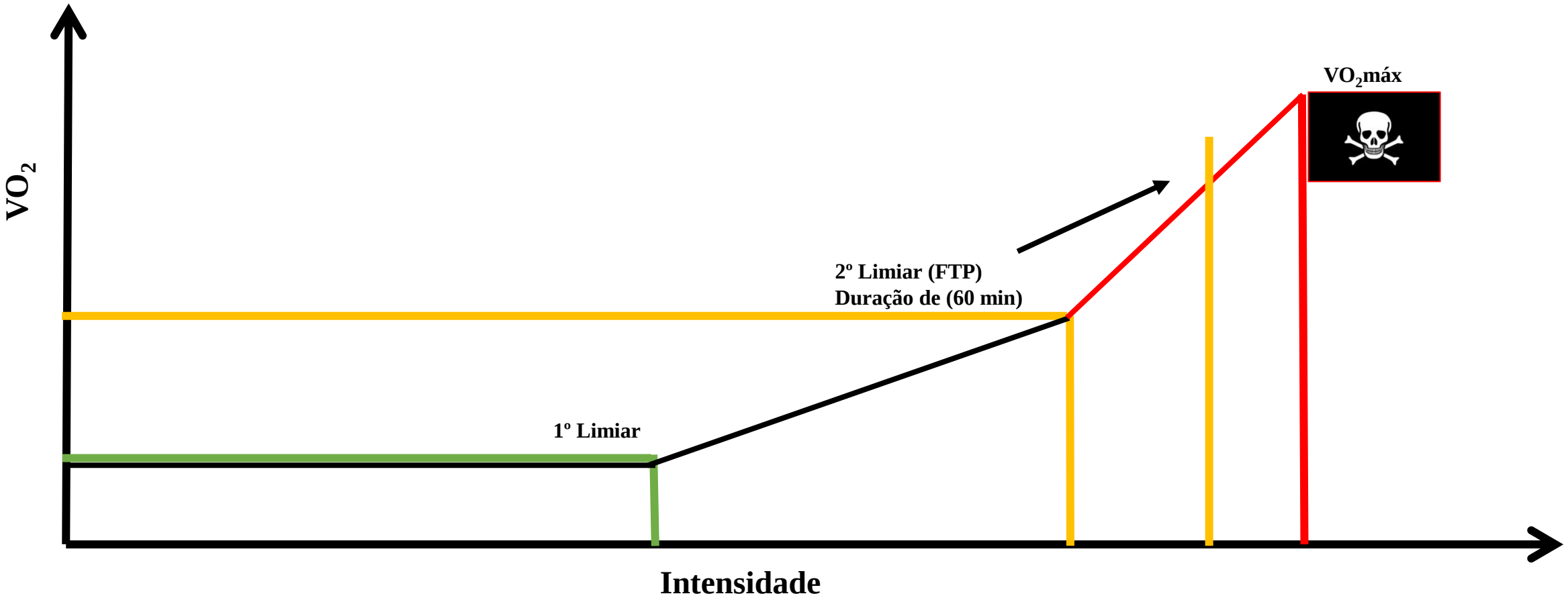


Fig. 1. A typical lactate-workload plot including the aerobic-anaerobic transition as a framework to derive endurance training intensities for different intensity zones. **MLSS** = maximal lactate steady state.

Faude et al. (2009); Bertuzzi et al. (2013)

Capacidade de sustentar elevado % do VO_2máx



Economia de Ciclismo

- Demanda energética ou o consumo de oxigênio necessário para uma dada intensidade submáxima em equilíbrio metabólico

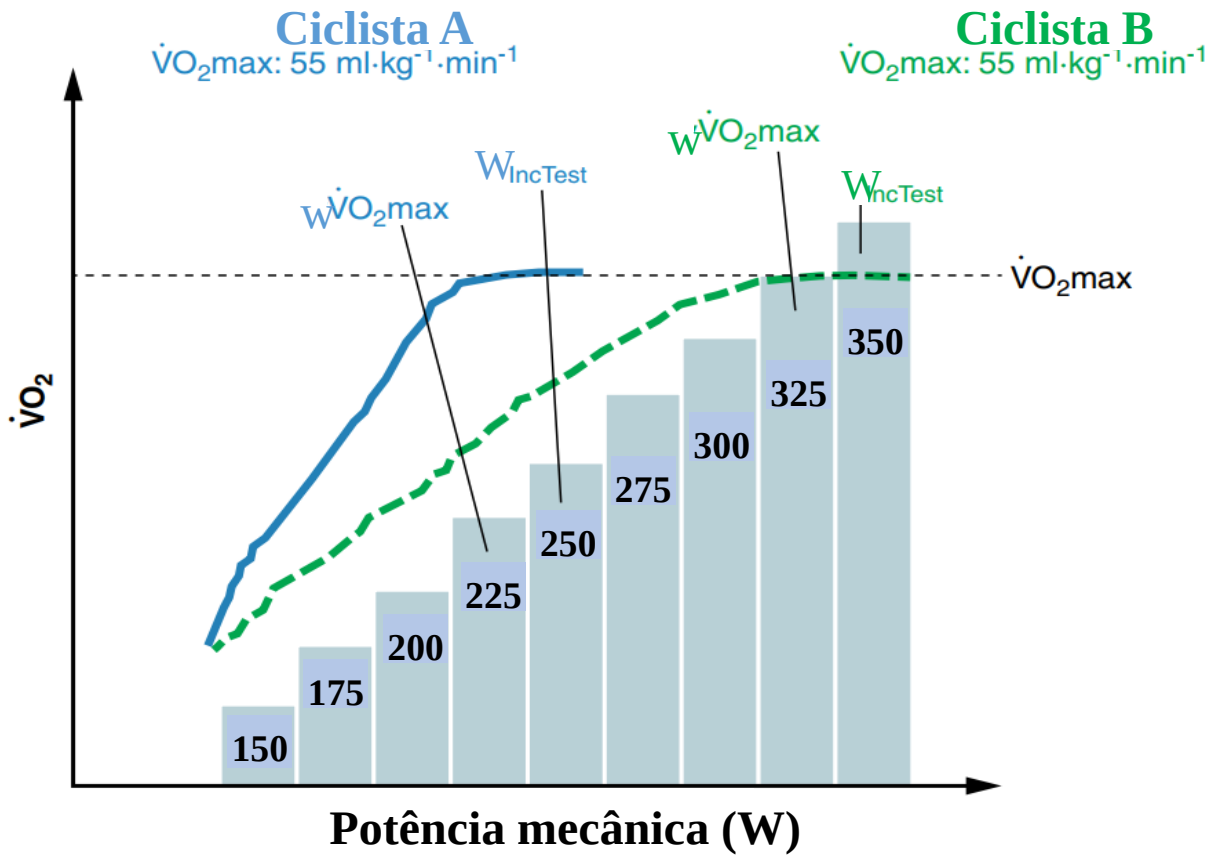


Imagem adaptada de Laursen e Buchheit (2019)

Características fisiológicas

VS

Table 1 ~~Morphological and~~ physiological characteristics of the professional road cyclists as compared to the sport science students

	Sport science students	Professional road cyclists
VO_2 max (ml min^{-1} kg^{-1})	55.9±4.7	74.6±5.1[a]
MPT (W)	334±24	477±28[a]
VT_1 (% MPT)	54±9	60±7[a]
VT_2 (% MPT)	80±5	89±5[a]

Adaptado de Hug et al. (2006)

Physiological Differences Between Professional and Elite Road Cyclists

A. Lucía [1,2], J. Pardo [1], A. Durántez [3], J. Hoyos [4], J. L. Chicharro [1]

Int. J. Sports Med. 19 (1998) 342 – 348

Table 2 Comparison between maximal values.

	EC (n = 25)	PC (n = 25)	p value
$\dot{V}O_2max$ ($l \cdot min^{-1}$)	4.9 ± 0.4	5.1 ± 0.6	NS
$\dot{V}O_2max$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	72.9 ± 5.7	73.9 ± 7.4	NS
W	428.6 ± 31.7	466.0 ± 30.8	$p < 0.001$
$W \cdot kg^{-1}$	6.4 ± 0.5	6.7 ± 0.4	$p < 0.05$
RER	1.17 ± 0.11	1.17 ± 0.10	NS
VE ($l \cdot min^{-1}$)	185.7 ± 23.7	186.2 ± 15.6	NS
$VE \cdot \dot{V}O_2^{-1}$	37.0 ± 6.1	37.8 ± 4.4	NS
$VE \cdot \dot{V}CO_2^{-1}$	32.5 ± 5.1	33.6 ± 4.1	NS
HR ($beats \cdot min^{-1}$)	192 ± 8	190 ± 7	NS
BLa ($mM \cdot l^{-1}$)	9.4 ± 3.0	7.4 ± 1.5	$p < 0.05$

All values are expressed as means ± SD.
Abbreviations: NS (no significant difference), BLa (blood lactate).

Table 3 Comparison between physiological parameters at VT_1.

	EC (n = 25)	PC (n = 25)	p value
$\dot{V}O_2$ (ml · kg^{-1} · min^{-1})	44.9 ± 6.1	46.1 ± 5.6	NS
%$\dot{V}O_2$max	61.5 ± 6.2	65.0 ± 6.9	$p < 0.05$
W	234.7 ± 34.6	262.1 ± 36.0	$p < 0.01$
W · kg^{-1}	3.5 ± 0.5	3.8 ± 0.5	$p < 0.05$
RER	0.85 ± 0.07	0.86 ± 0.05	NS
VE (l · min^{-1})	60.7 ± 9.4	63.5 ± 17.0	NS
VE · $\dot{V}O_2^{-1}$	20.6 ± 1.8	20.6 ± 1.5	NS
VE · $\dot{V}CO_2^{-1}$	24.3 ± 2.0	23.8 ± 1.9	NS
HR (beats · min^{-1})	141 ± 9	138 ± 7	NS

All values are expressed as means ± SD.
Abbreviations: NS (no significant difference).

Table 4 Comparison between physiological parameters at VT_2.

	EC (n = 25)	PC (n = 25)	p value
$\dot{V}O_2$ (ml · kg^{-1} · min^{-1})	58.8 ± 7.4	62.2 ± 6.8	NS
%$\dot{V}O_2$max	80.4 ± 6.6	87.0 ± 5.9	$p < 0.001$
W	323.2 ± 70.5	385.9 ± 25.3	$p < 0.001$
W · kg^{-1}	5.0 ± 0.5	5.5 ± 0.4	$p < 0.001$
RER	0.95 ± 0.07	0.99 ± 0.05	$p < 0.05$
VE (l · min^{-1})	93.6 ± 13.9	113.0 ± 12.8	$p < 0.001$
VE · $\dot{V}O_2^{-1}$	23.9 ± 2.1	25.1 ± 2.5	NS
VE · $\dot{V}CO_2^{-1}$	25.1 ± 2.0	25.6 ± 3.0	NS
HR (beats · min^{-1})	171 ± 8	172 ± 7	NS

All values are expressed as means ± SD.
Abbreviations: NS (no significant difference).

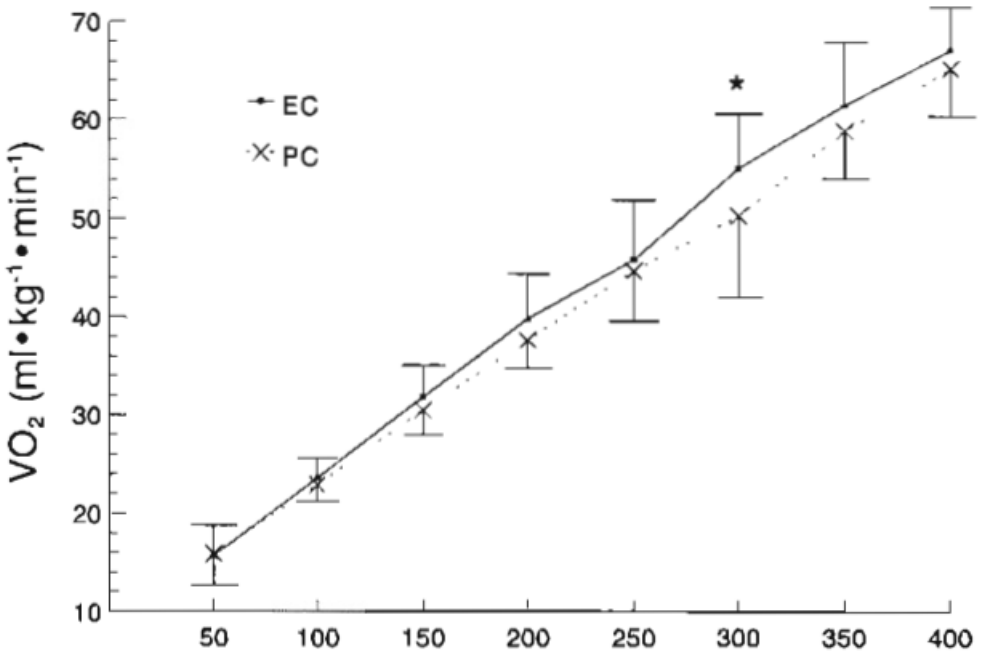


Fig. 3 Comparison of $\dot{V}O_2$ values (means ± SD) during the tests. *p < 0.05.

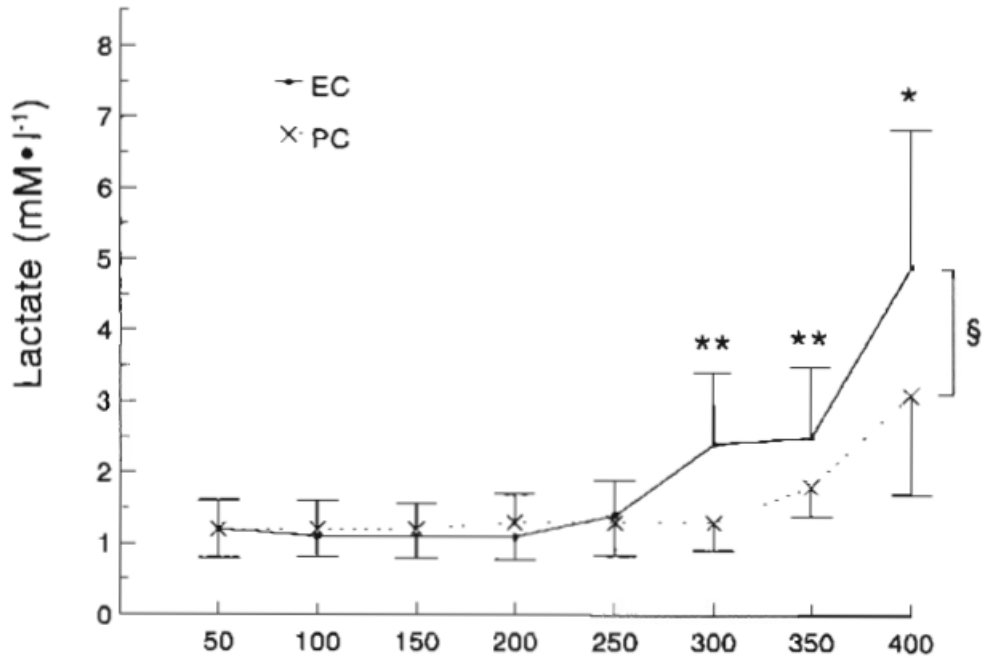
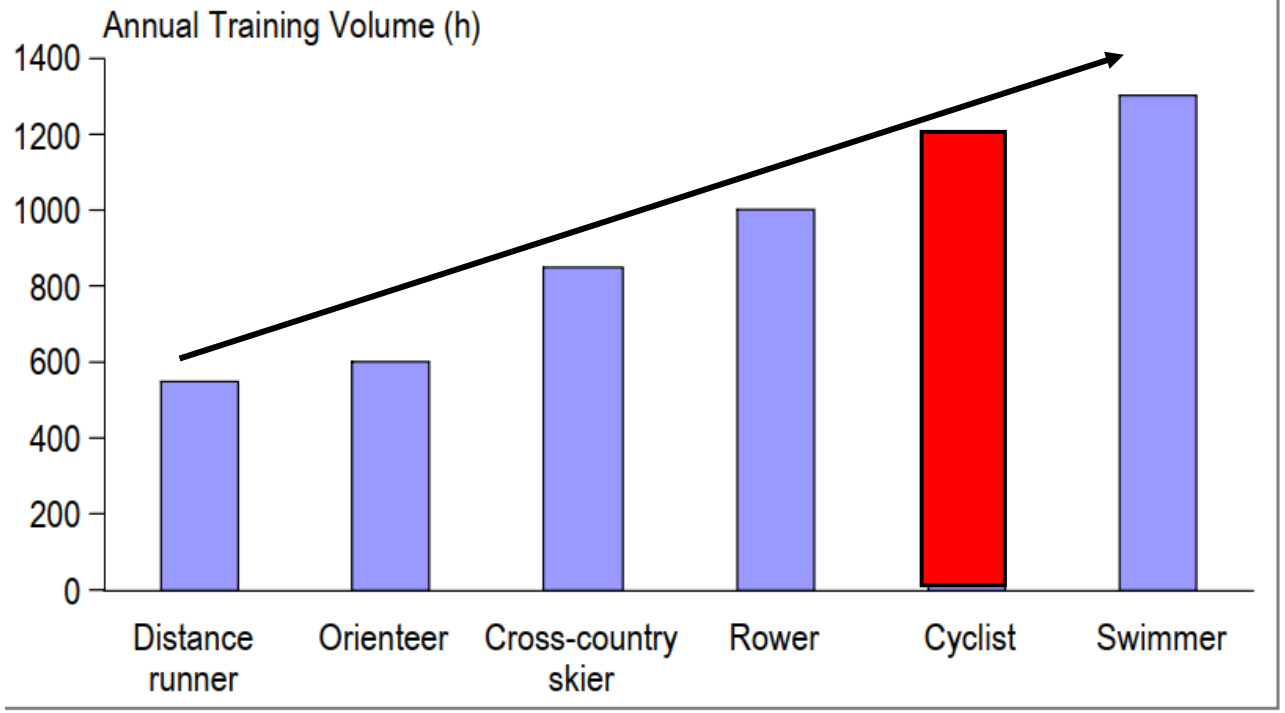


Fig. 5 Comparison of blood lactate values (means ± SD) during the tests. *p < 0.05; **p < 0.01; § significant (p < 0.001) interactive effect (group × workload).

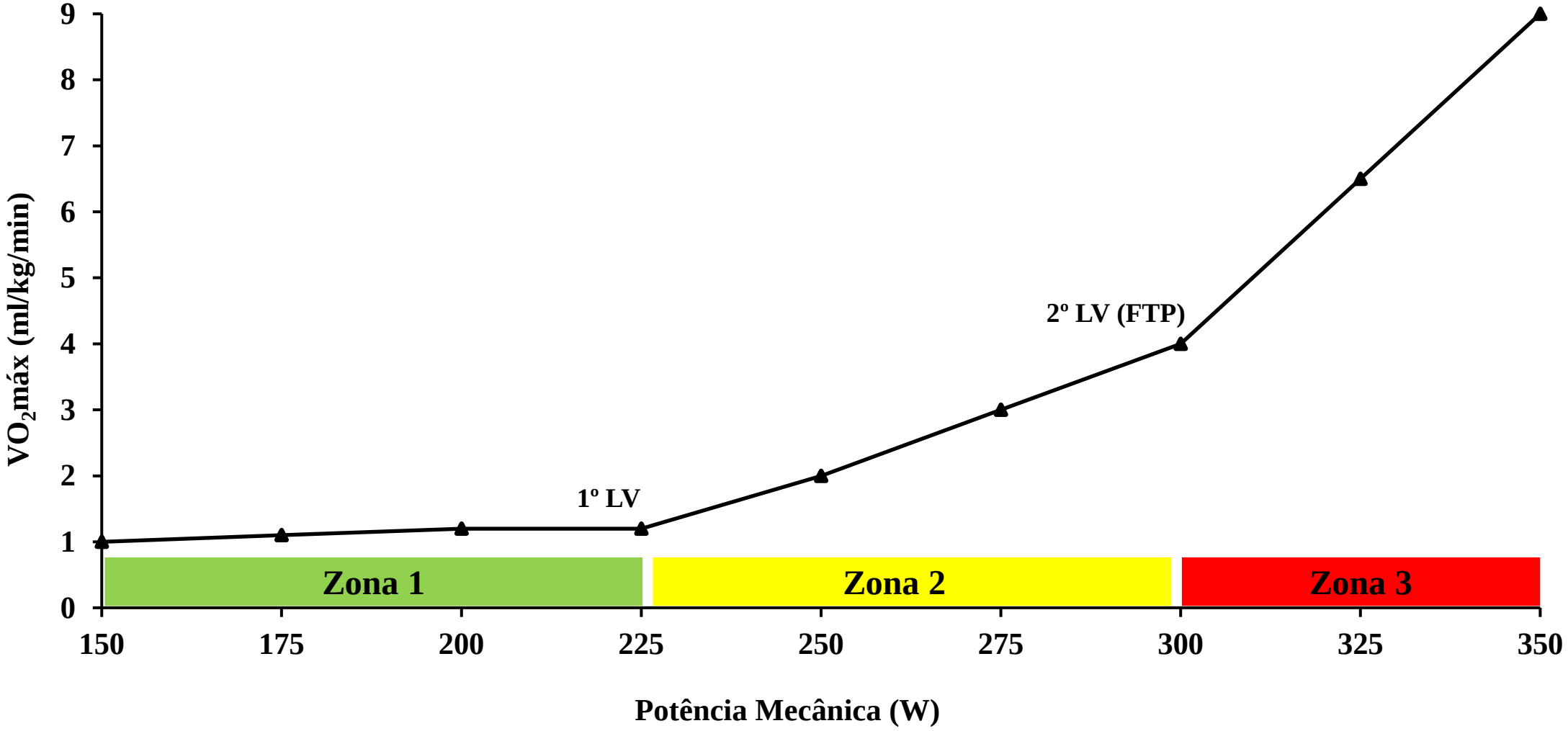
Volume Total (Treino+Competições)

- **25-35 mil km/ano**

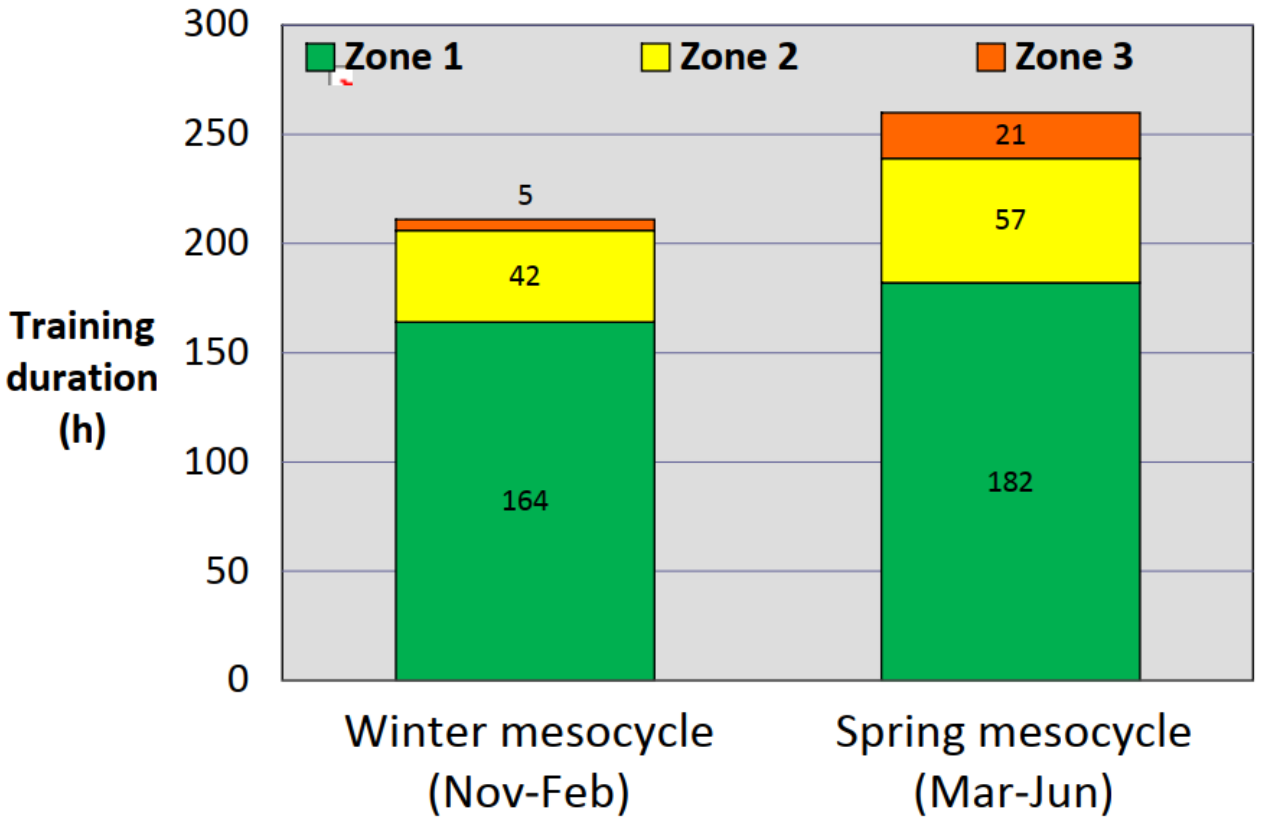
Figure 6. Representative peak annual training volumes for champion athletes from different sports. Ballistic and eccentric loading differences, demands on technical entrainment, and non-specific training volume may all contribute to the differences.



Mujika e Padilla (2001); Zapico et al. (2007); Seiler & Tonnenssen (2009)


9
8
7
6
5
4
3
2
1
0
VO2máx (ml/kg/min)
1º LV
2º LV (FTP)
Zona 1
Zona 2
Zona 3
150
175
200
225
250
275
300
325
350
Potência Mecânica (W)

Distribuição do volume total de treinamento nas três zonas de intensidade

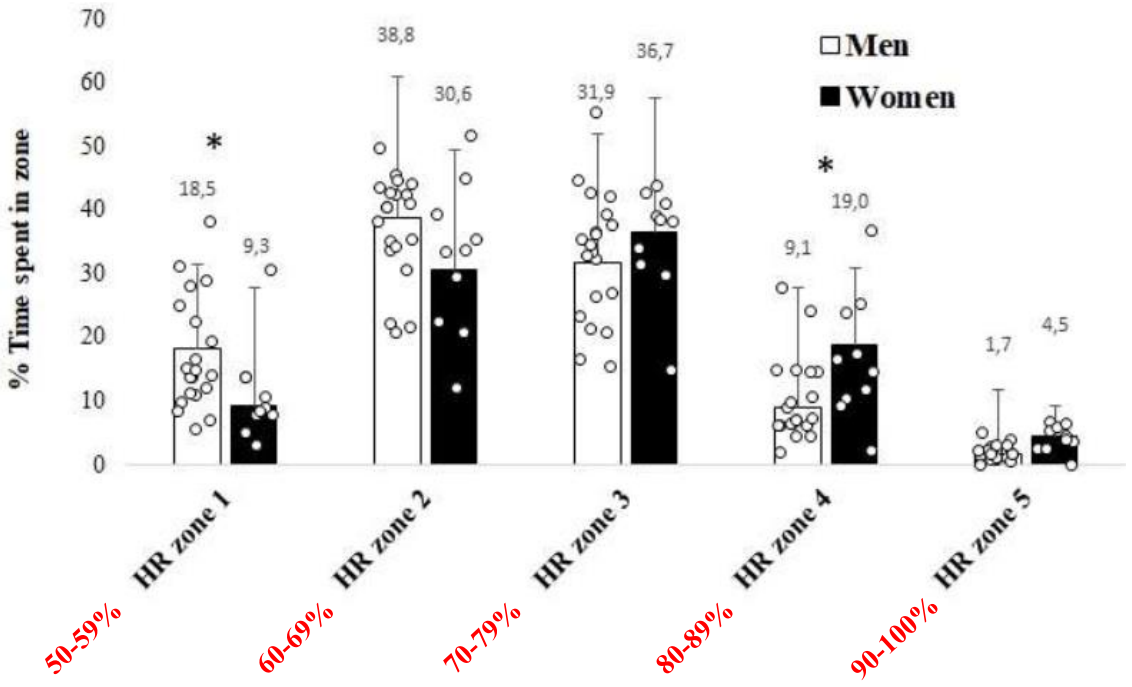


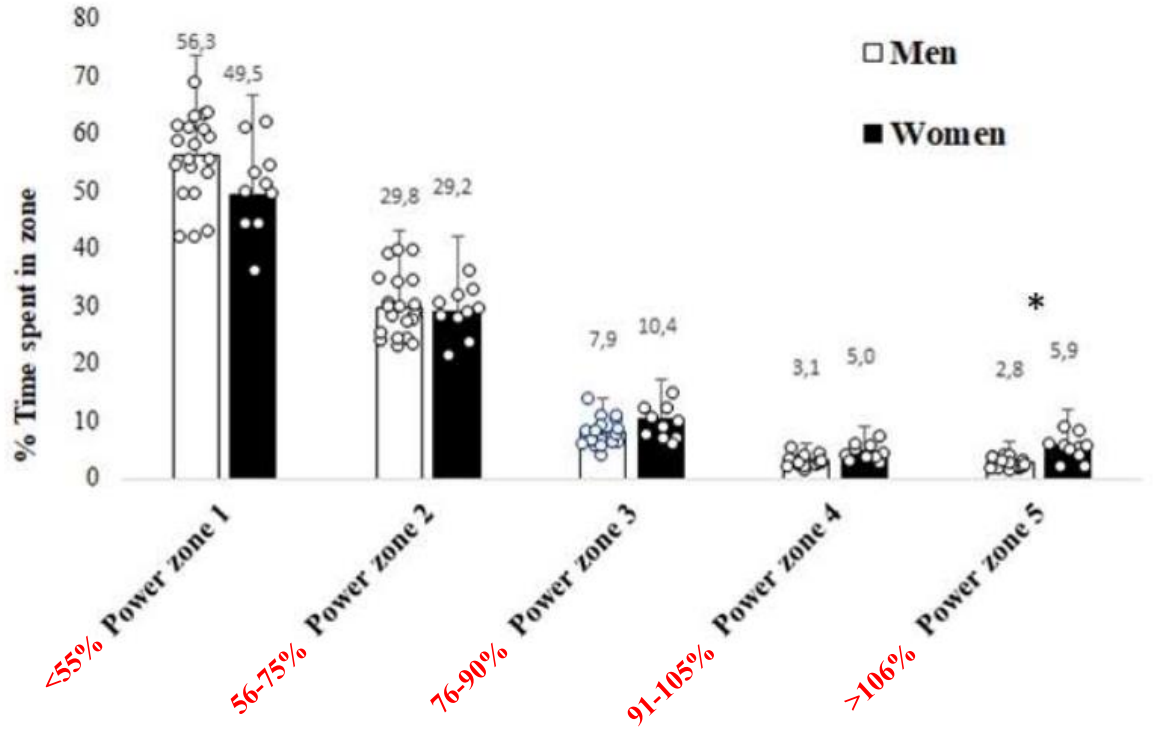
Training Characteristics of Male and Female Professional Road Cyclists: A Four-Year Retrospective Analysis

Teun van Erp, Dajo Sanders, Jos J de Koning

Article *in* International Journal of Sports Physiology and Performance · July 2019

DOI: 10.1123/ijspp.2019-0320





Calculada pela FC_máxima atingida durante a temporada

Calculado pelo FTP

De jogador de Futebol à Ciclista de Elite – Um estudo de caso

Knut Anders Fostervold

1994-2002 – Lesão no Joelho

Após 2,5 anos treinando em alta intensidade e baixo volume, Fostervold reorganizou seu treino em parceria com o Centro Olímpico Norueguês.

Table 7. Comparison of weekly training intensity distribution and total volume in 2004 season and 2005 season – Case 1.

Intensity zone (%HRmax)	Season 2004 (h:min)	Season 2005 (h:min)
5 (95-100 %)	0:45 (8.5 %)	0:05 (0.5 %)
4 (90-95 %)	–	0:40 (4.0 %)
3 (85-90 %)	0:30 (5.5 %)	1:00 (5.5 %)
2 (75-85 %)	3:05 (36 %)	1:00 (5.5 %)
1 (55-75 %)	4:20 (50 %)	15:20 (85 %)
Weekly total[a]	8:40	18:05
Annual total[a]	420:00	850:00

HRmax: maximum heart rate.
[a]Estimates based on diaries for the first 18 wk.

Table 8. Physiological testing before and after training reorganization – Case 1.

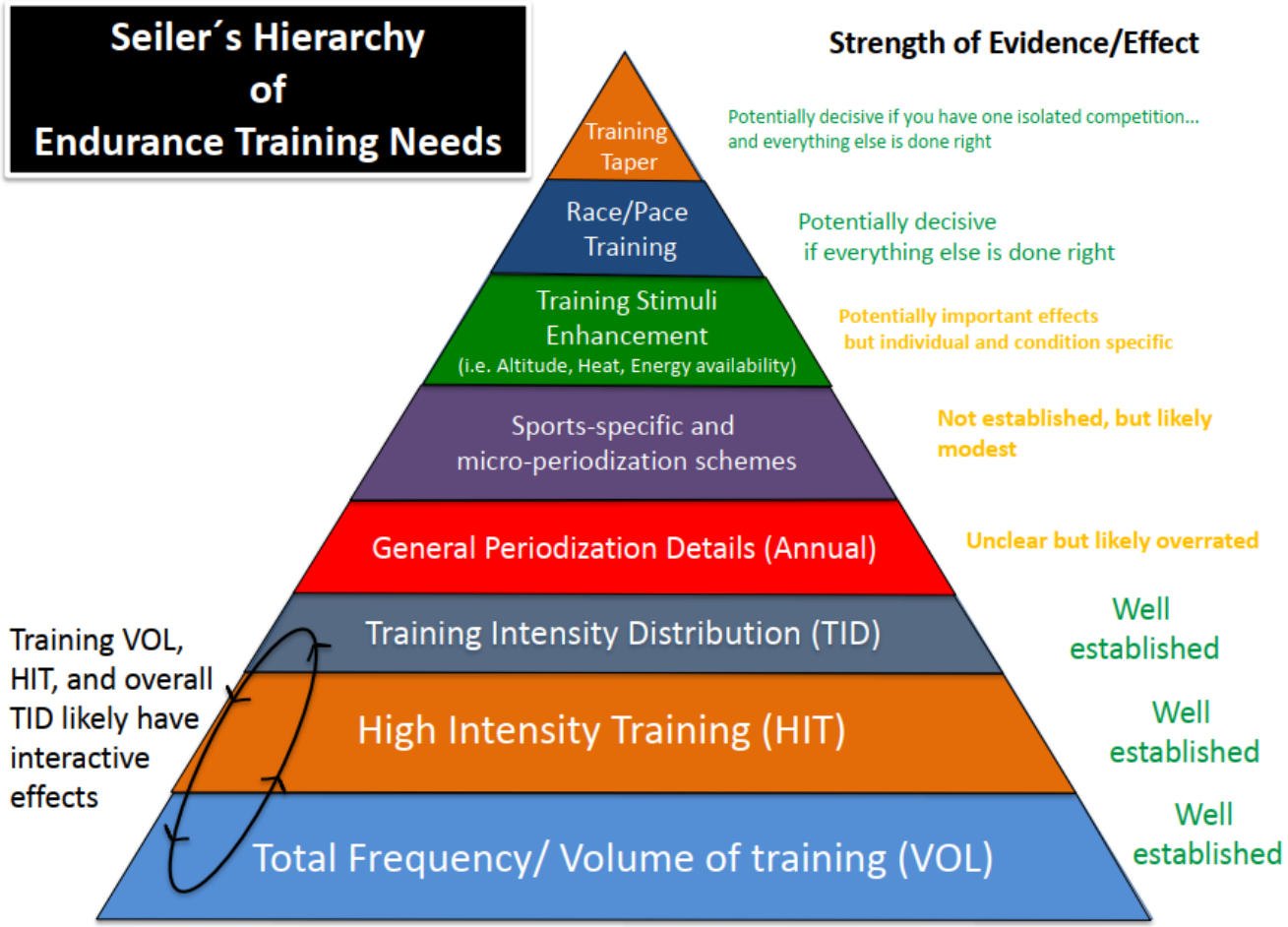
	Pre	8 wk post	18 wk post	Change 0-18 wk
BW (kg)	84	81	84	0 %
VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$)	81	90	88	11 %
VO_2max ($L \cdot min^{-1}$)	6.8	7.3	7.3	7 %
LT power (W)	375	420	440	14 %
LT power ($W \cdot kg^{-1}$)	4.5	5.2	5.2	15 %

Resultados

- Medalha de Bronze no Campeonato Nacional de TT.
- Em 2006 e 2007 representou a Noruega no Campeonato Mundial de TT.

Seiler & Tonnenssen (2009)

Seiler´s Hierarchy of Endurance Training Needs



RESUMO

- O tempo (anos) e o volume (horas) de treinamento parecem exercer papel fundamental nas adaptações fisiológicas e no desempenho físico-esportivo de atletas de endurance.

- O maior percentual do volume total do treinamento (~80%) é realizado em intensidade moderada (< LV1/LL1).

- Embora o treinamento de alta intensidade (ex. HIIT, SIT; >LV2/LL2) seja realizado em menor percentual, não significa que não seja importante. Esta estratégia de treinamento é fundamental para induzir adaptações fisiológicas e preparar o ciclista para momentos desafiadores da prova, tais como, a fuga de um pelotão ou o *sprint* final.

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Pinheiro, F.A. (2021)