Trainen met een vermogensmeter

Loek Vossen, Aart Goossens

SPORTWETENSCHAP

Vermogensmeters maken inspanningen in het wielrennen kwantificeerbaar. Ben je op de hoogte van de mogelijkheden, dan (onder)bouw je de effectiefste trainingen, toegespitst op het individu. Laat je data links liggen en vertrouw je op ervaring en gevoel, dan loop je in no-time mijlenver achter.

'De perfecte fietstraining' op basis van critical power en anaerobe capaciteit

Loek Vossen & Aart Goossens

In de afgelopen decennia is trainen op vermogen veranderd van een exotische tool voor professionele wielrenners in een onmisbaar handvat dat zelfs door de recreatieve fietser wordt gebruikt. Hoewel vermogensmeters al sinds 1989 commercieel verkrijgbaar zijn en ze inmiddels ook betaalbaar zijn voor recreanten, is er aan de analyse van de data tot voor kort niet veel veranderd. Eigenlijk heeft er sinds de introductie bekeken werden, kunnen modellen nu ook van voorspellende waarde zijn. In dit artikel lees je hoe je als coach of wielrenner met behulp van power duration modellen de perfecte training ontwerpt.

Power duration model

Voordat er een begin gemaakt kan worden met het maken van de perfecte training is er eerst een kleine introduc-

Sportgericht 2017-6

Recap arbeid/vermogen

grootheid	**symbool**	**eenheid**	**formule**
arbeid (work)	W	Joule	$W = F \cdot s$ $W = P \cdot t$
vermogen (power)	P	Watt (Joule/seconde)	$P = W / t$ $P = F \cdot v$
kracht (force)	*F*	*Newton*	

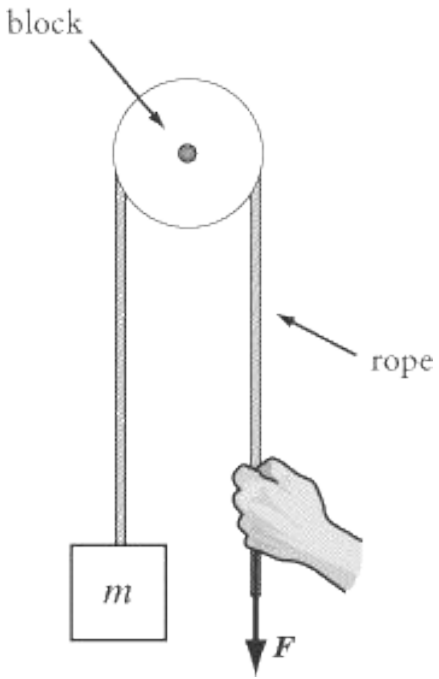
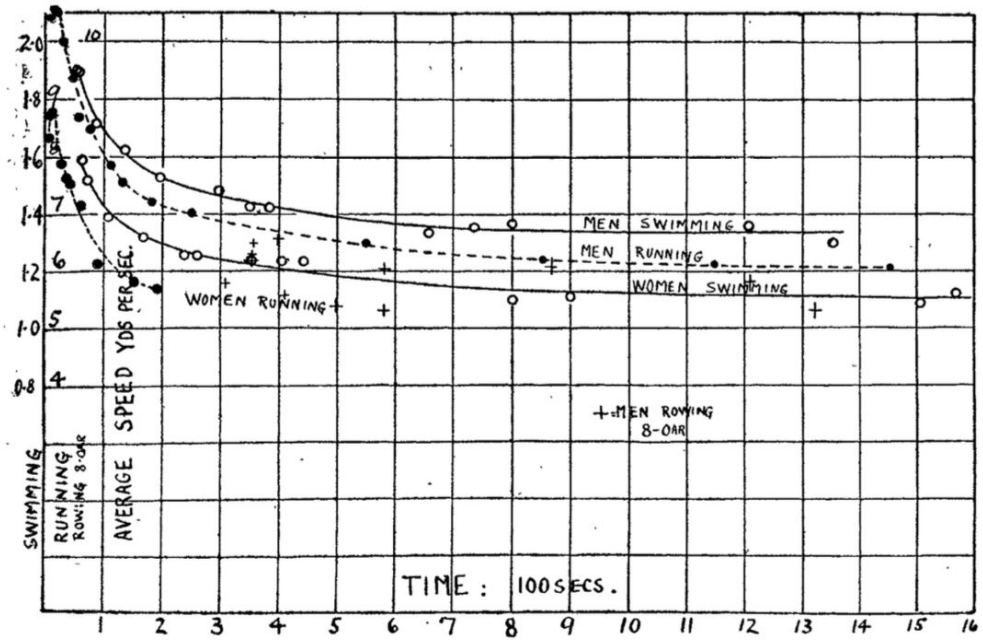
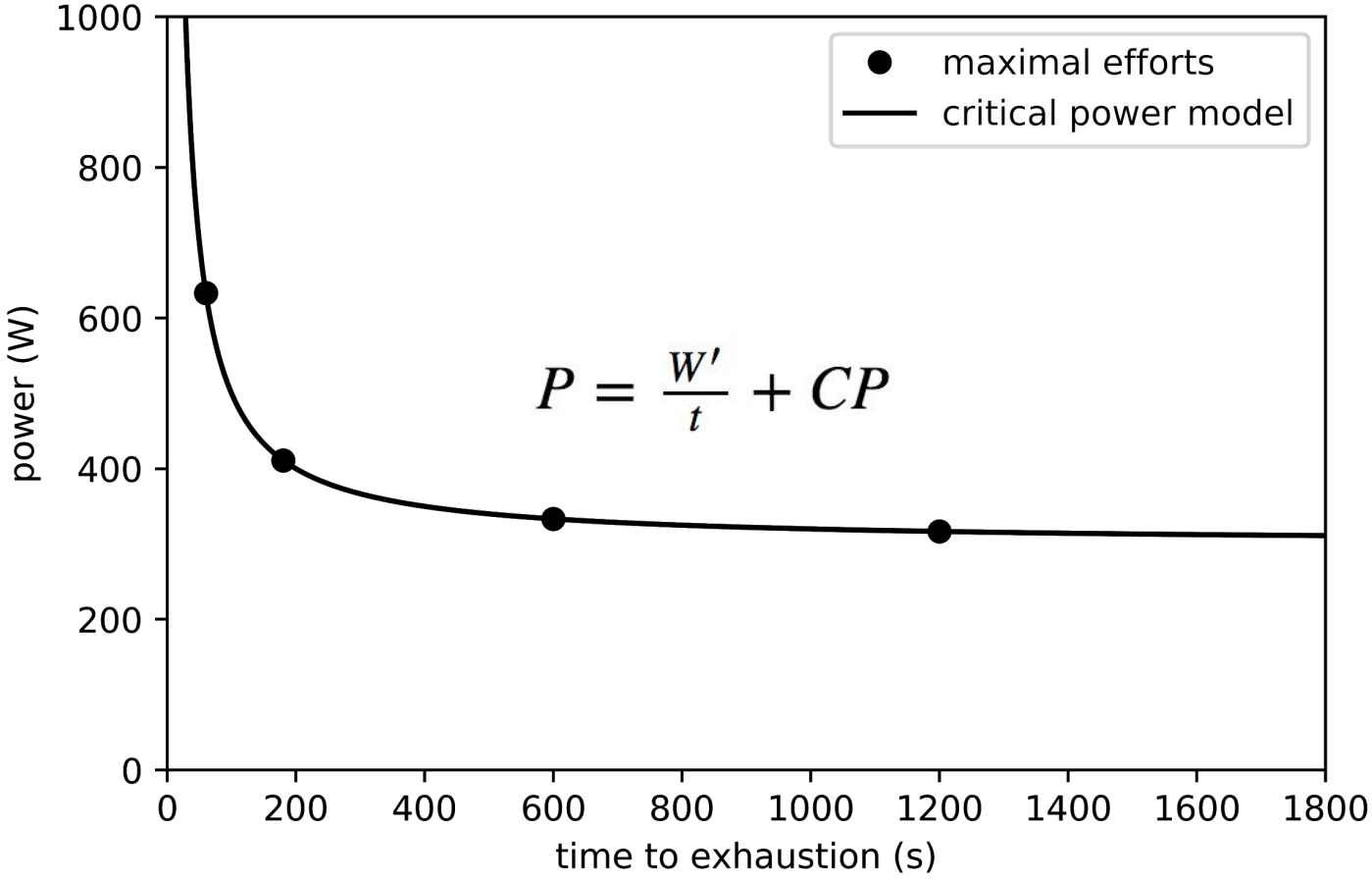


FIG. 1.

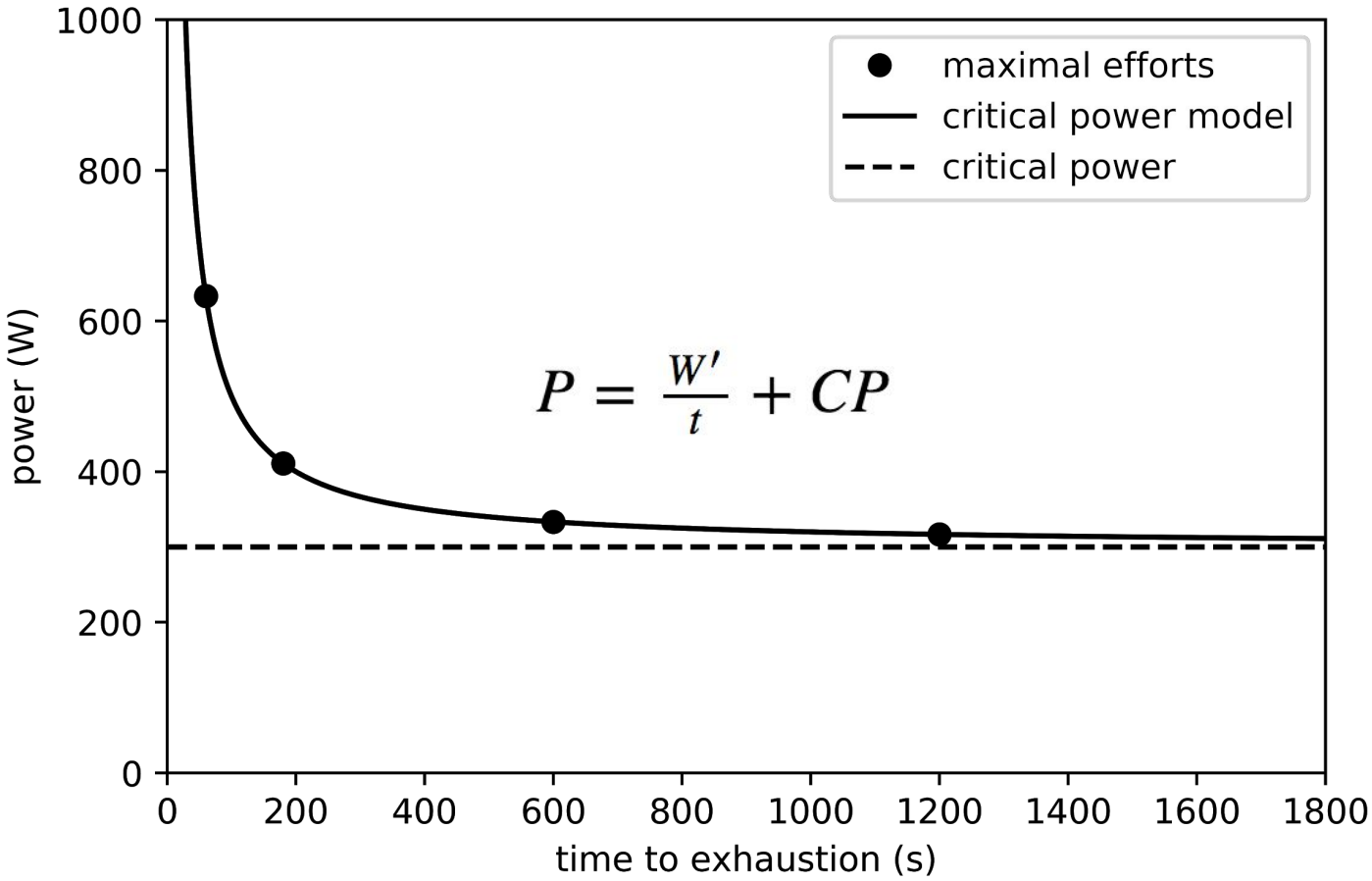


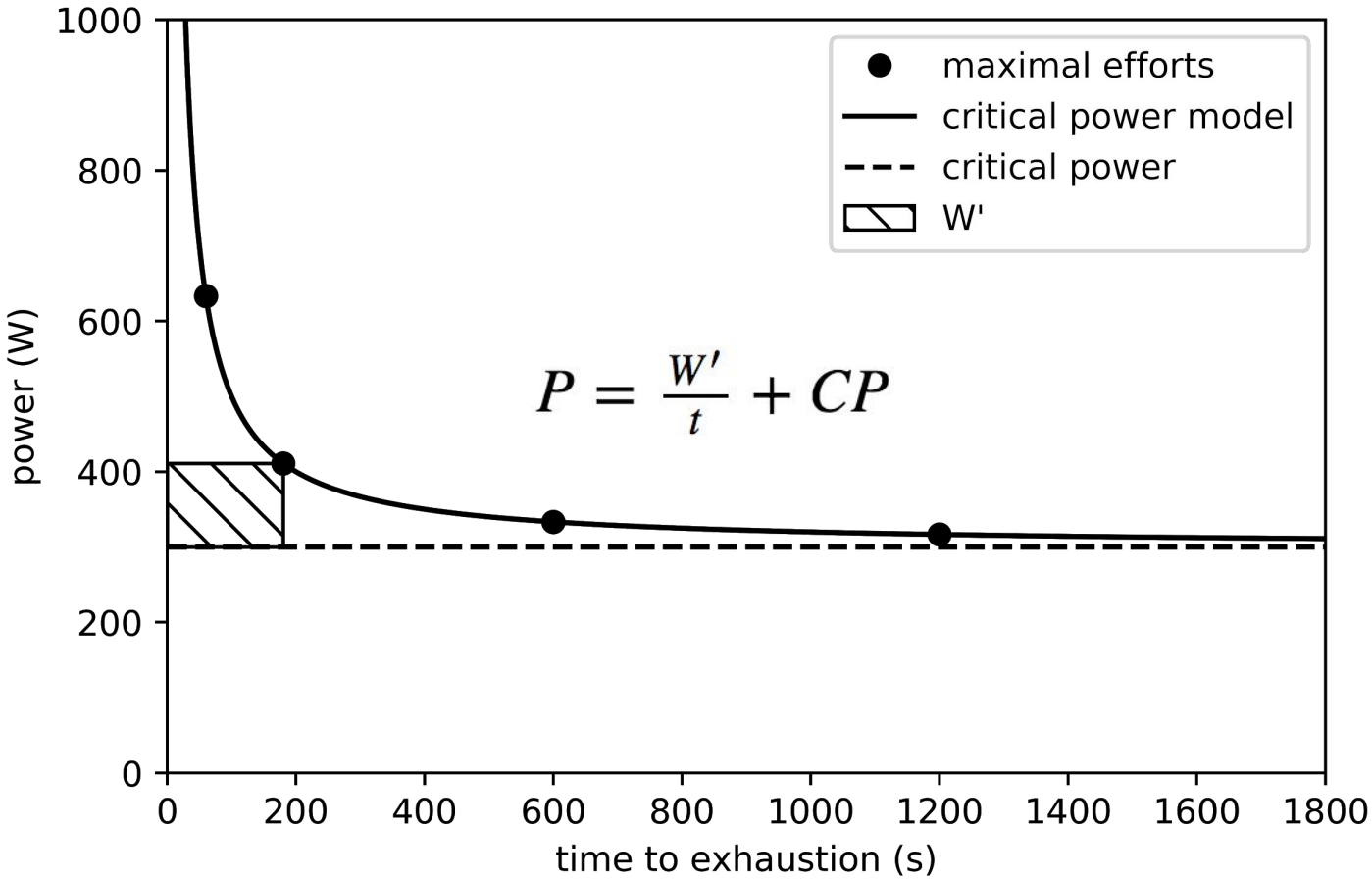
World's records for men and women swimming and running; average speed in yards per second against time in seconds. *Note.*—The scale for swimming is five times as great as for running. The observations for men rowing an eight-oar boat are on the same scale as running and are referred to later in the text.

Hill, A. V. (1925). The physiological basis of athletic records. *The Scientific Monthly*, *21*(4), 409-428.



Hill, D. W. (1993). The critical power concept. *Sports medicine*, *16*(4), 237-254.


maximal efforts
critical power model
critical power
$P = \frac{W'}{t} + CP$
power (W)
time to exhaustion (s)
0
200
400
600
800
1000
1200
1400
1600
1800


maximal efforts
critical power model
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W'
$P = \frac{W'}{t} + CP$
power (W)
time to exhaustion (s)
0
200
400
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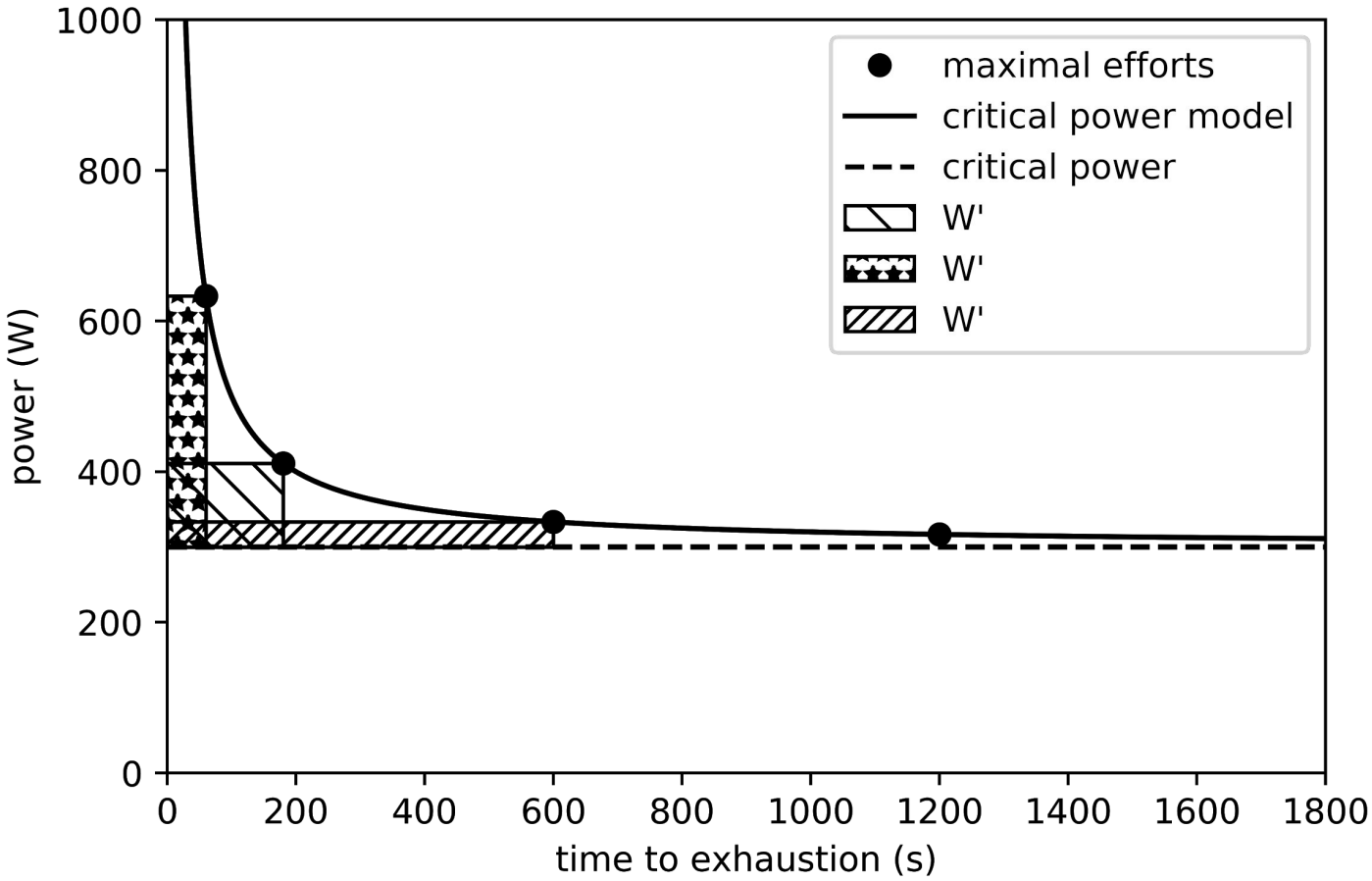
maximal efforts
critical power model
critical power
W'
W'
W'
power (W)
time to exhaustion (s)
0
200
400
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800
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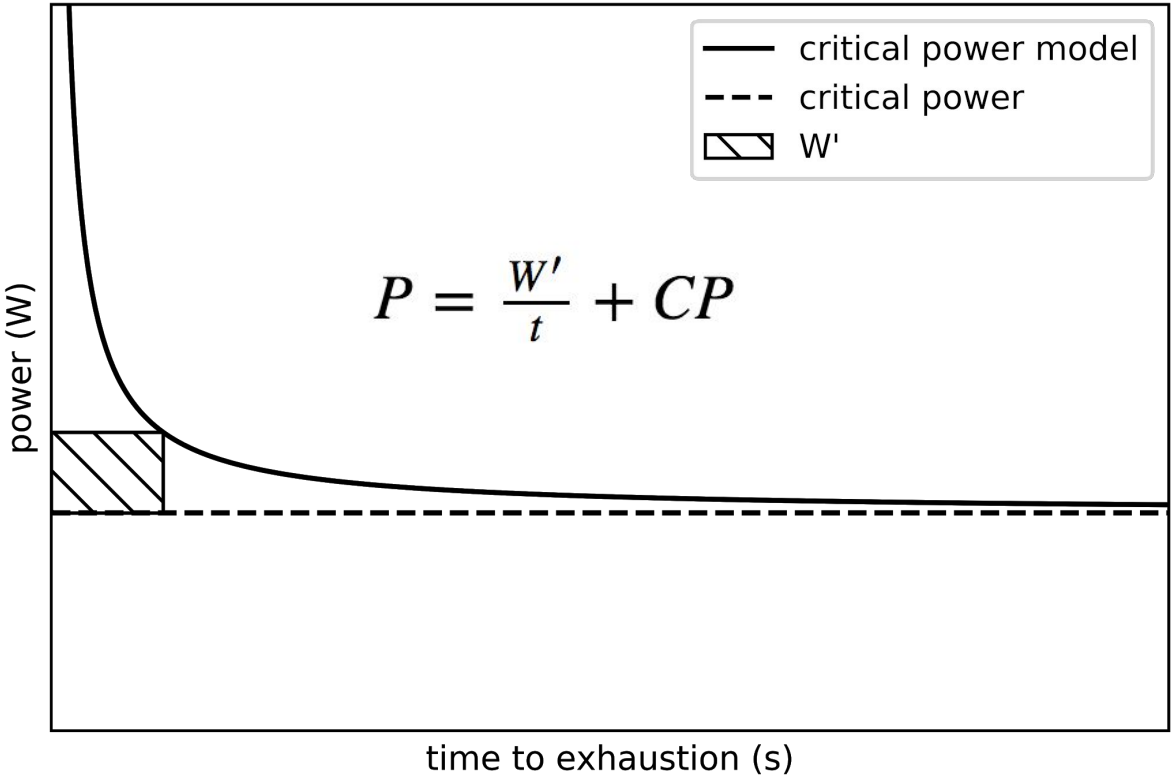
1200
1400
1600
1800

2-parameter critical power model



2-parameter critical power model

Voordelen

- Sterk voorspellend vermogen (binnen bepaalde grenzen)
- Parameters relatief makkelijk te bepalen

Nadelen

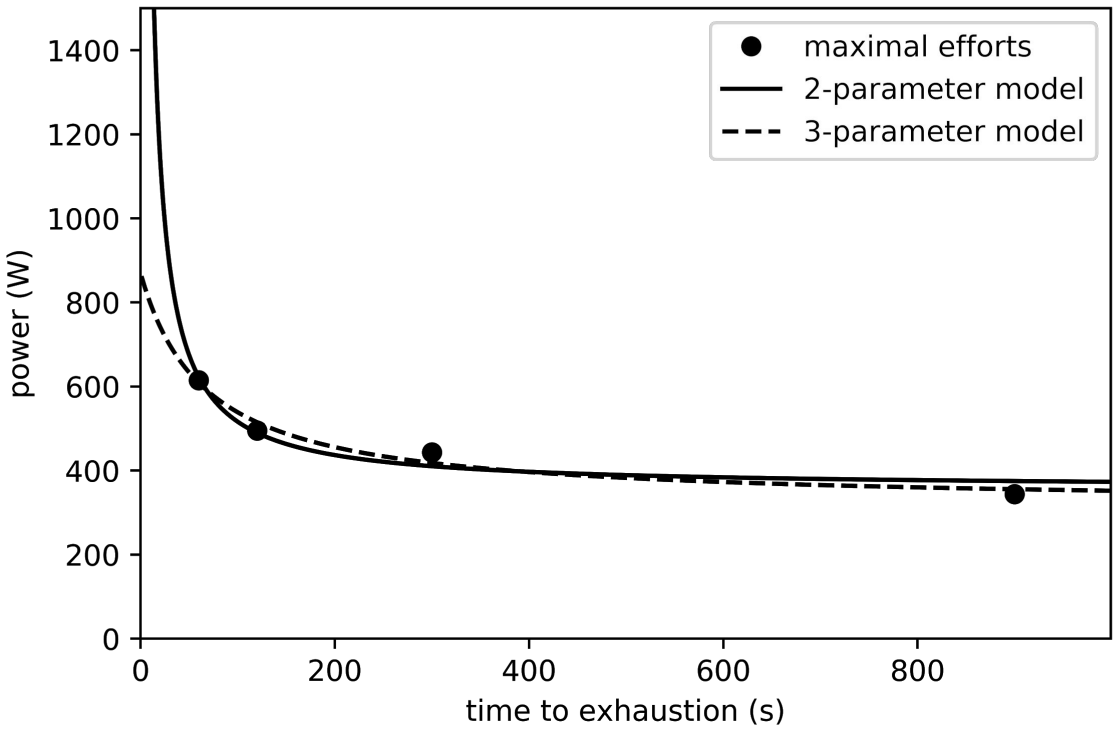
- Verticale asymptoot
- Horizontale asymptoot
- Enkel valide voor P >= CP

Alternatieve modellen

1. (linear total work model)
2. (2-parameter linear)
3. **2-parameter non-linear**
4. 3-parameter non-linear model
5. (exponential model)
6. extended critical power model

Bergstrom, H. C. et al (2014). Differences among estimates of critical power and anaerobic work capacity derived from five mathematical models and the three-minute all-out test. The Journal of Strength & Conditioning Research, 28(3), 592-600.

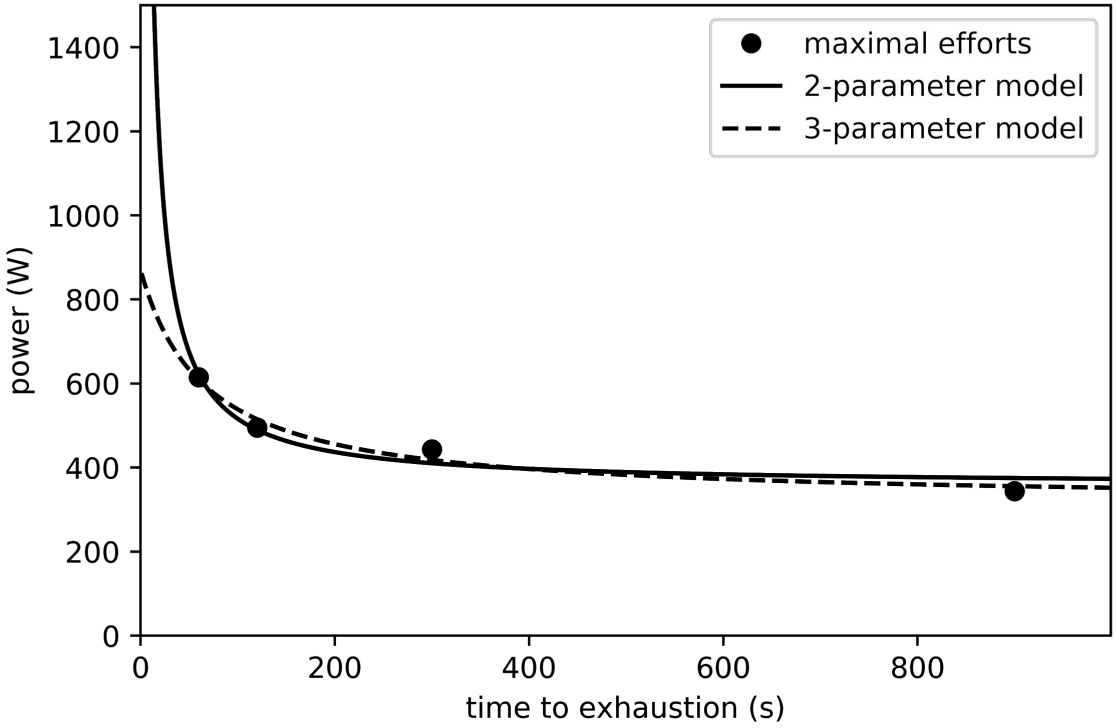
3-parameter non-linear critical power model



$$P = \frac{W'}{t} + CP$$

$$P = \frac{W'}{t + \frac{W'}{Pmax - CP}} + CP$$

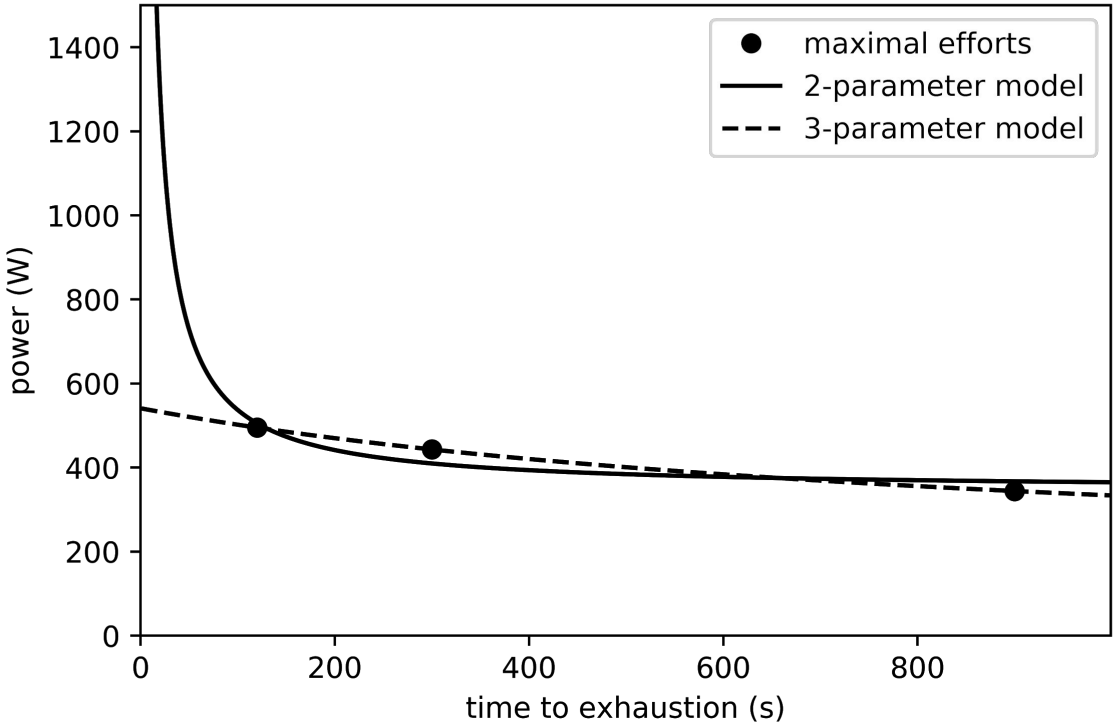
3-parameter non-linear model



duur	vermogen
60 s	615 W
120 s	495 W
300 s	443 W
900 s	344 W

	2 param	3 param
CP	357 W	317 W
W’	15893 J	36908 J
Pmax	-	871 W

3-parameter non-linear model



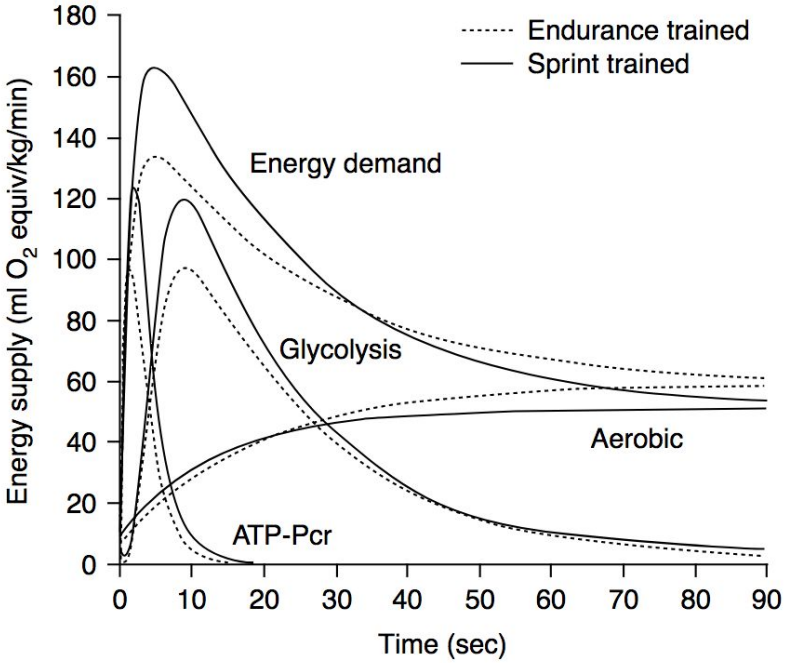
duur	vermogen
~~60 s~~	~~615 W~~
120 s	495 W
300 s	443 W
900 s	344 W

	2 param	3 param
CP	346 W	143 W
W'	19130 J	365781 J
Pmax	-	541 W

extended critical power model

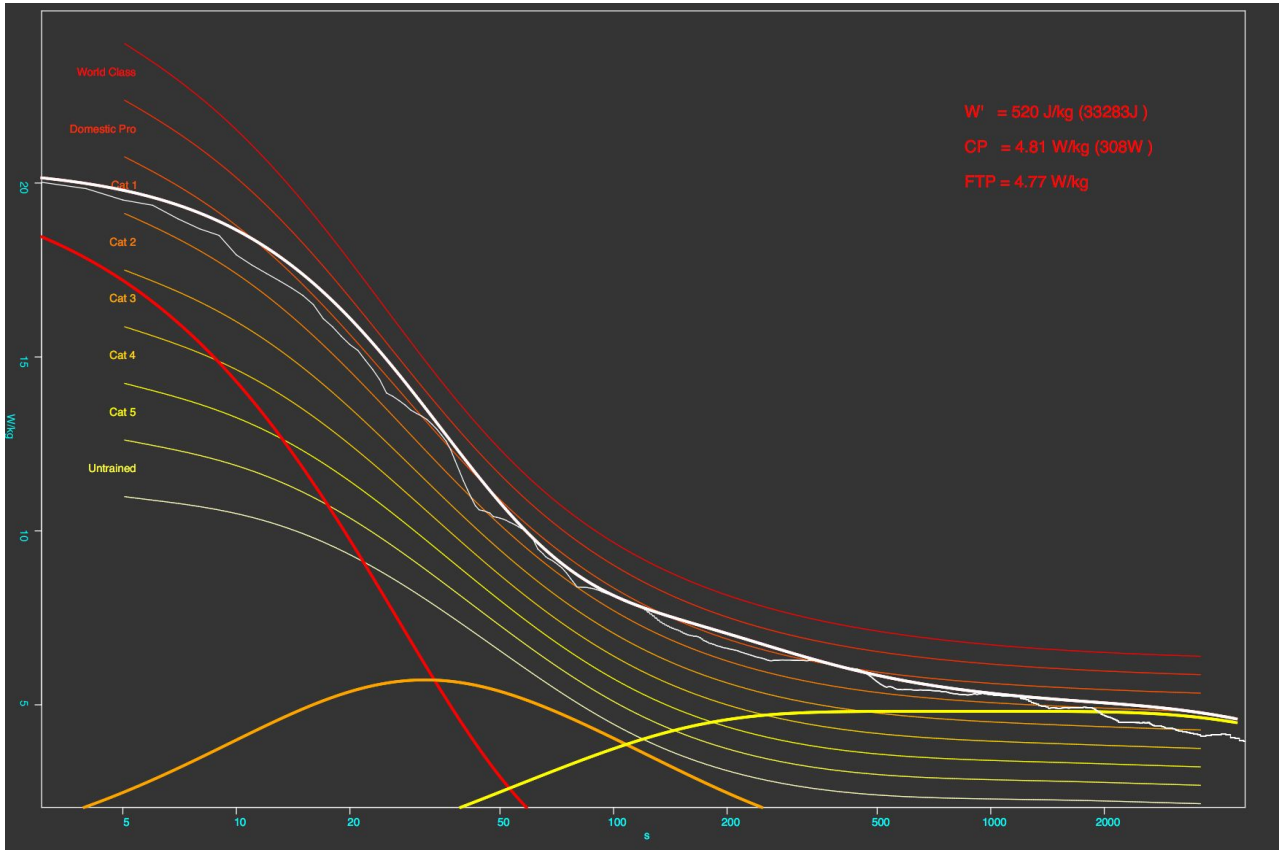
Pathways:

- ATP-Pcr
- Anaerobic
- Aerobic

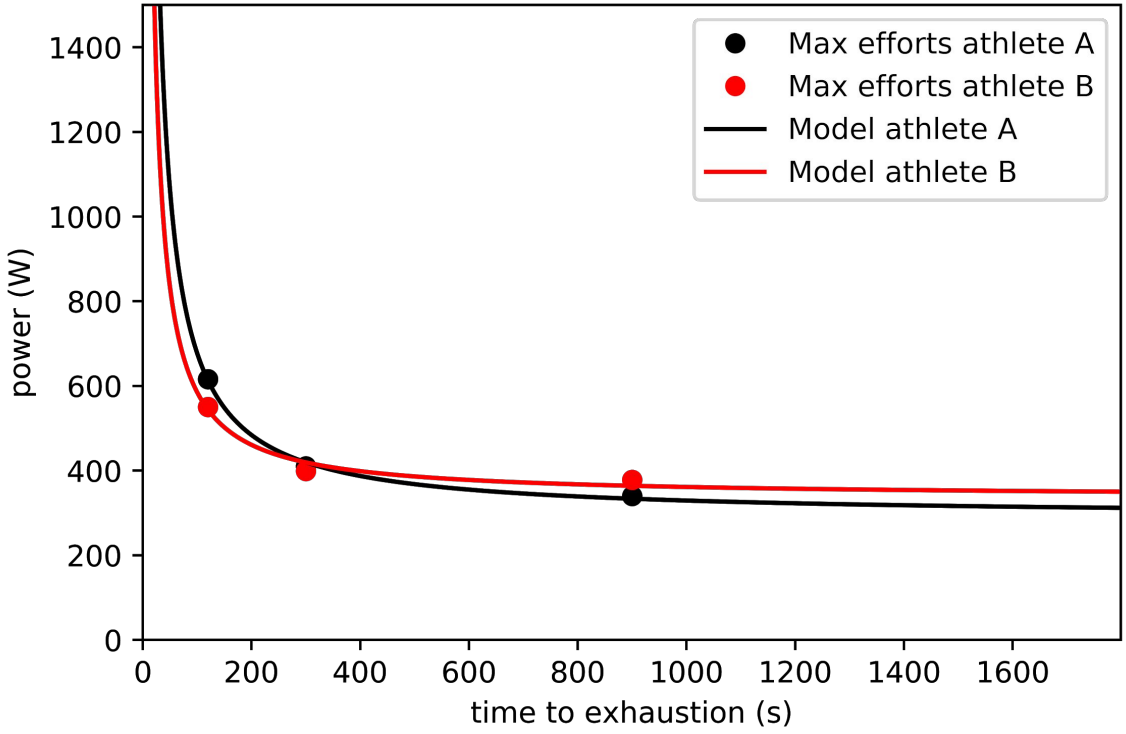


Gastin, P. B. (2001). Energy system interaction and relative contribution during maximal exercise. Sports medicine, 31(10), 725-741.

extended critical power model

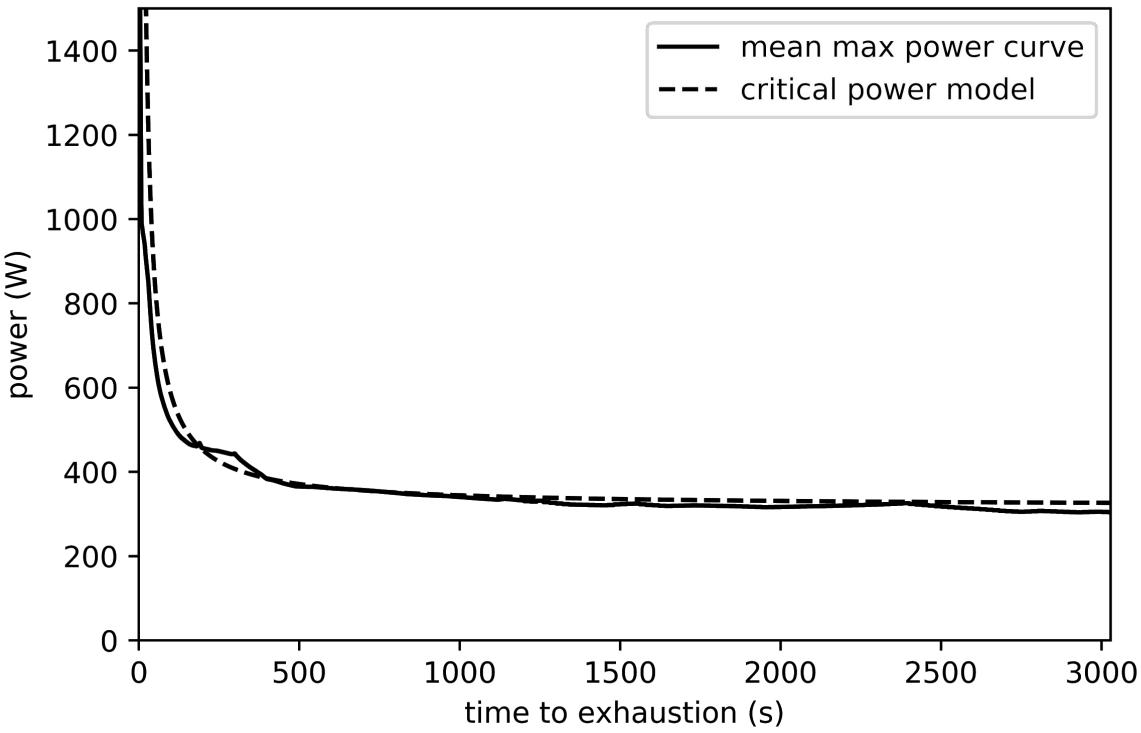


Power profile test

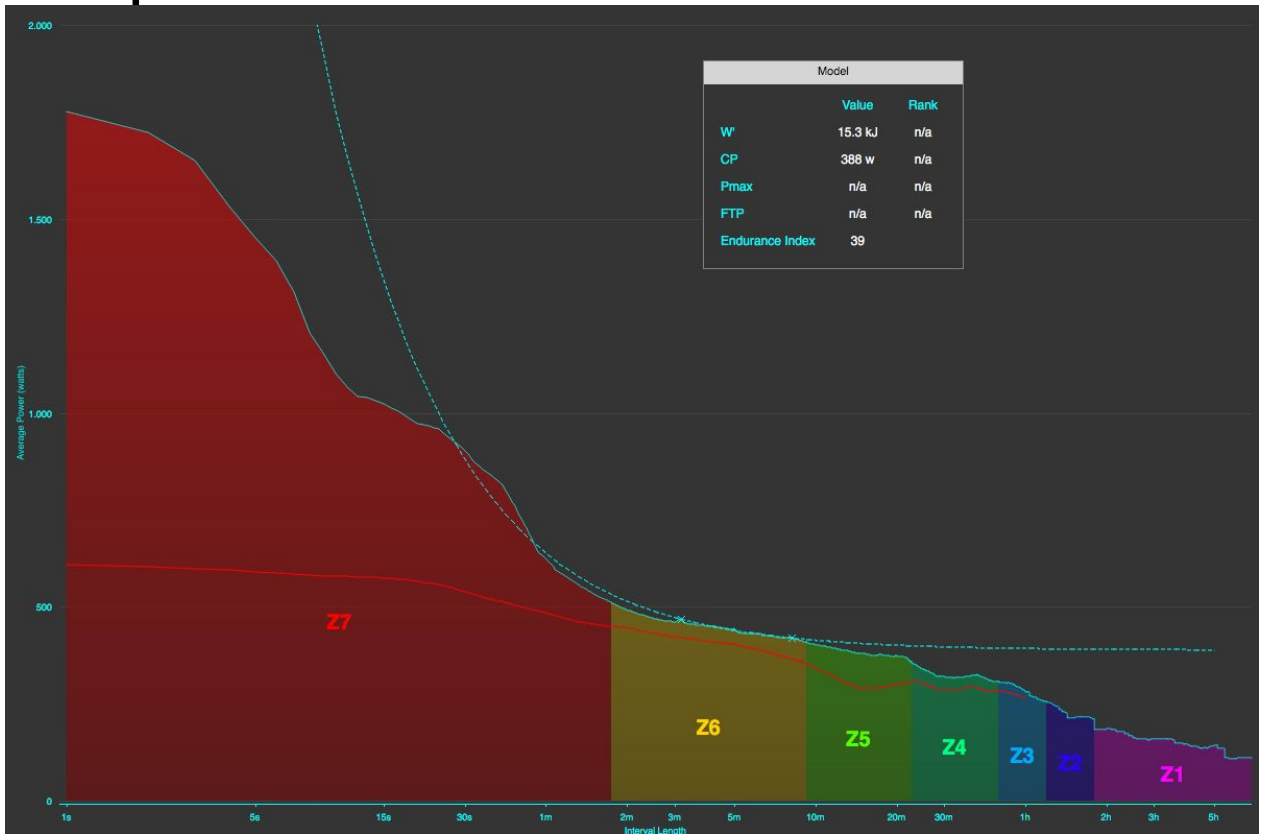


duur	sporter A	sporter B
2 min	616 W	550 W
5 min	410 W	399 W
15 min	340 W	378 W
CP	290 W	336 W
W’	38720 J	24895 J

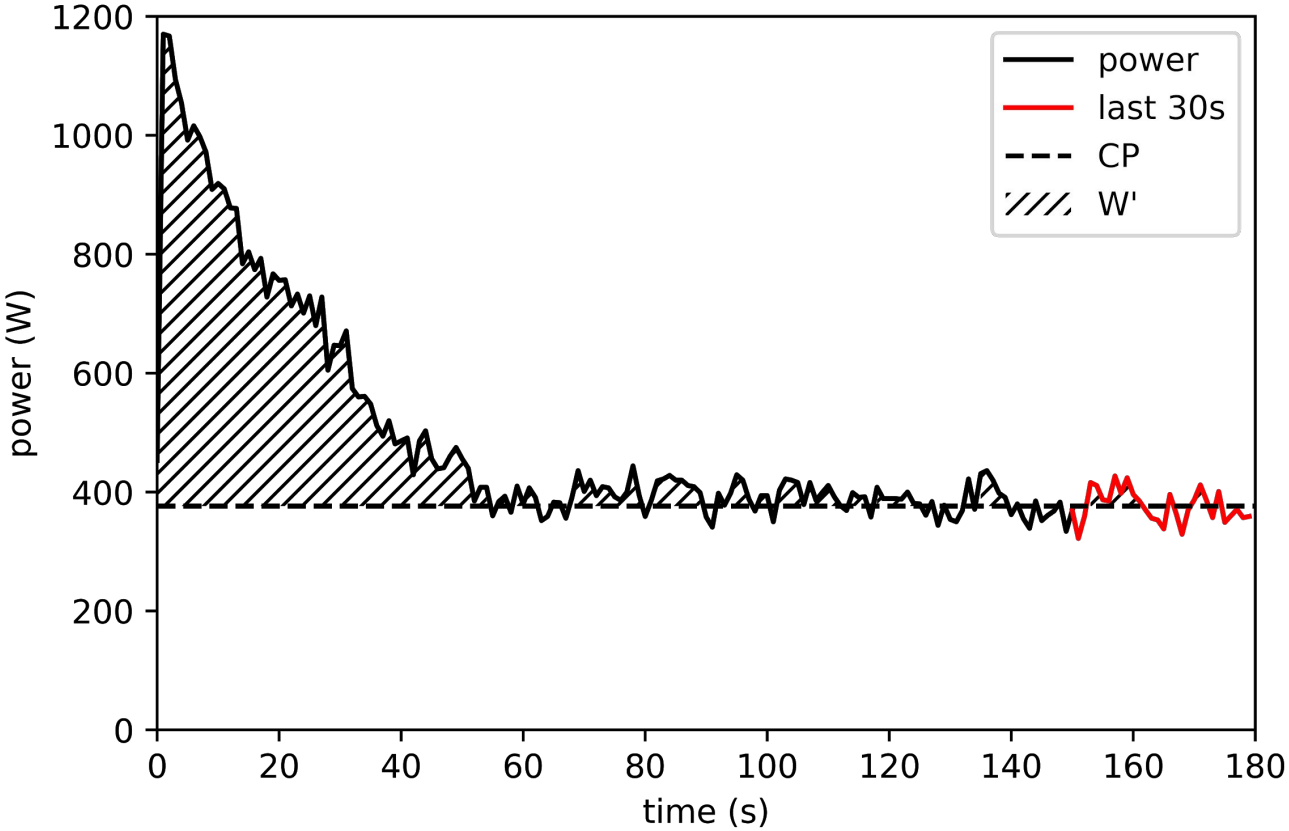
Mean max power curve



Mean max power curve



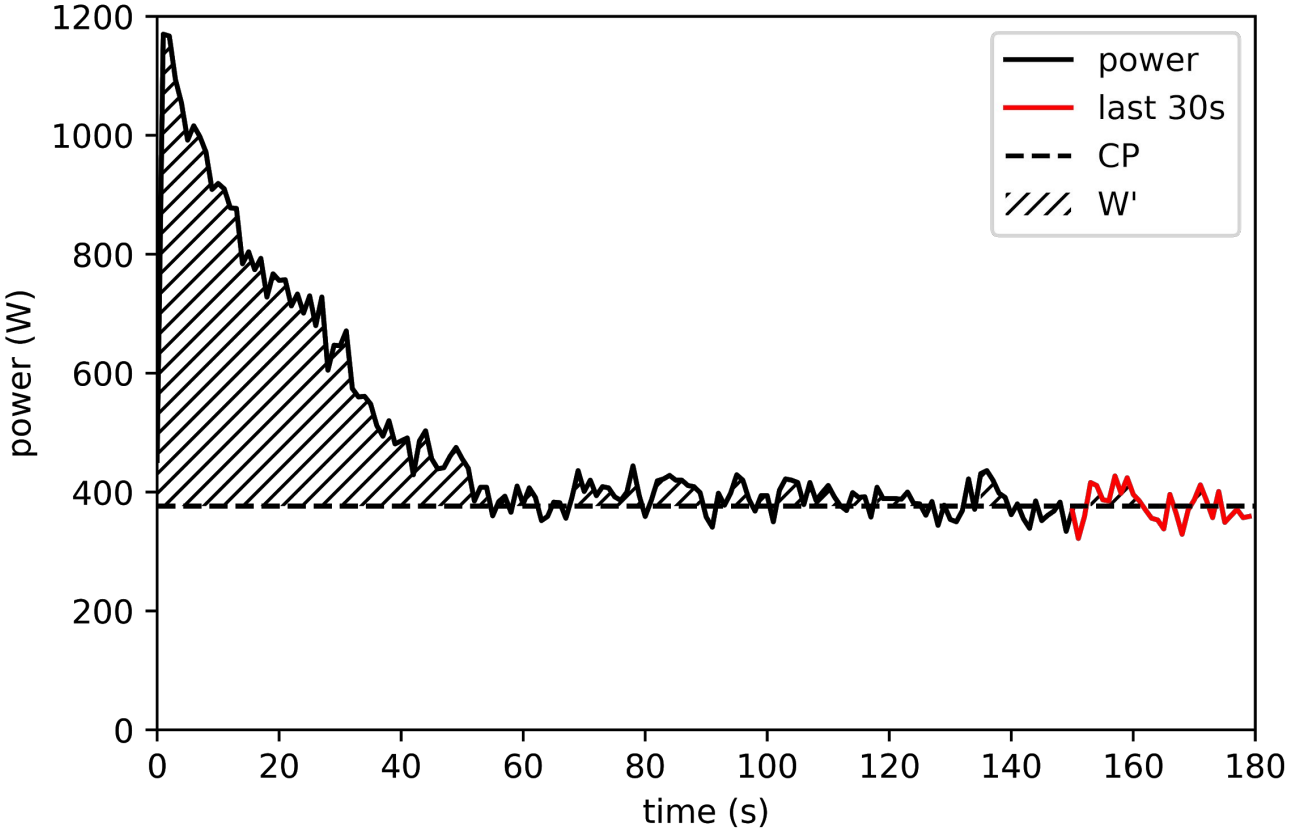
3 minute all out test



CP	375 W
W’	18172 J

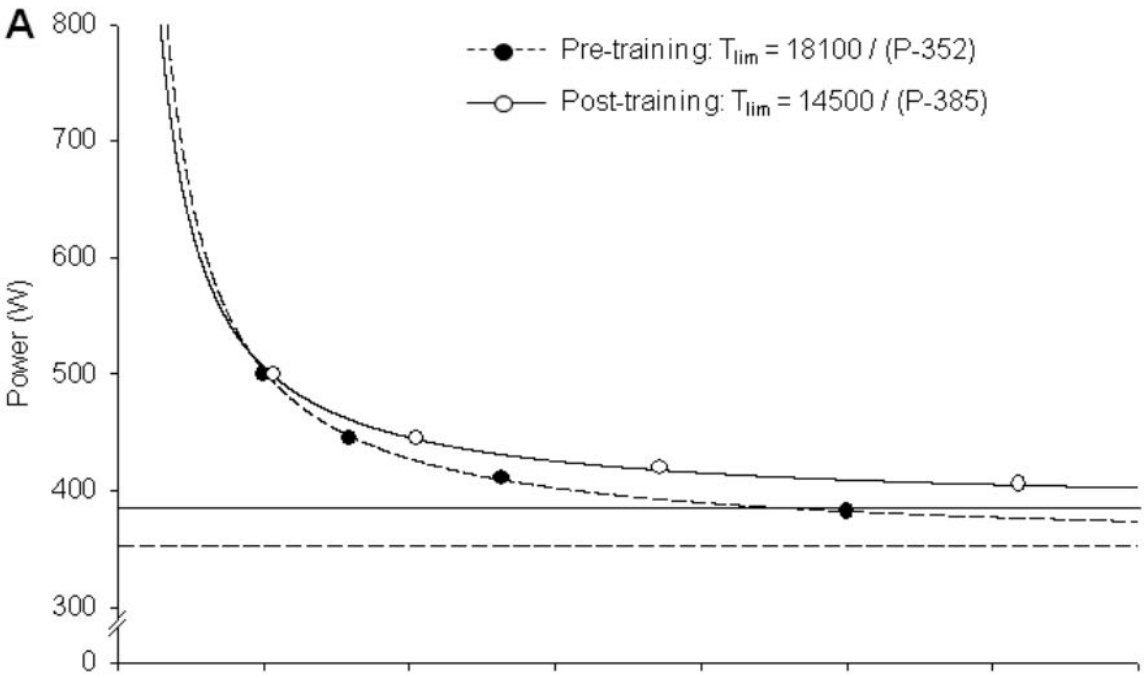
https://www.youtube.com/watch?v=Si6cExiFajI

3 minute all out test

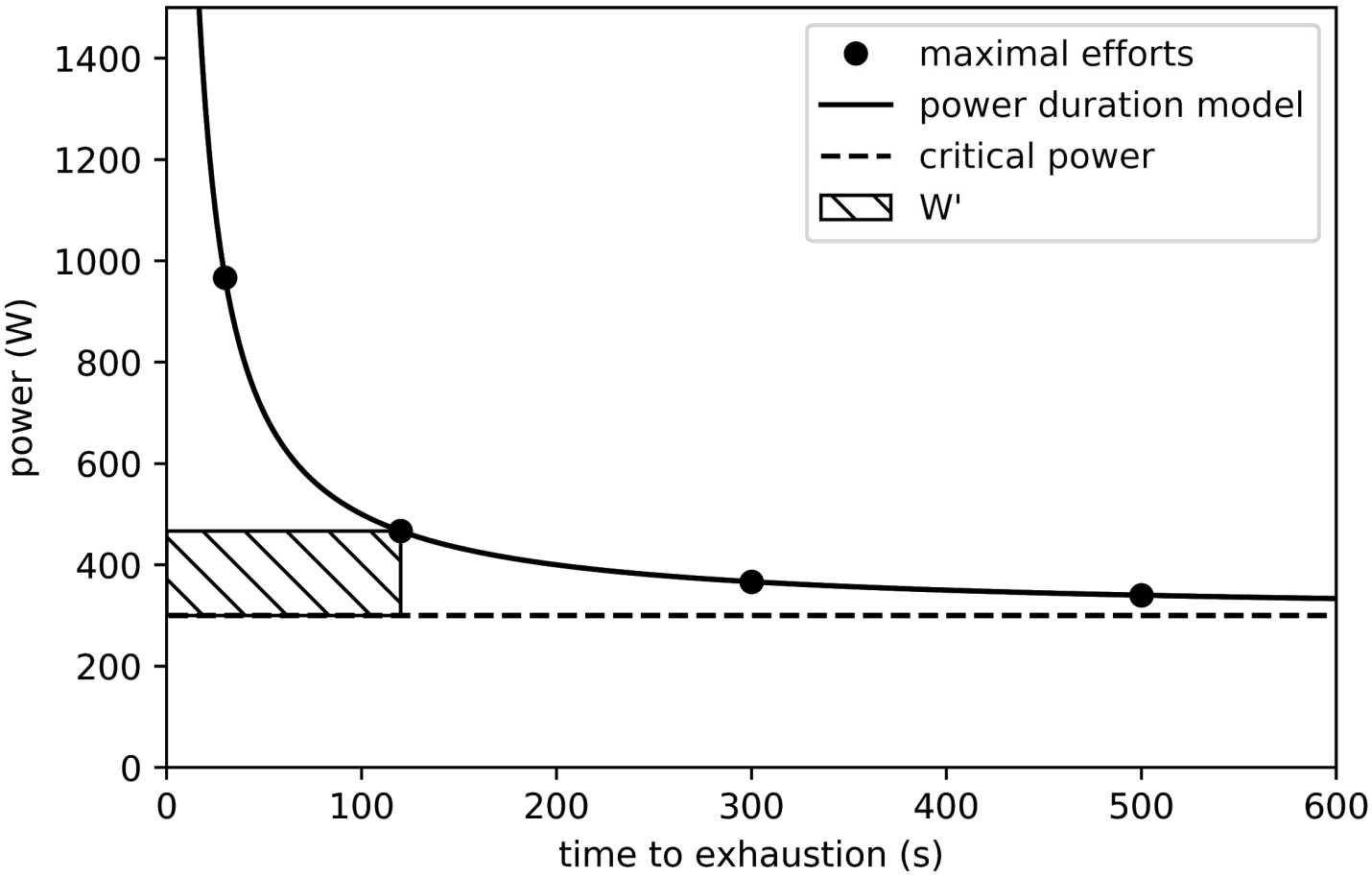


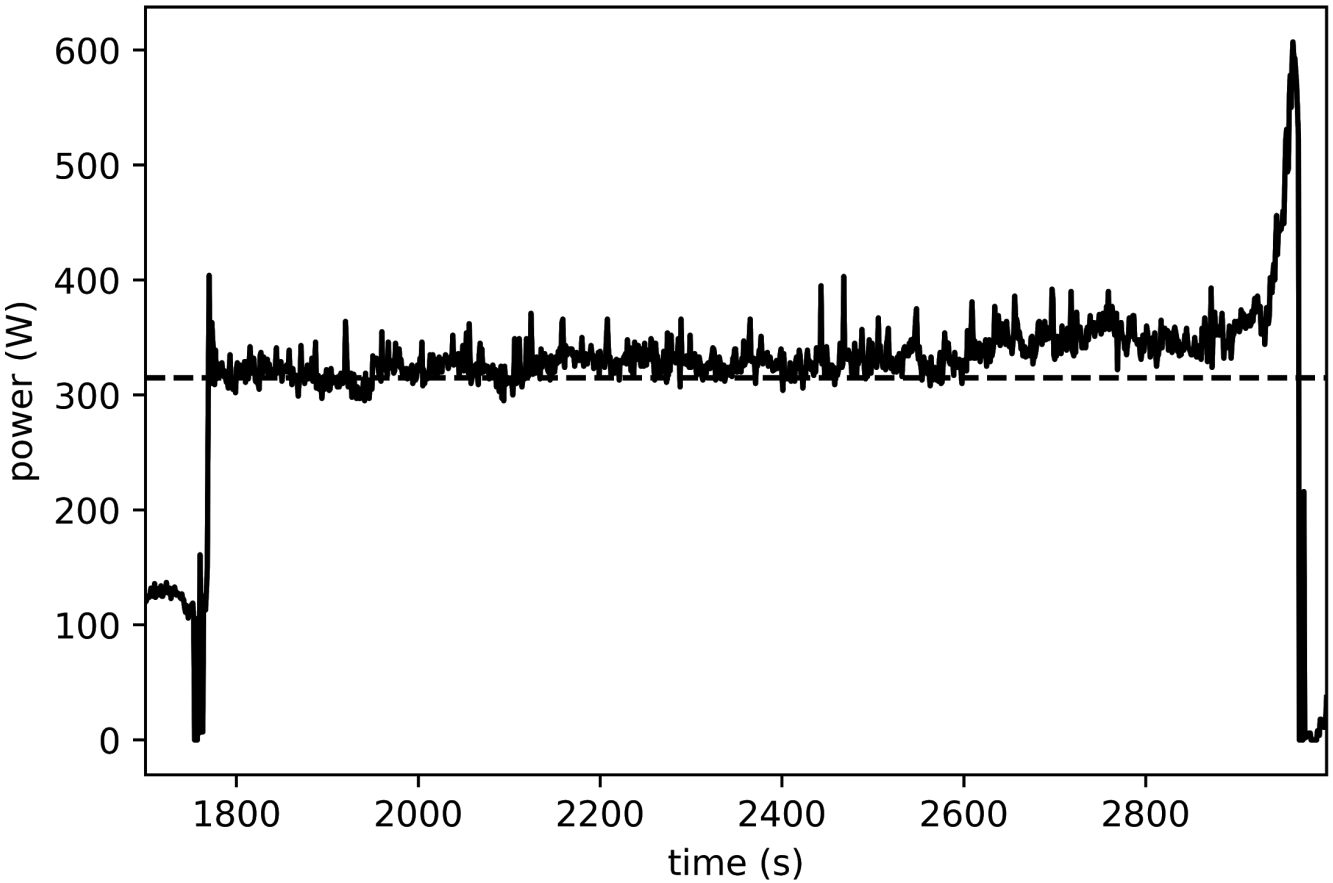
CP	375 W
W’	18172 J

Effect van training op model parameters

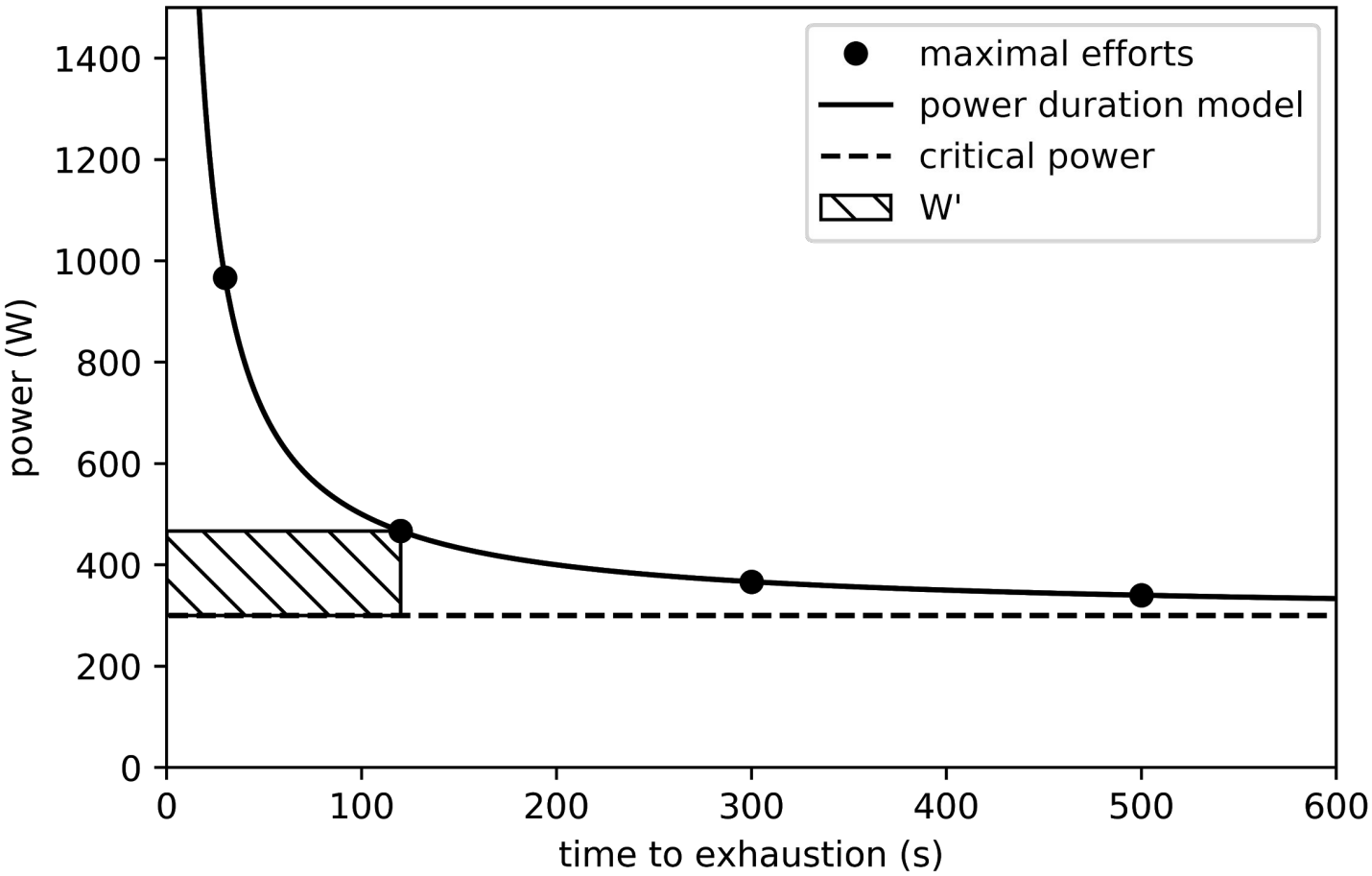


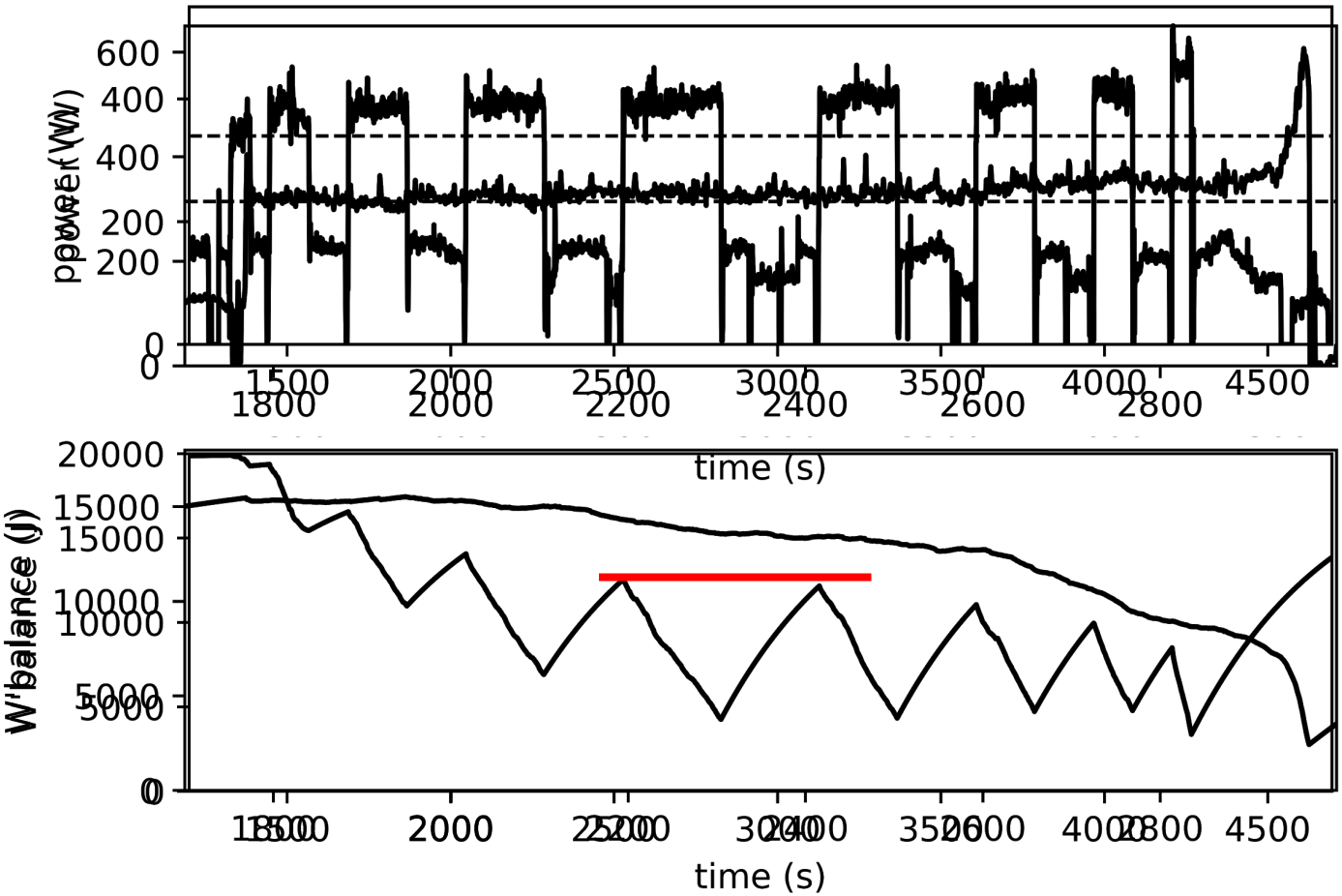
Vanhatalo, A., Jones, A. M., & Burnley, M. (2011). Application of critical power in sport. International journal of sports physiology and performance, 6(1), 128-136.


maximal efforts
power duration model
critical power
W'
power (W)
time to exhaustion (s)
0
200
400
600
800
1000
1200
1400
0
100
200
300
400
500
600



CP	315 W
W’	18000 J
P(20min)	337 W


maximal efforts
power duration model
critical power
W'
power (W)
time to exhaustion (s)
0
200
400
600
800
1000
1200
1400
0
100
200
300
400
500
600

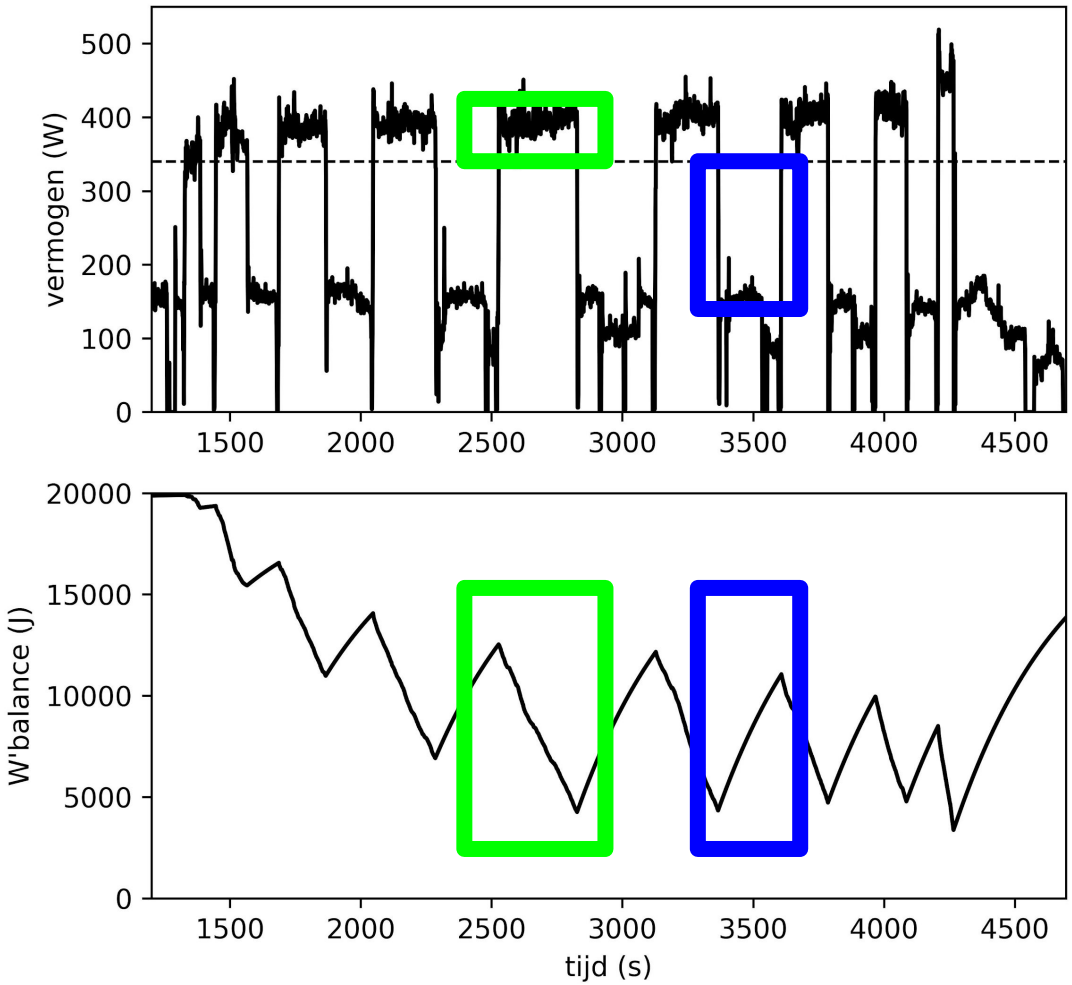

power (W)
600
400
400
200
200
0
0
1500
2000
2500
3000
3500
4000
4500
1800
2000
2200
2400
2600
2800
time (s)
W'balance (J)
20000
15000
15000
10000
10000
5000
5000
0
0
1500
2000
2500
3000
3500
4000
4500
time (s)

Dr. Skiba

$$W'_{bal}(t) = W' - \sum_{u=0}^{t} W'_{exp}(u) \cdot e^{-\frac{t-u}{\tau_{W'}}}$$

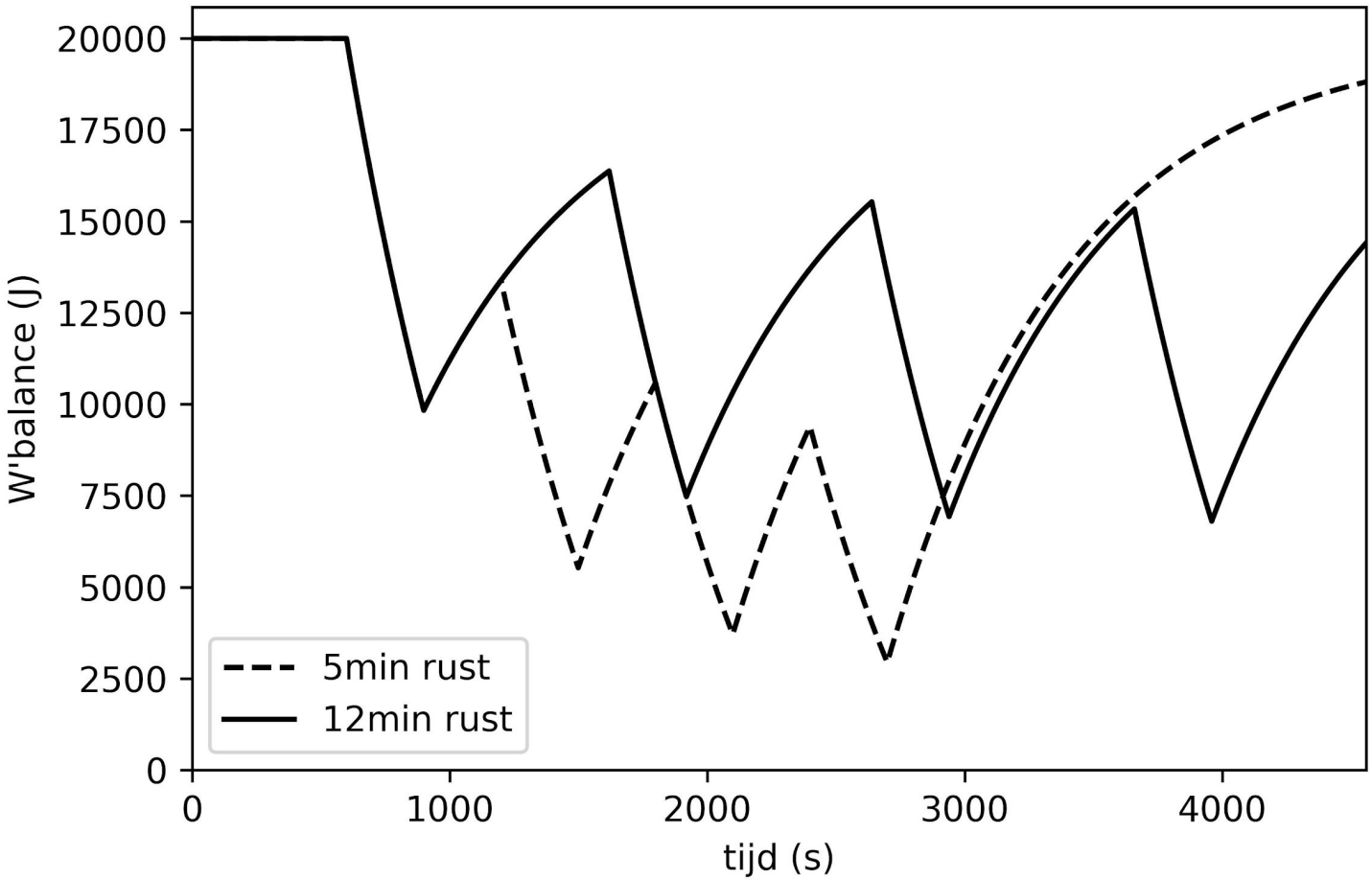
$$W'_{exp}(t) = \begin{cases} 0 & \text{where } P(t) < CP \\ P(t) - CP & \text{else} \end{cases}$$

$$\tau_{W'} = 546 \cdot e^{-0.01 \cdot D_{CP}} + 316$$


vermogen (W)
500
400
300
200
100
0
1500
2000
2500
3000
3500
4000
4500
W'balance (J)
20000
15000
10000
5000
0
1500
2000
2500
3000
3500
4000
4500
tijd (s)

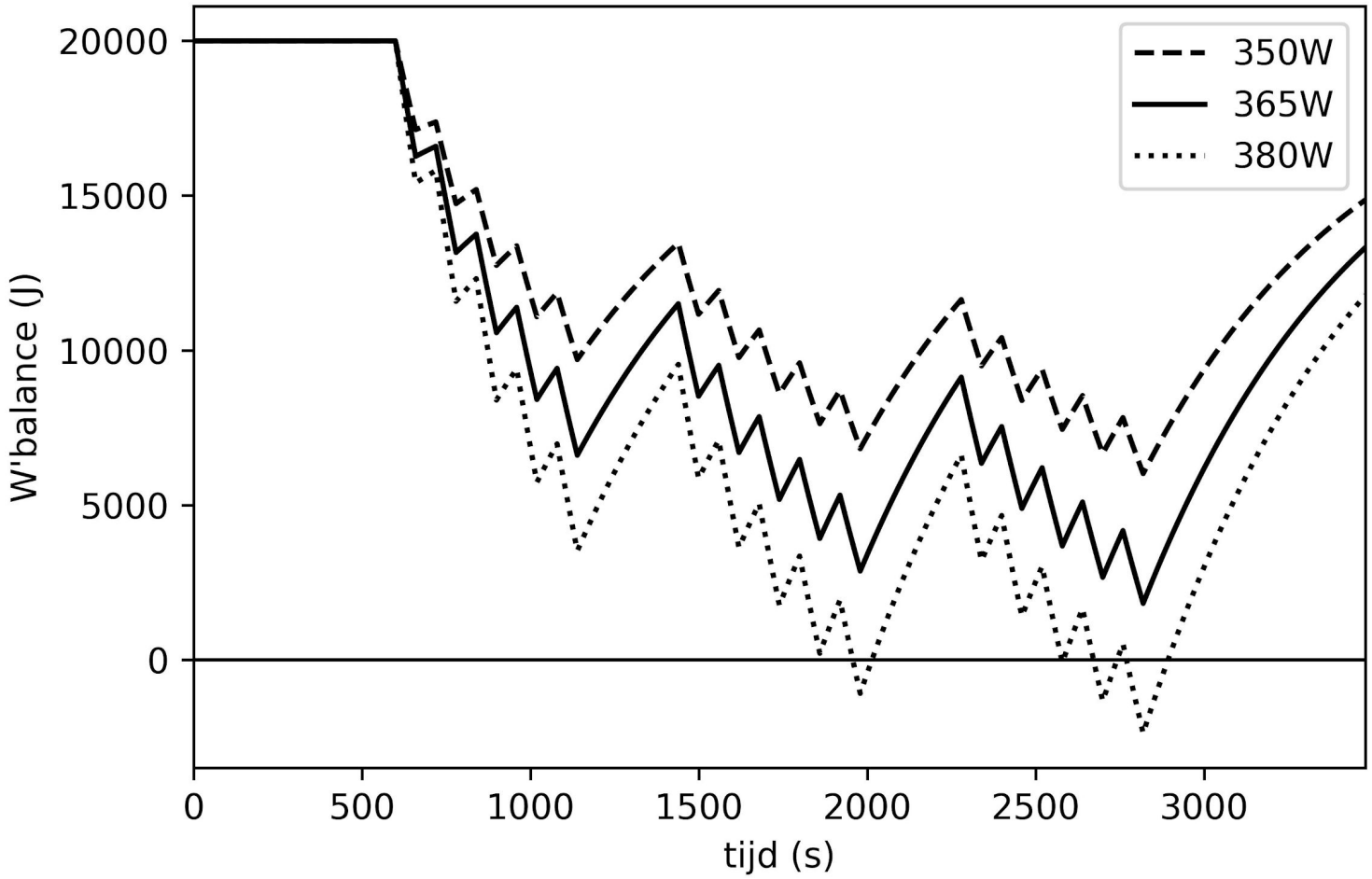
“Ik wil 4 keer 5 minuten op mijn VO2-max vermogen trainen. Tussen elk interval wil ik minstens weer voor 75% hersteld zijn. Hoeveel rust moet ik tussendoor nemen?”

#rust


20000
17500
15000
12500
10000
7500
5000
2500
0
W'balance (J)
0
1000
2000
3000
4000
tijd (s)
5min rust
12min rust

“Ik wil in 60 minuten een intensieve training doen met 3 sets van 5 keer ‘1 minuut op, 1 minuut af’. Hoe intensief kan ik het maken?”

#intensiteit

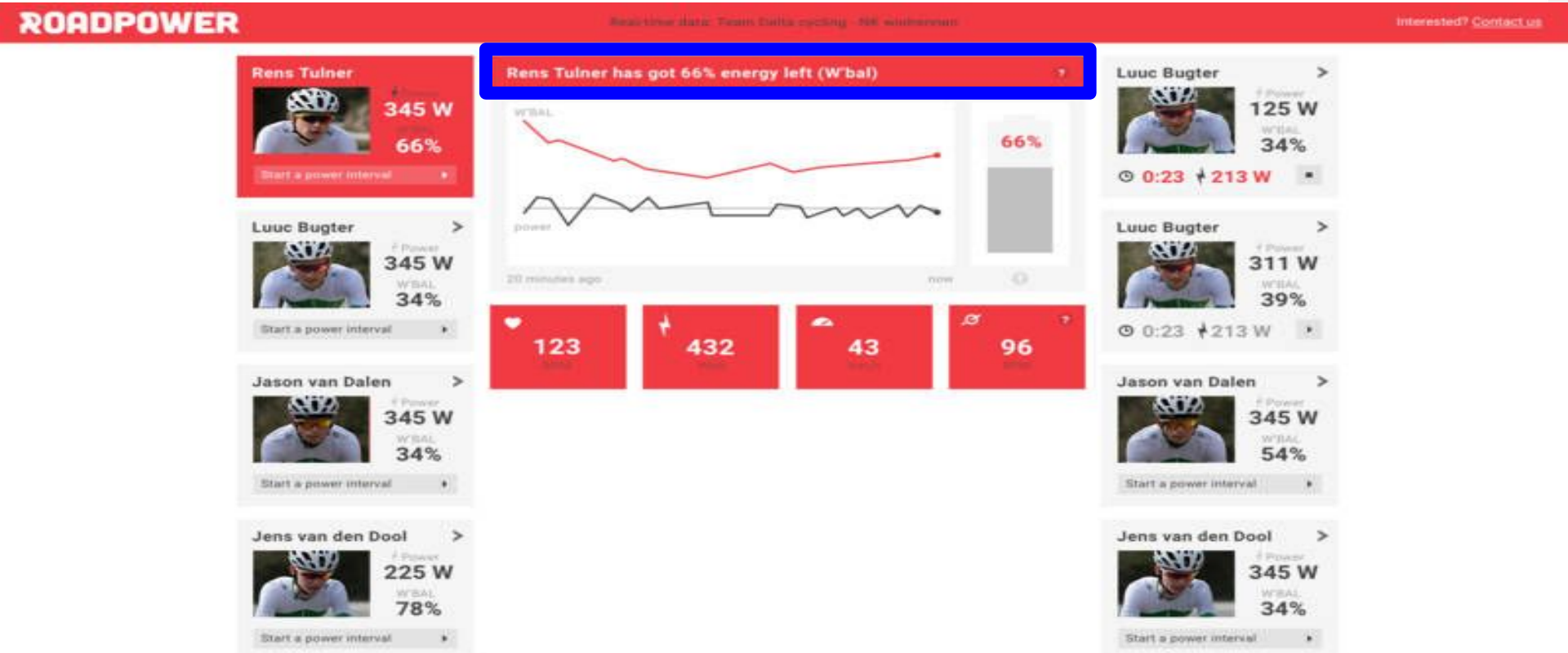

350W
365W
380W
W'balance (J)
20000
15000
10000
5000
0
0
500
1000
1500
2000
2500
3000
tijd (s)

“Ik roei mijn wedstrijd op ?? % CP. Hoe train ik deze intensiteit zo lang mogelijk in één training?”

#haalbaarheid

Innovatie bij NK: op de bank zien of renner nog fit is

25-06-2017, 10:53 AANGEPAST 25-06-2017, 11:19 WIELRENNEN



Vragen!

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loek@wattworks.nl

Slides + code

https://github.com/AartGoossens/publications/tree/master/gastcollege