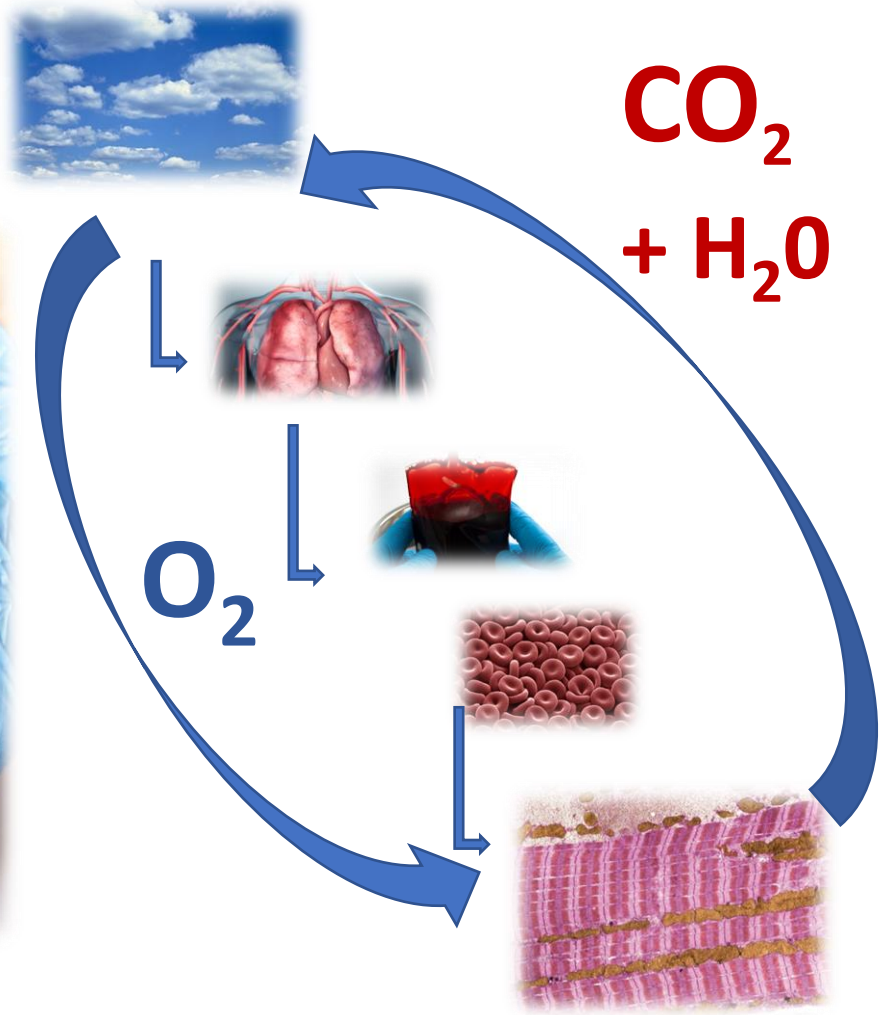
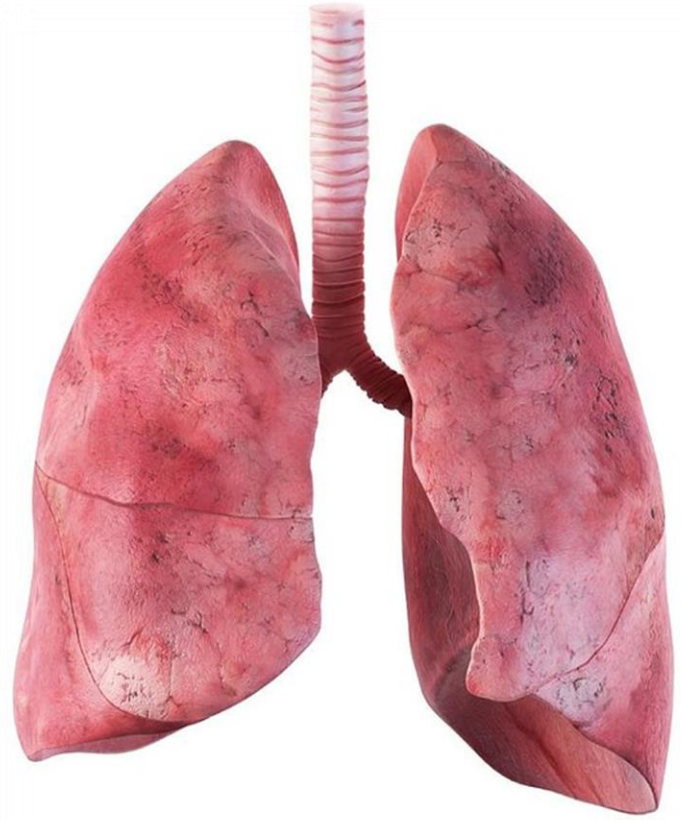
Ventilation measurement during training: Can breathing + heart rate tell us more?

Stephen Seiler PhD
University of Agder
Kristiansand
Norway

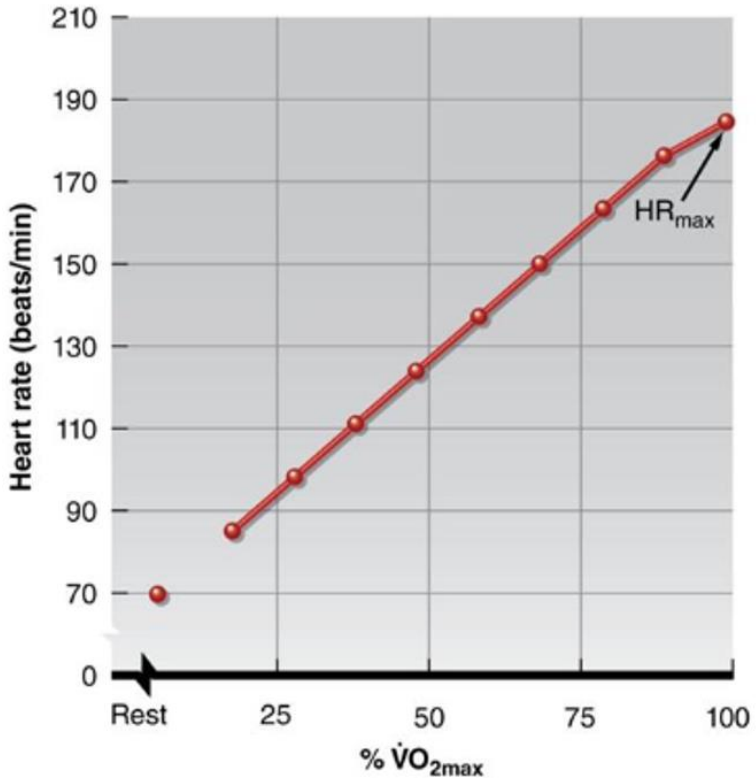
Oxygen Delivery + Carbon Dioxide Removal = Vital Functions





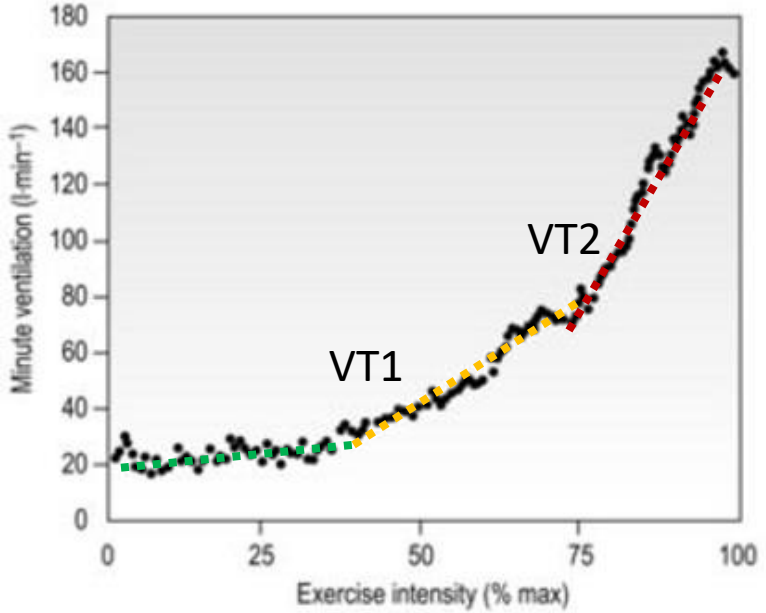
Heart **R**ate x **S**troke **V**olume = $\dot{Q}$

Cardiac Output



Breathing **F**requency x **T**idal **V**olume = **VE**

Ventilation Volume



a = significantly different from CON; b = from 40:20s; c = from 30:30s

* = significantly different from the previous data point

OPEN ACCESS Freely available online PLOS ONE

Comparing Continuous and Intermittent Exercise: An "Isoeffort" and "Isotime" Approach

Andrea Nicolò, Ilenia Bazzucchi, Jonida Haxhi, Francesco Felici, Massimo Sacchetti*
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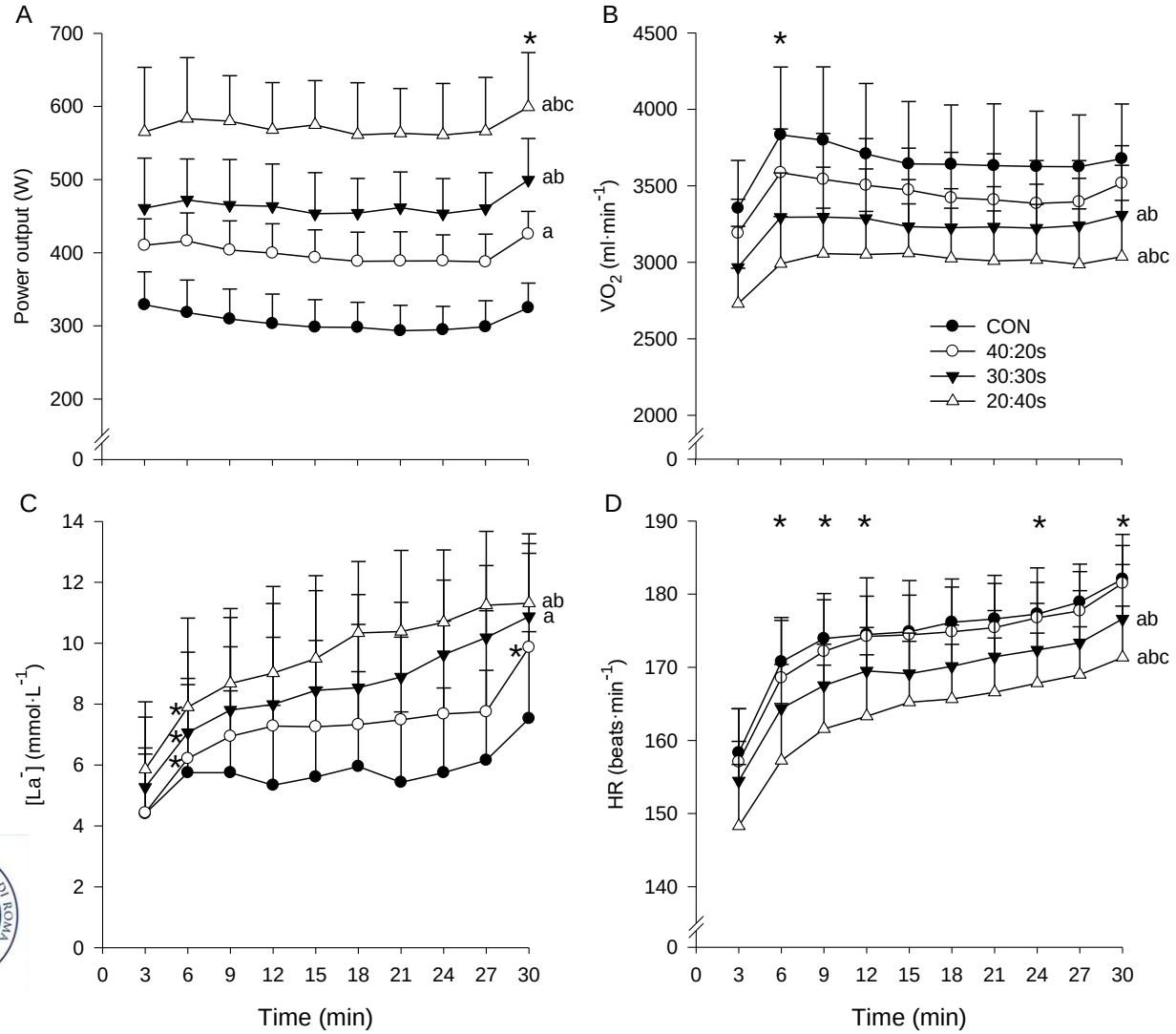
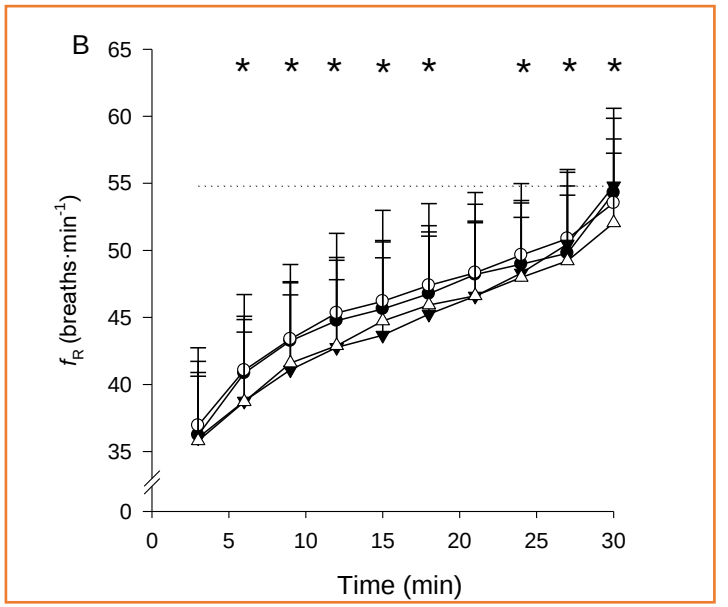
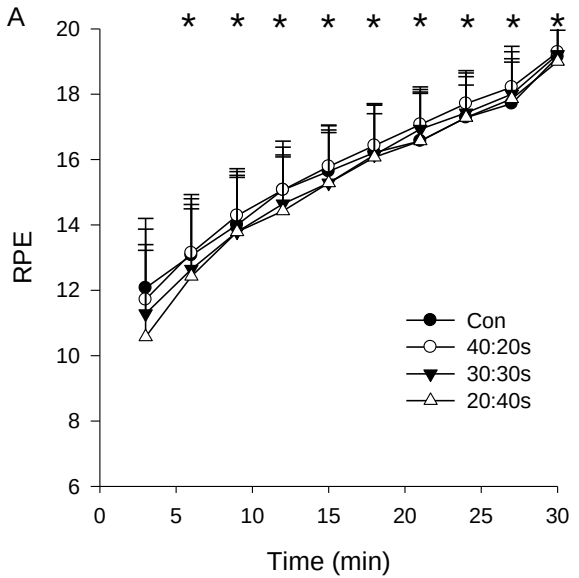
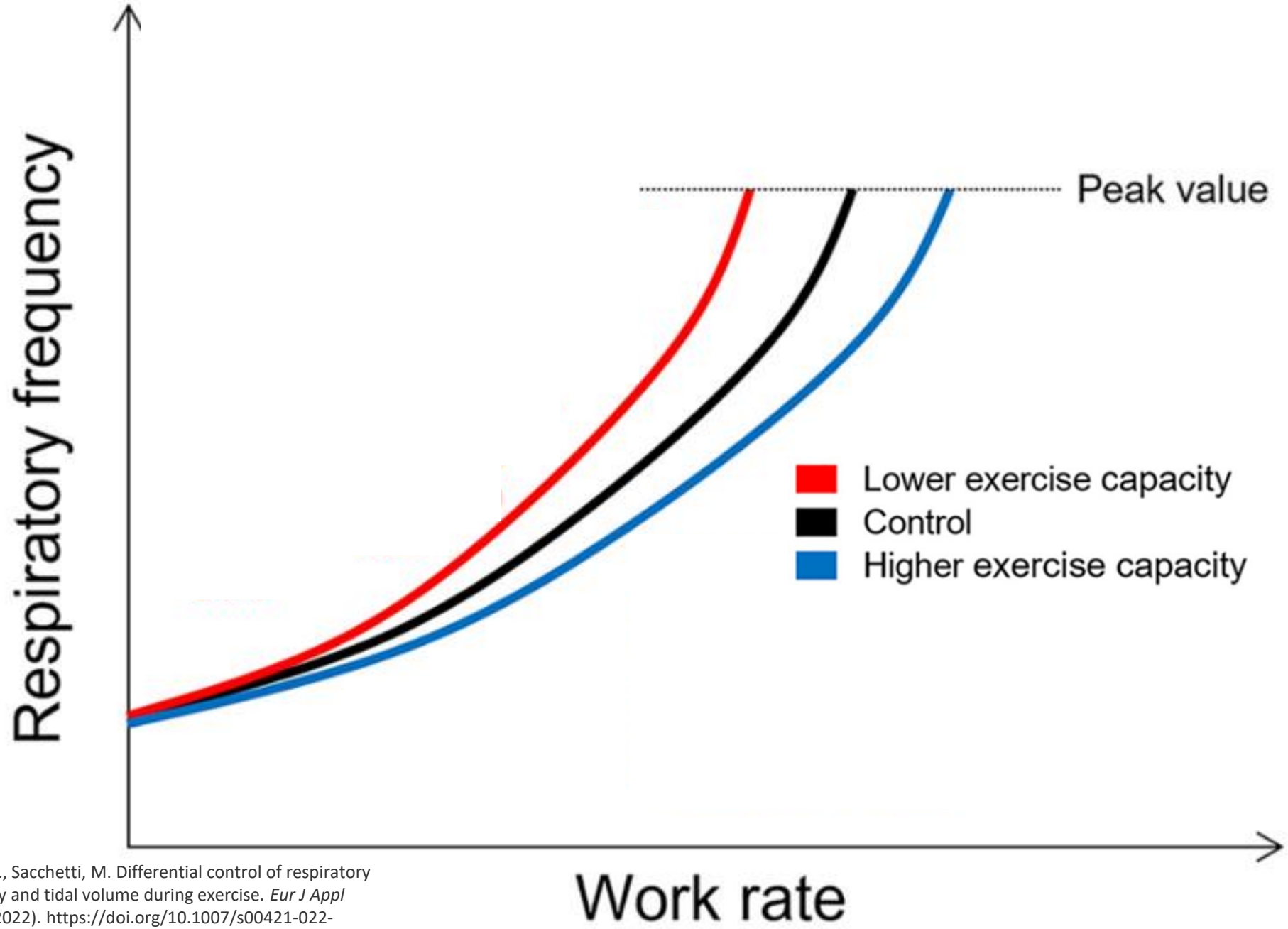
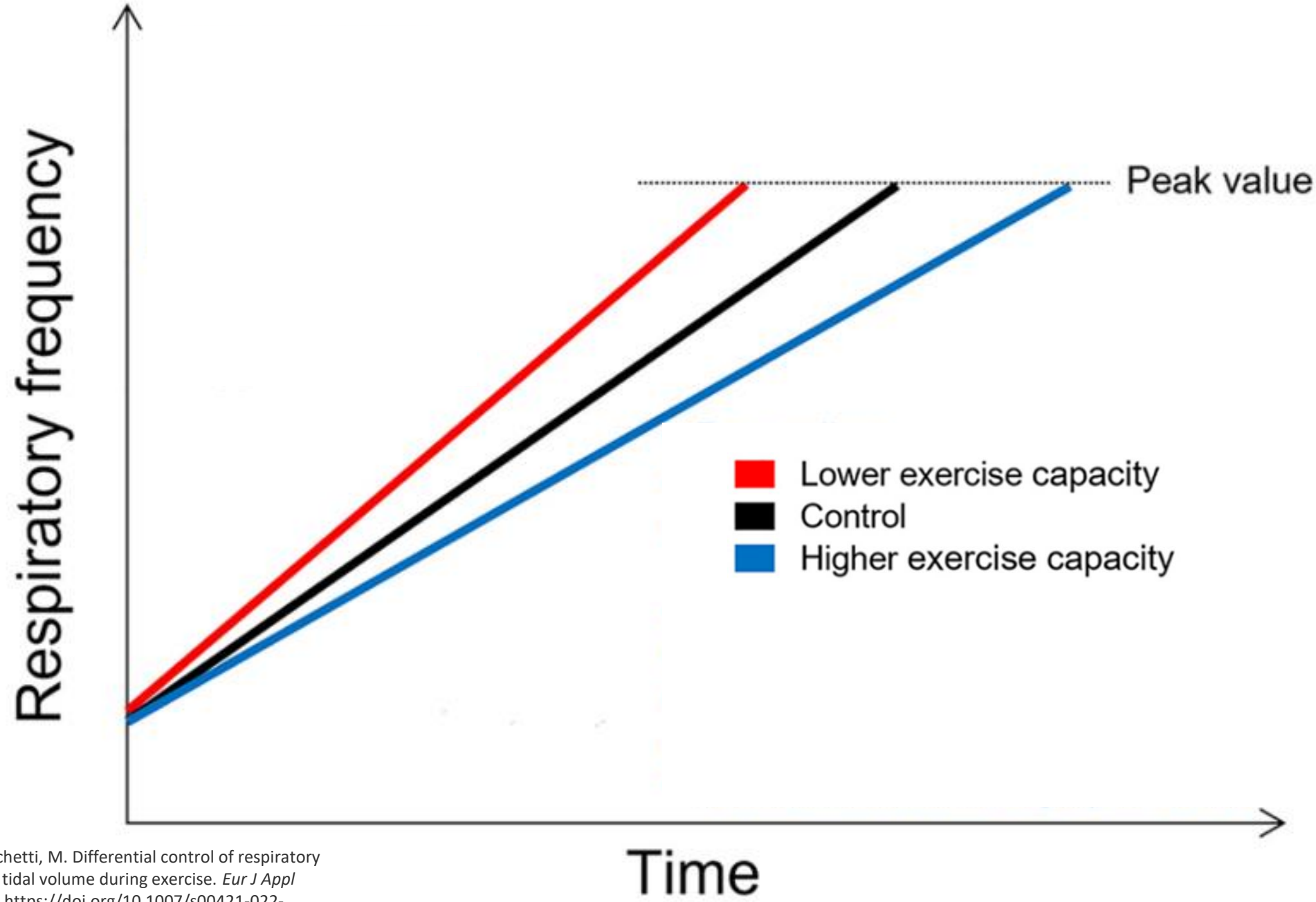






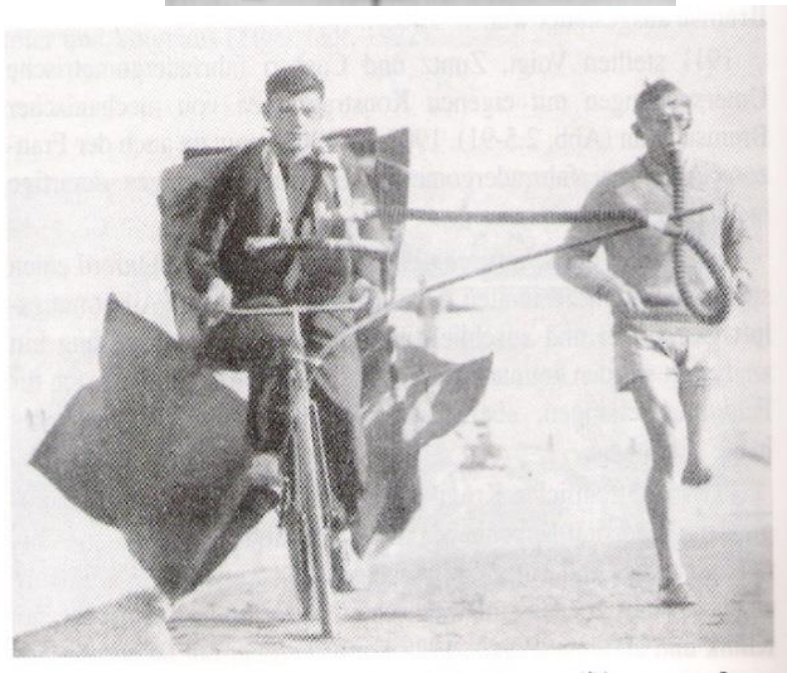


Nicolò, A., Sacchetti, M. Differential control of respiratory frequency and tidal volume during exercise. *Eur J Appl Physiol* (2022). https://doi.org/10.1007/s00421-022-05077-0



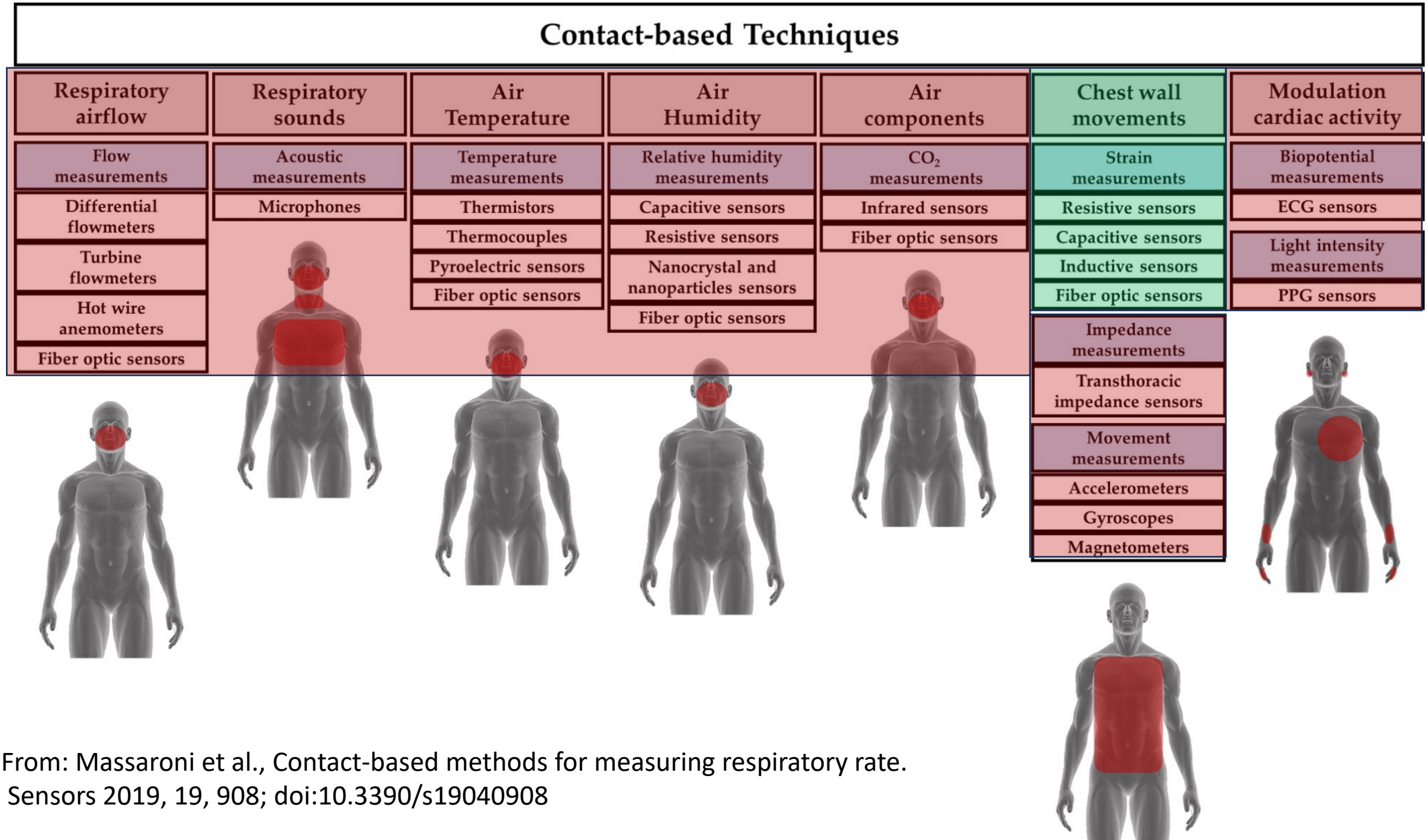
Nicolò, A., Sacchetti, M. Differential control of respiratory frequency and tidal volume during exercise. *Eur J Appl Physiol* (2022). https://doi.org/10.1007/s00421-022-05077-0

CAN we
measure ventilation
“on the road”
in a **valid** but also
“useful” way?




COSMED

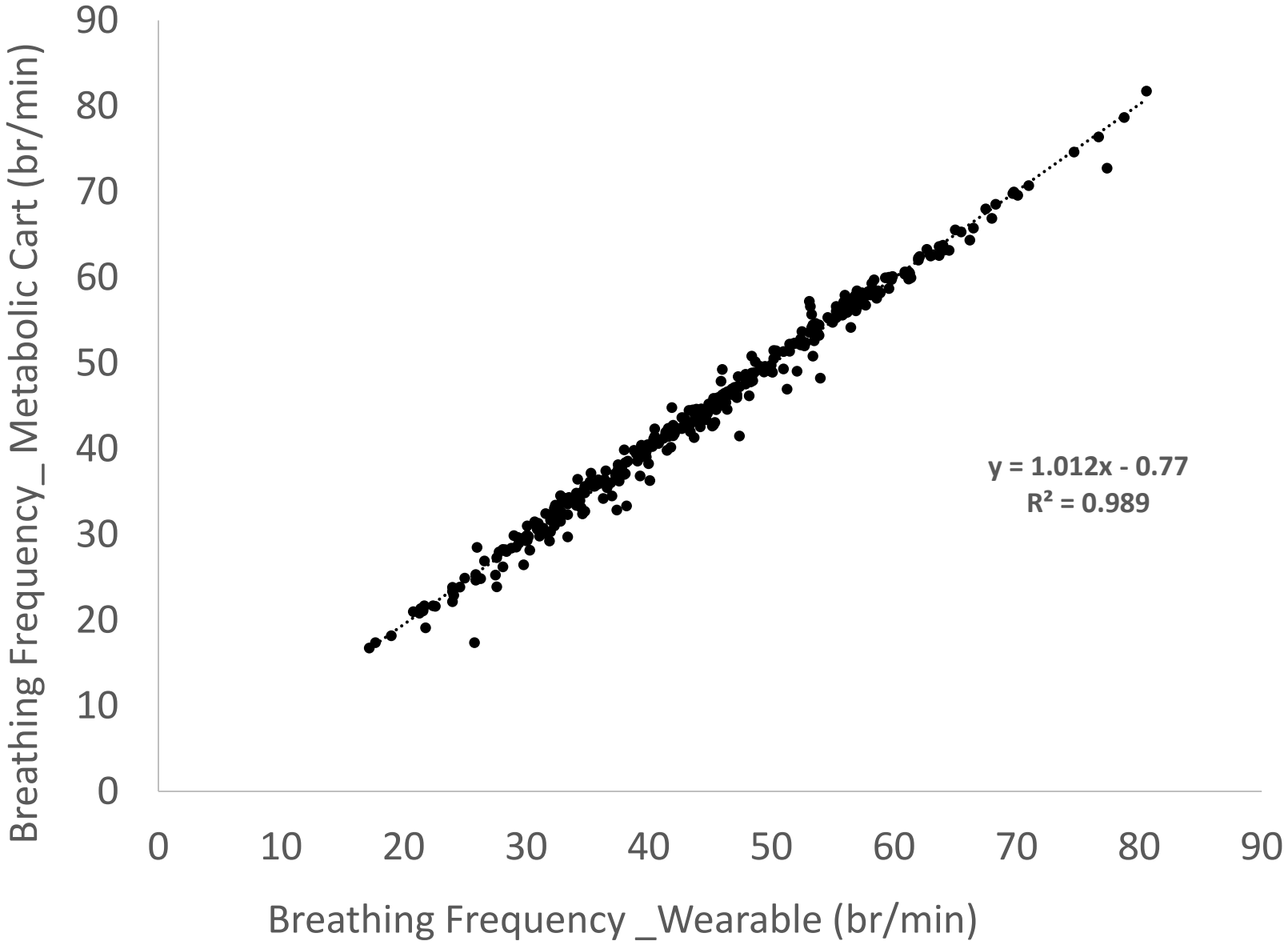

Red Bull
CADEX
TEXACO
TRIMTEX



From: Massaroni et al., Contact-based methods for measuring respiratory rate. Sensors 2019, 19, 908; doi:10.3390/s19040908

Breathing Frequency
+ Tidal Volume

Breathing Frequency
Only



OK, but does wearing a mouthpiece/mask change how we breathe during testing?

Running on a treadmill

Simultaneous Measurements	
BF max (From Cart)	BF max (From Shirt)
62	62
66	67
71	73
62	63
67	68
61	62
70	71
67	68
67	66
67	67
63	64
63	63
62	62
65	65
79	81
66.0	**66.8**
4.7	**5.1**

YES, it does!

BrF/TV
relationship changes

But, total VE seems
to stay ~constant

SHOULD we
measure ventilation during training?

Would breathing frequency feedback inform the training process?

We manage this relationship with our athletes

$$\frac{\text{Adaptive Cellular Signals}}{\text{Systemic Stress/Strain Responses}}$$

The Endurance Training Monitoring Trinity

Power/Pace

Physiological Responses

Internal "Cost"

External Work

Perceived Effort/ Exertion

6	No exertion
7	
8	
9	
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	
20	Maximal exertion

UiA

UiA | The co-creation university

Strain

(24h+ post training)

- Mood state change
- Decreased Readiness to Train
- Large HR/load Shift (up or down)
- Decreased Peak Blood La-
- Peak 6s power/CMJ decline
- Decreased resting HRV
- Decreased testosterone response
- Decreased cortisol response
- Decreased Libido

ACCUMULATED side-effects

Stress

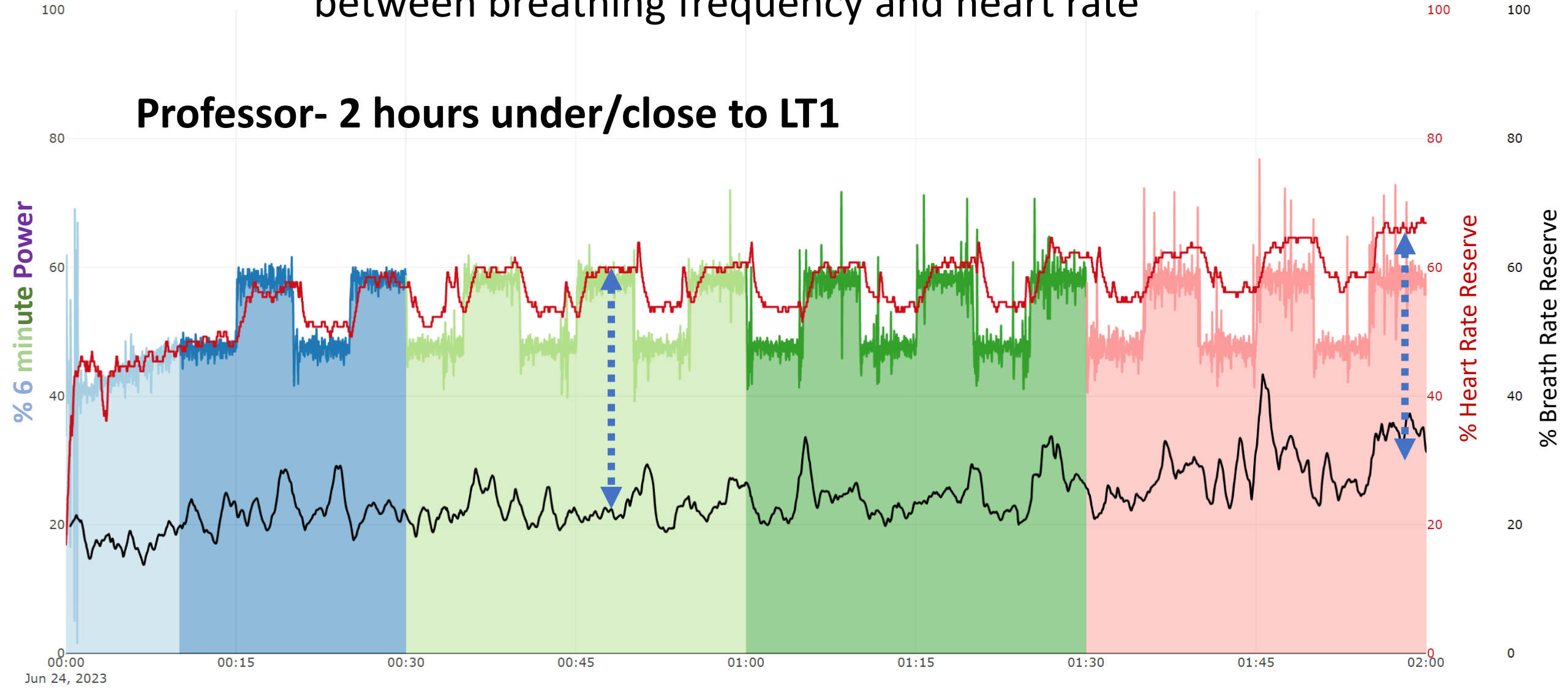
ACUTE Responses

- RPE/HR/**Ventilation** shift vs power/pace
- Efficiency deterioration (technique collapse)
- Greater pace variation when attempting steady-state
- Increased cortisol release (saliva or blood)
- Increased/altered muscle activation at same power or pace

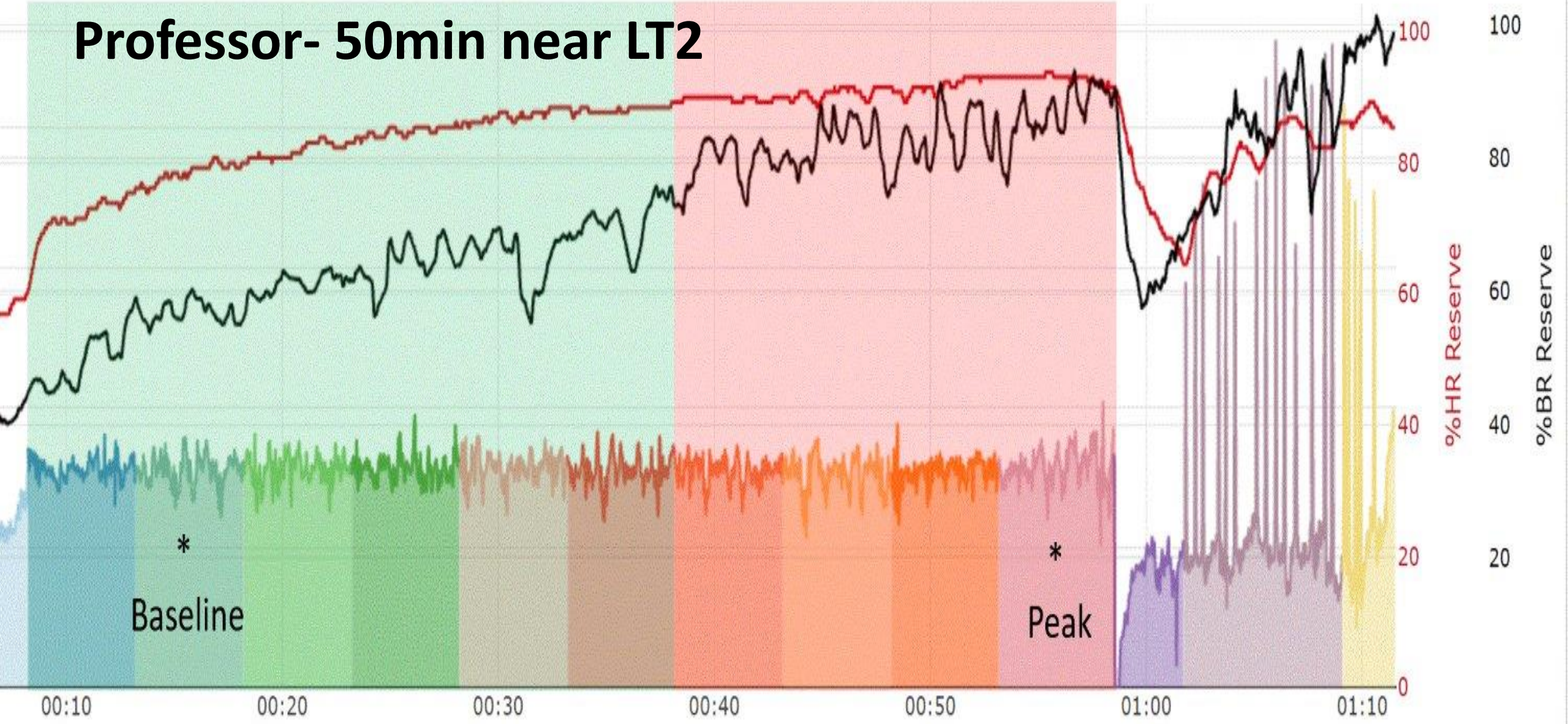
Load

NEUTRAL: Different combinations of intensity x duration can give same load!

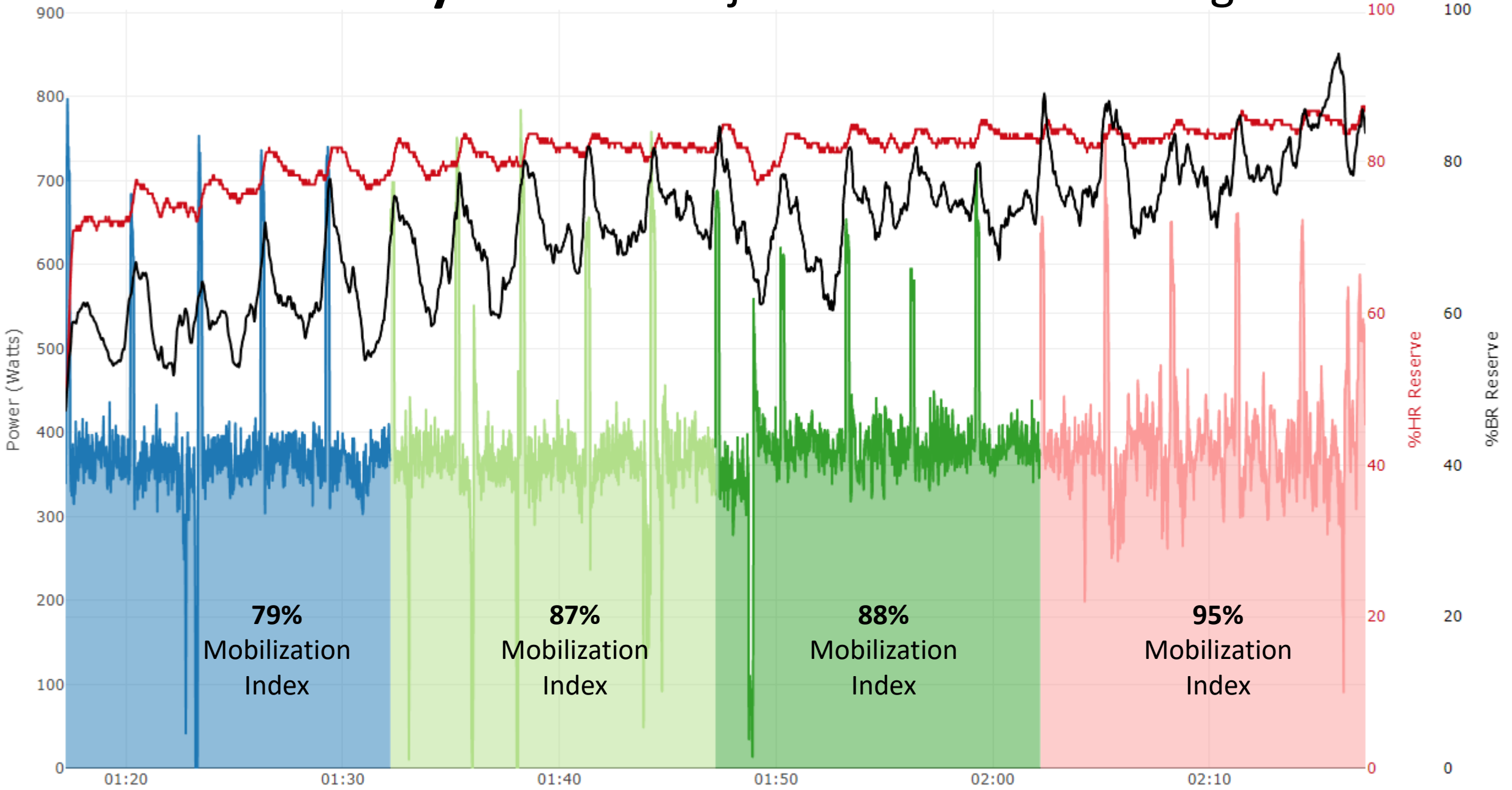
In the rested state, there is a large **“Mobilization Gap”** between breathing frequency and heart rate



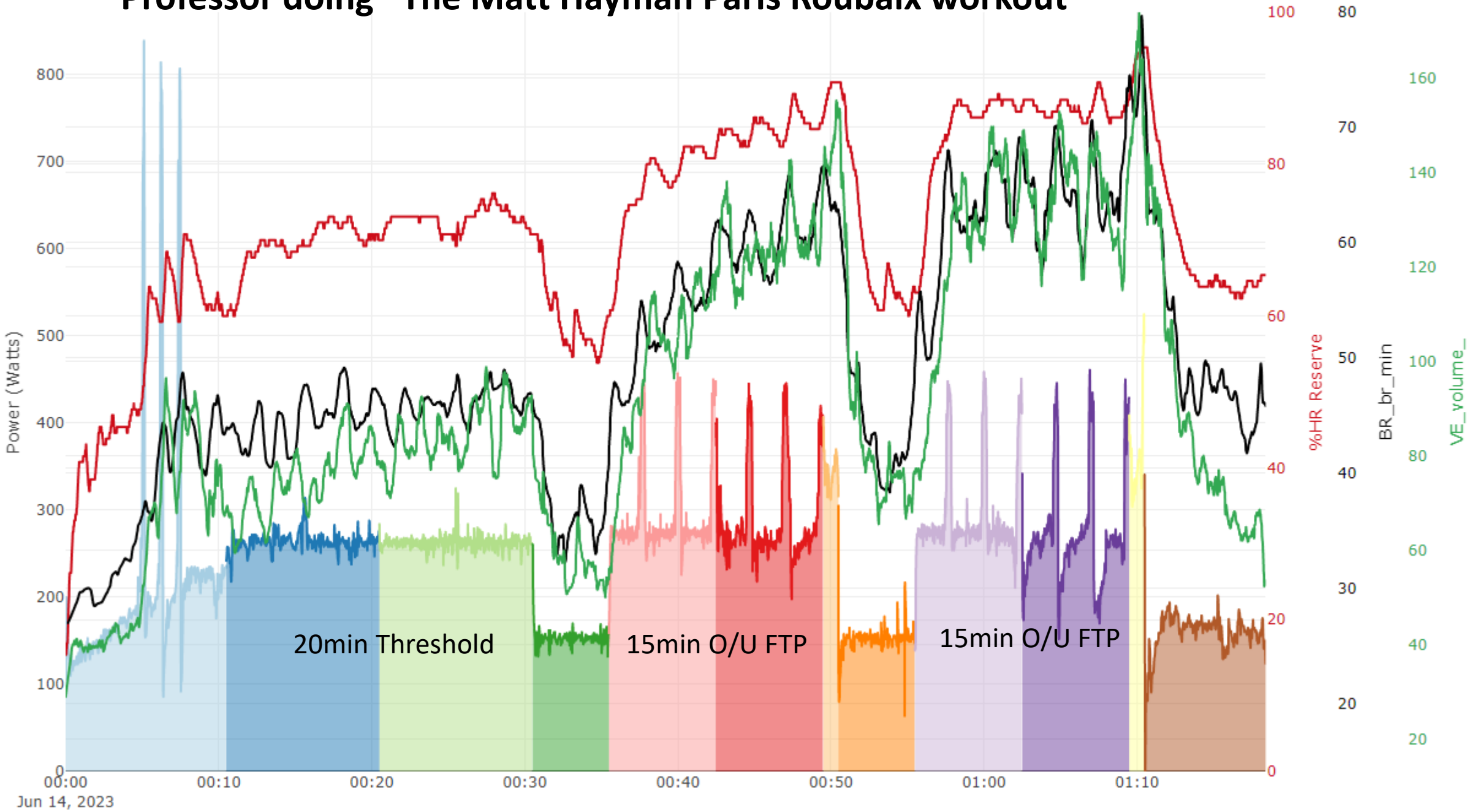
Professor- 50min near LT2



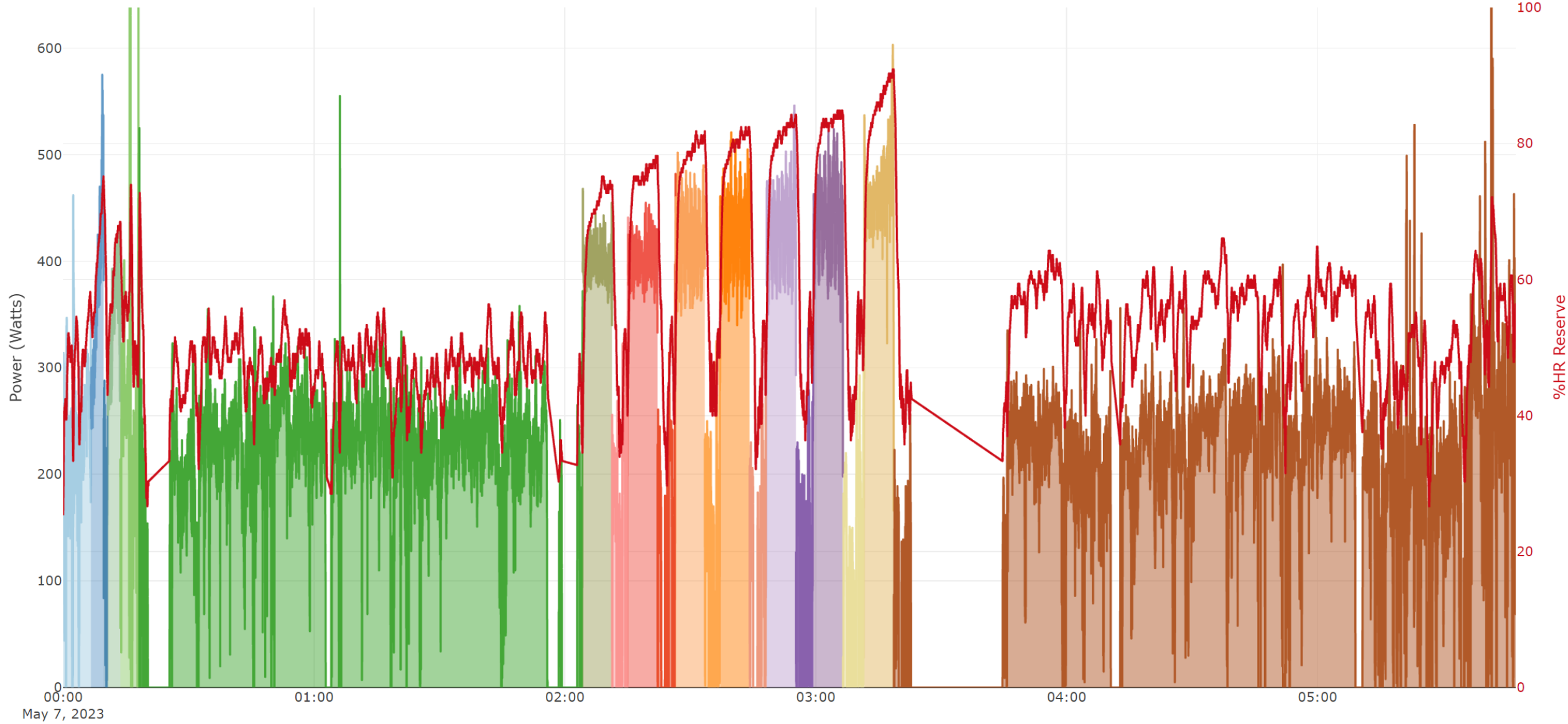
Professional Cyclist- 60min just under LT2 with surges

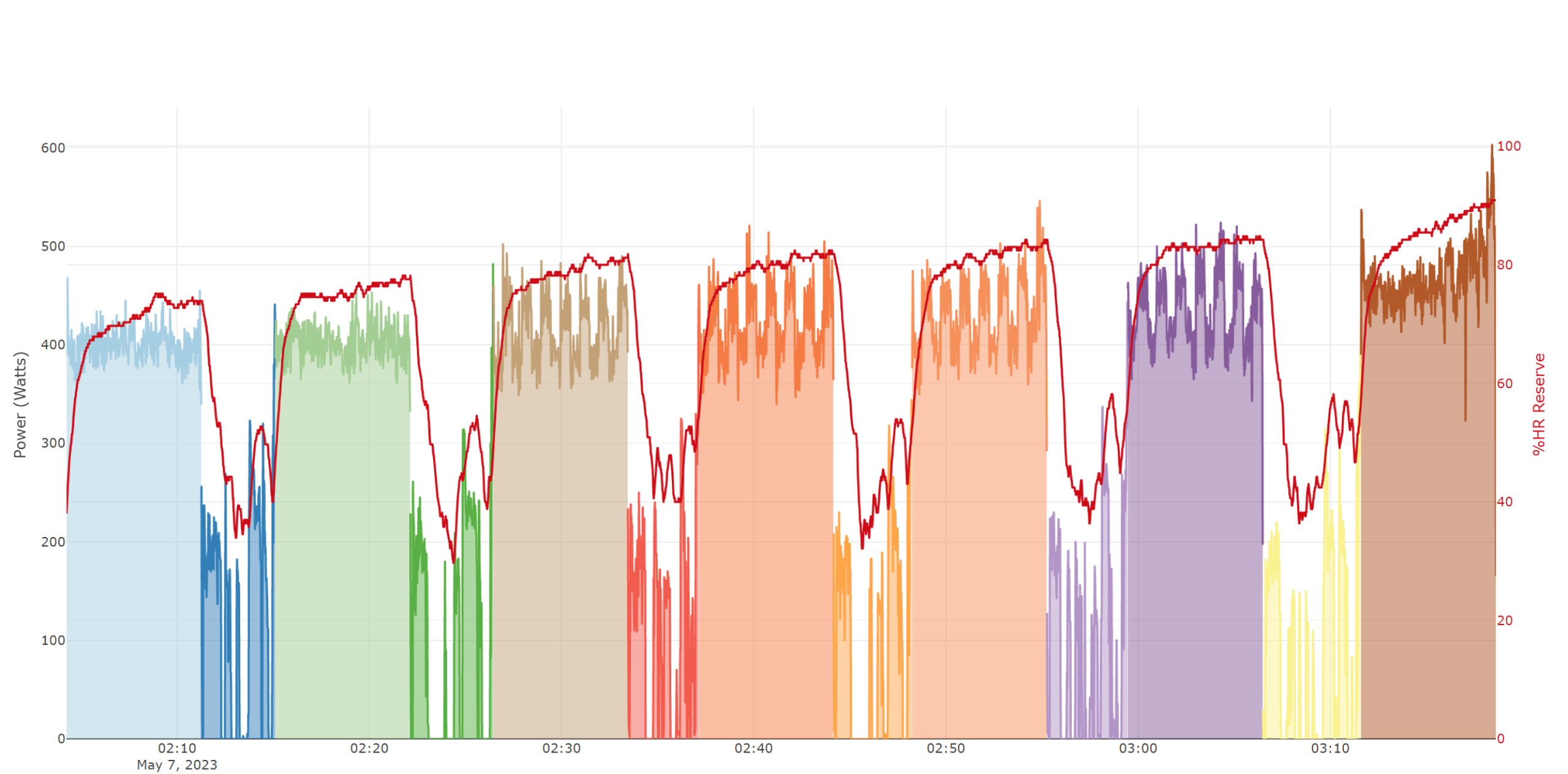


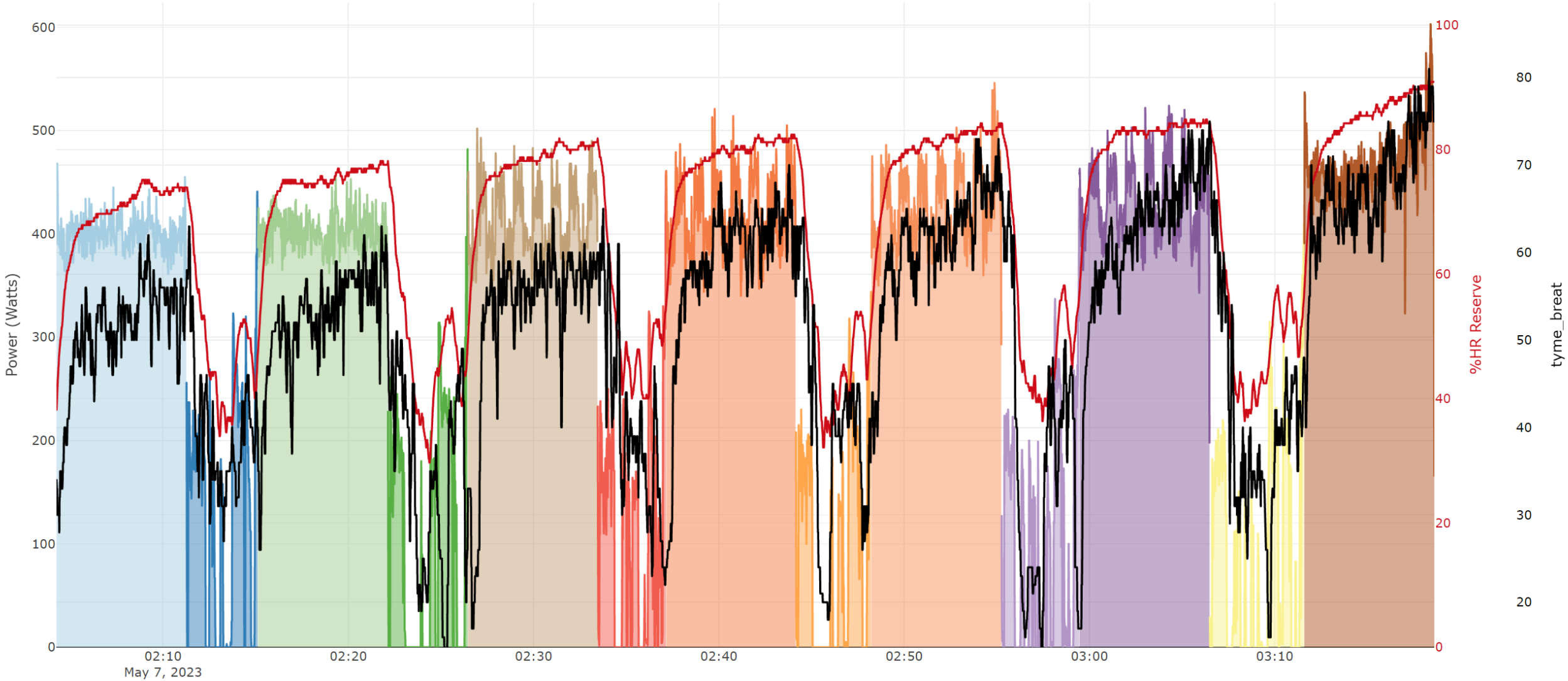
Professor doing “The Matt Hayman Paris Roubaix workout”



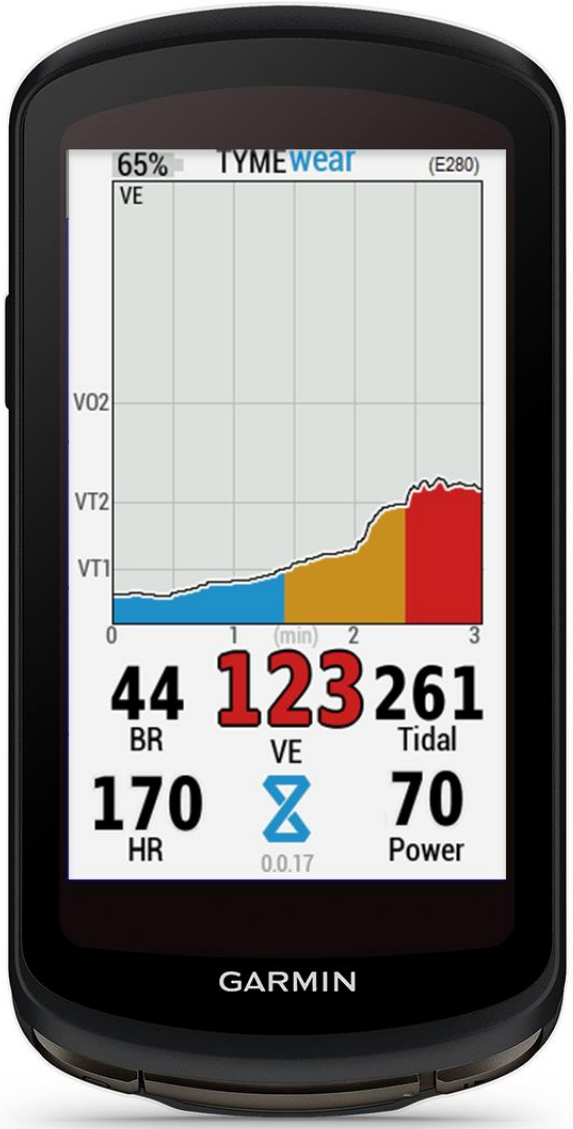
Professional cyclist, 7 x 7 min during a 6 hour ride




Power (Watts)
600
500
400
300
200
100
0
%HR Reserve
100
80
60
40
20
0
02:10
May 7, 2023
02:20
02:30
02:40
02:50
03:00
03:10


Power (Watts)
600
500
400
300
200
100
0
%HR Reserve
100
80
60
40
20
0
tyme_breat
80
70
60
50
40
30
20
02:10
May 7, 2023
02:20
02:30
02:40
02:50
03:00
03:10

My current take on monitoring breathing:



1. Breathing frequency can be measured in a valid and repeatable manner in the field now (strain sensor).

2. The ideal technical solution will likely be **integration** of a **strain sensor in the team training kit**.

3. Ventilatory threshold testing can be performed in the field, alone or in parallel with Lactate profile as confirmation.

4. HR + BF monitoring, expressed as %BRR/%HRR (**Mobilization Index?**) can quantify internal stress better than HR alone during demanding sessions.

Tyme wear interface with Garmin head unit.

eskerrik asko!

In

J Appl Physiol 128: 1447–1449, 2020.
First published February 13, 2020; doi:10.1152/japplphysiol.00814.2019.

VIEWPOINT

Time to reconsider how ventilation is regulated above the respiratory compensation point during incremental exercise

Andrea Nicolò,[1] Samuele M. Marcora,[2] and Massimo Sacchetti[1]
[1]Department of Movement, Human and Health Sciences, University of Rome "Foro Italico", Rome, Italy; and [2]Department of Biomedical and Neuromotor Sciences, University of Bologna, Bologna, Italy

The f_R increase above the respiratory compensation point is not driven by metabolic acidosis

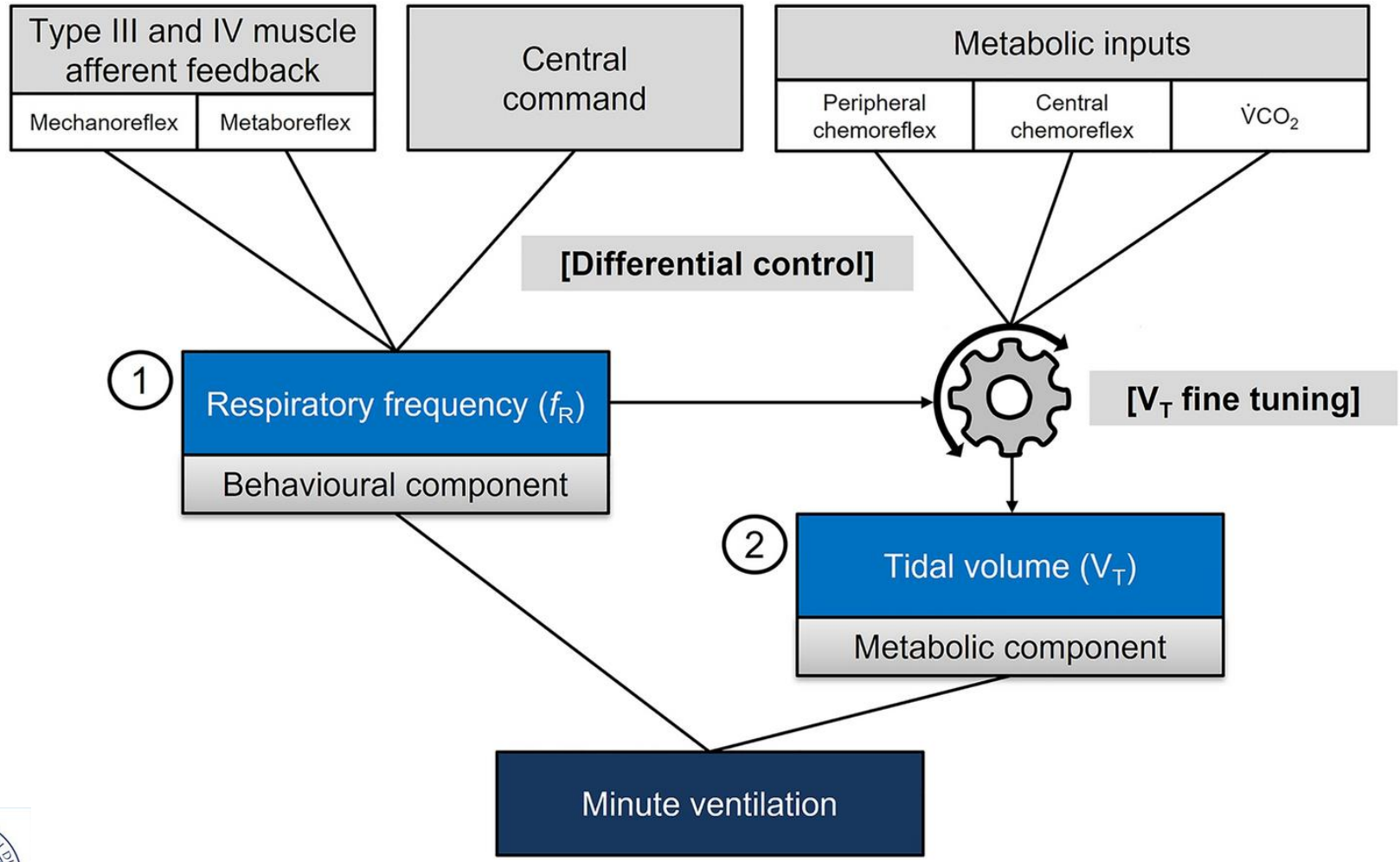
J Appl Physiol 128: 1456, 2020;
doi:10.1152/japplphysiol.00285.2020.

VIEWPOINT

Last Word on Viewpoint: Time to reconsider how ventilation is regulated above the respiratory compensation point during incremental exercise

Andrea Nicolò,[1] Samuele M. Marcora,[2] and Massimo Sacchetti[1]
[1]Department of Movement, Human and Health Sciences, University of Rome "Foro Italico", Rome, Italy; and [2]Department of Biomedical and Neuromotor Sciences, University of Bologna, Bologna, Italy

A new model of ventilatory control during exercise



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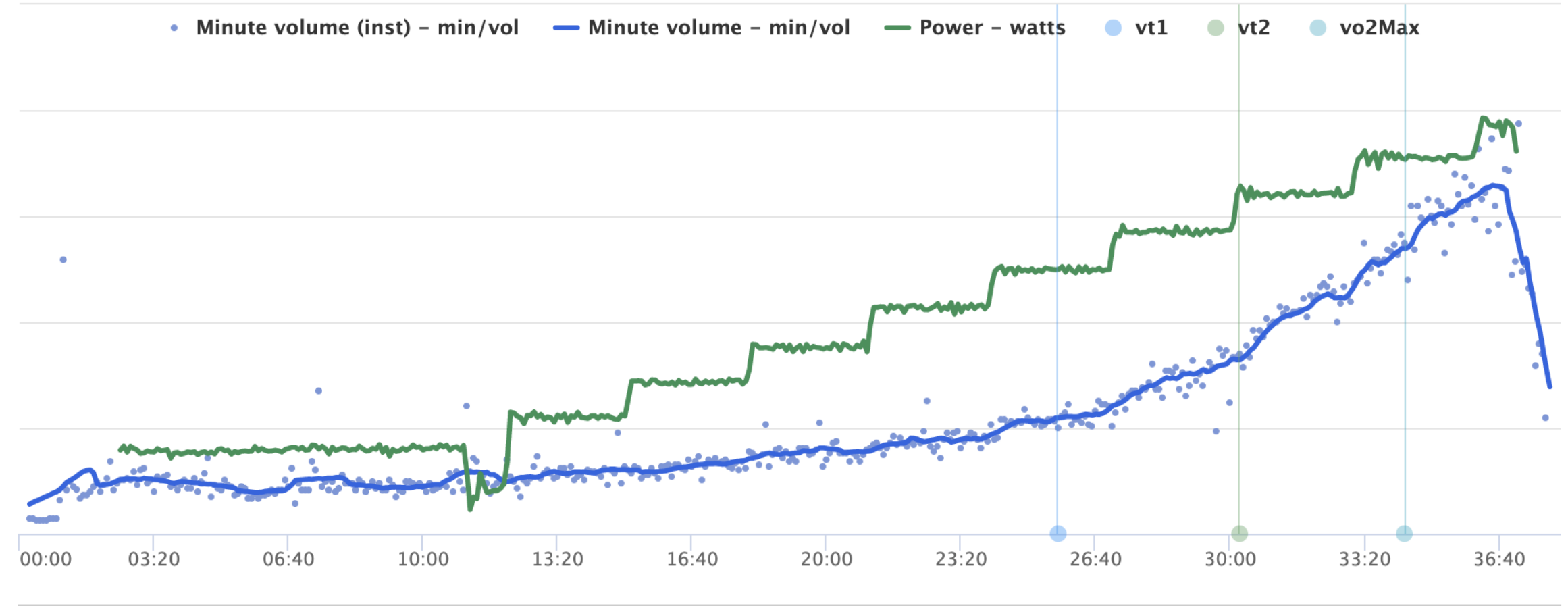
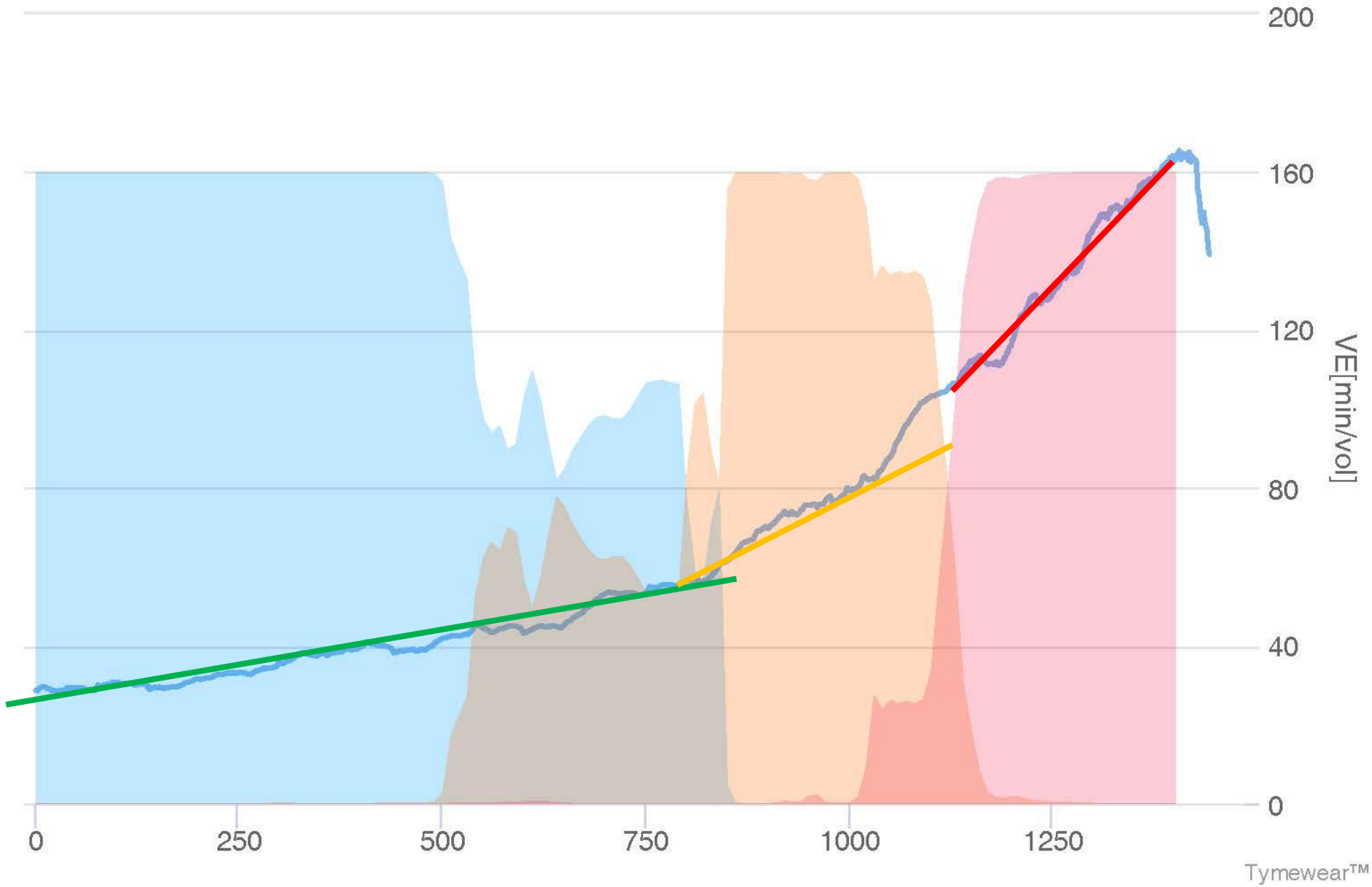
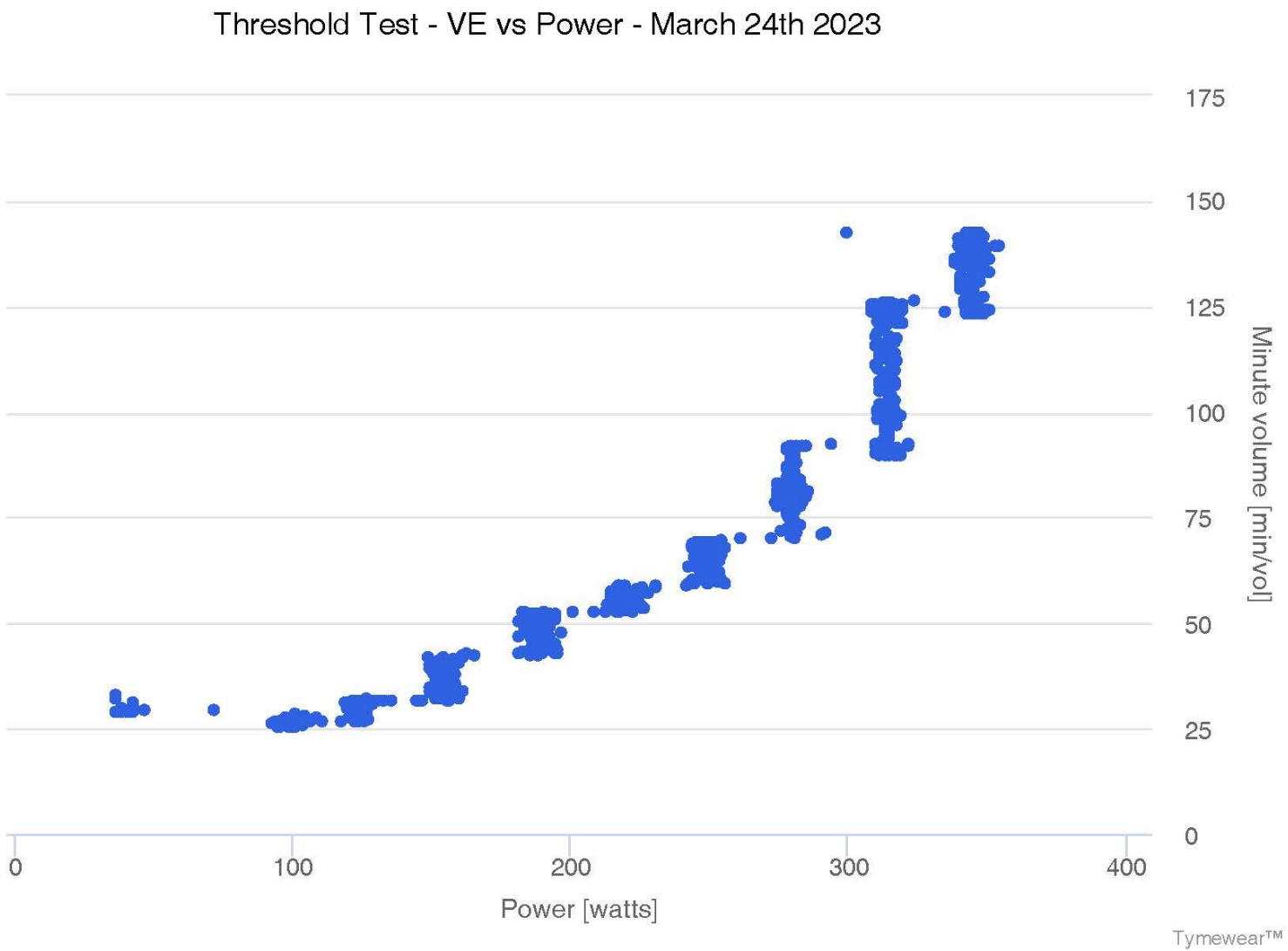
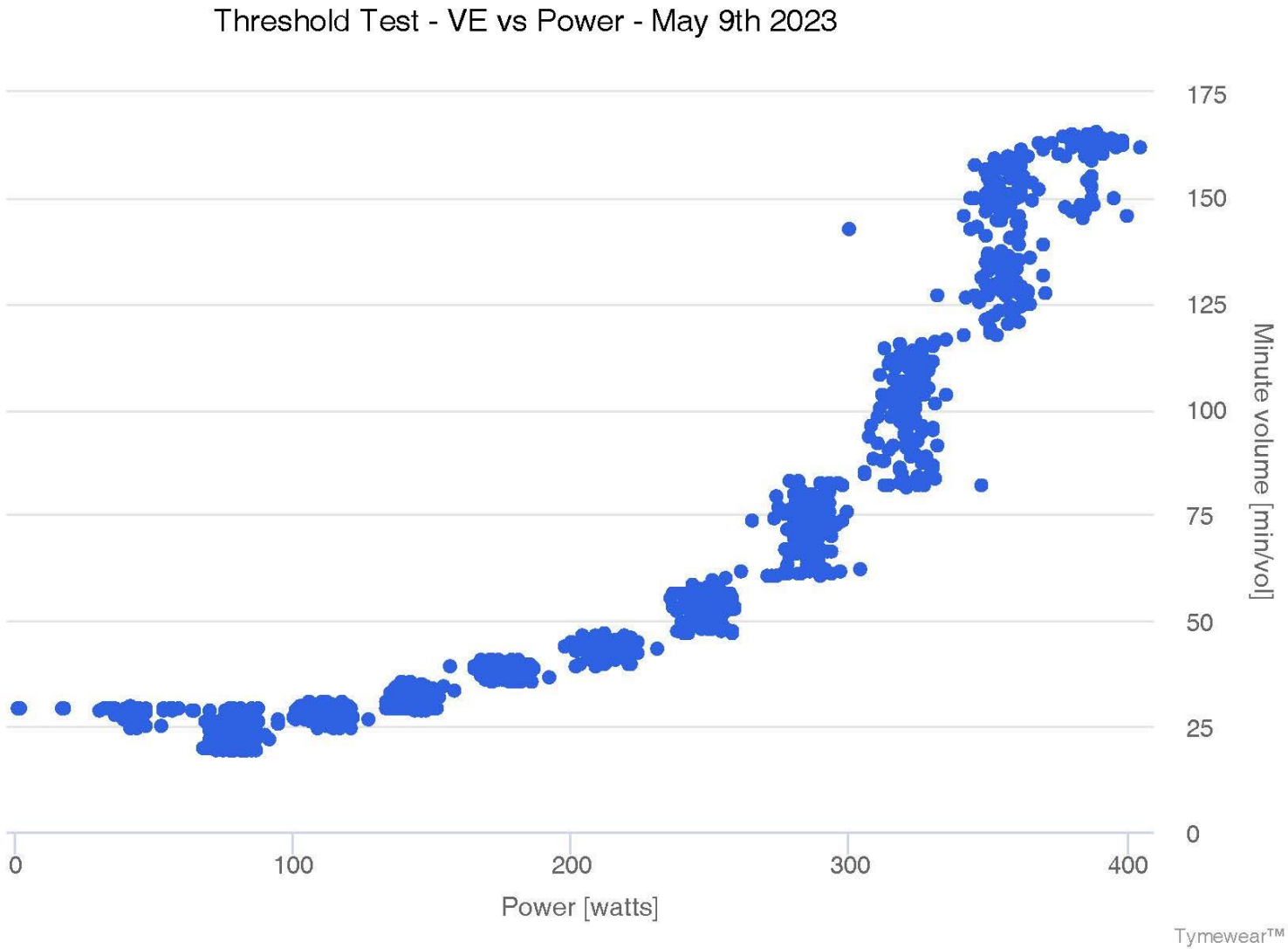
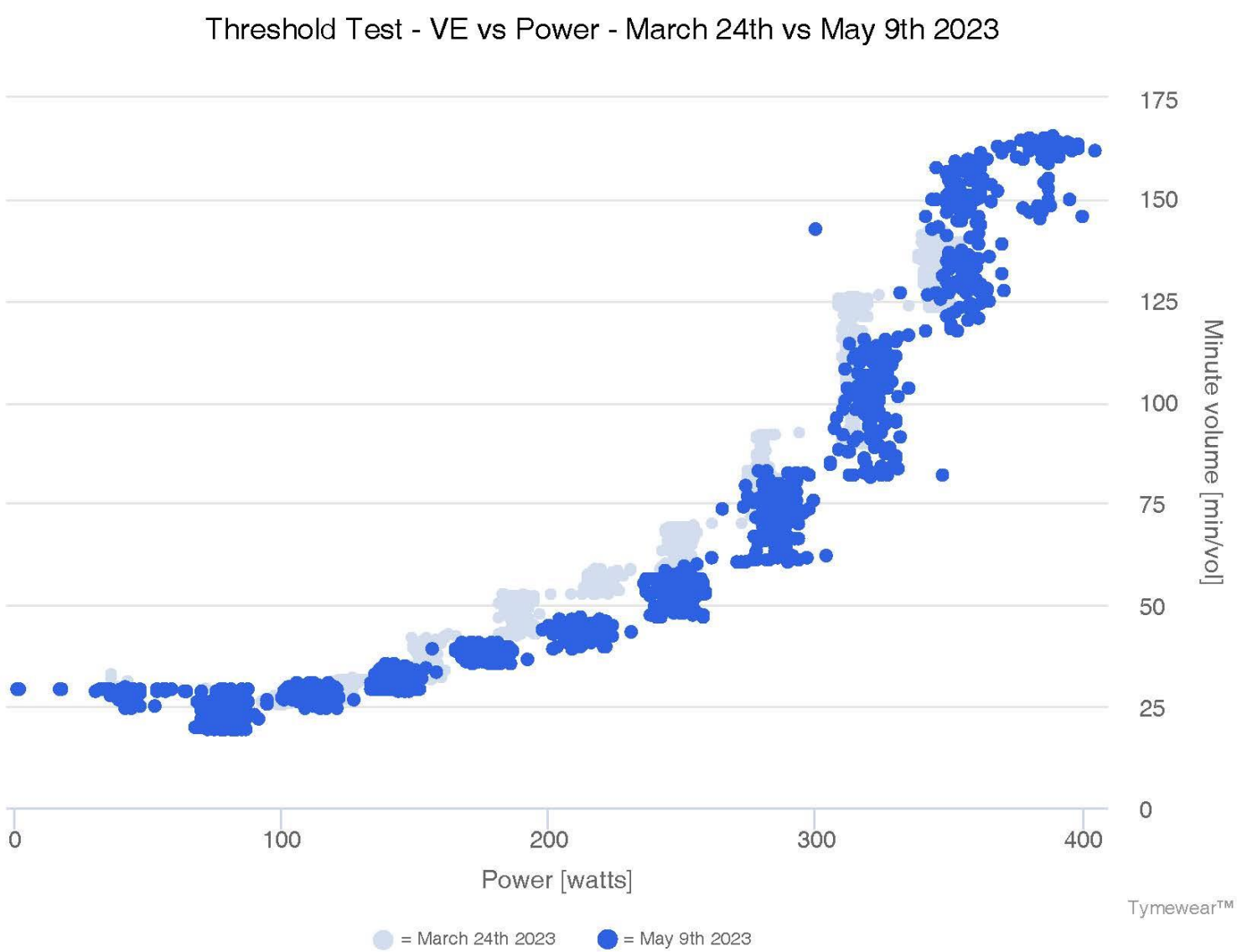

Minute volume (inst) – min/vol
Minute volume – min/vol
Power – watts
vt1
vt2
vo2Max
00:00
03:20
06:40
10:00
13:20
16:40
20:00
23:20
26:40
30:00
33:20
36:40

Zone Prediction - May 9th 2023




Threshold Test - VE vs Power - March 24th 2023
175
150
125
100
75
50
25
0
Minute volume [min/vol]
0
100
200
300
400
Power [watts]
Tymewear™


Threshold Test - VE vs Power - May 9th 2023
175
150
125
100
75
50
25
0
Minute volume [min/vol]
0
100
200
300
400
Power [watts]
Tymewear™


Threshold Test - VE vs Power - March 24th vs May 9th 2023
175
150
125
100
75
50
25
0
Minute volume [min/vol]
0
100
200
300
400
Power [watts]
Tymewear™
= March 24th 2023
= May 9th 2023