

# 7<sup>th</sup> International Congress Mountain, Sport & Health



9-10 November 2017 Rovereto (TN) Italy

## Laboratory- derived measures of critical intensity: what's new?

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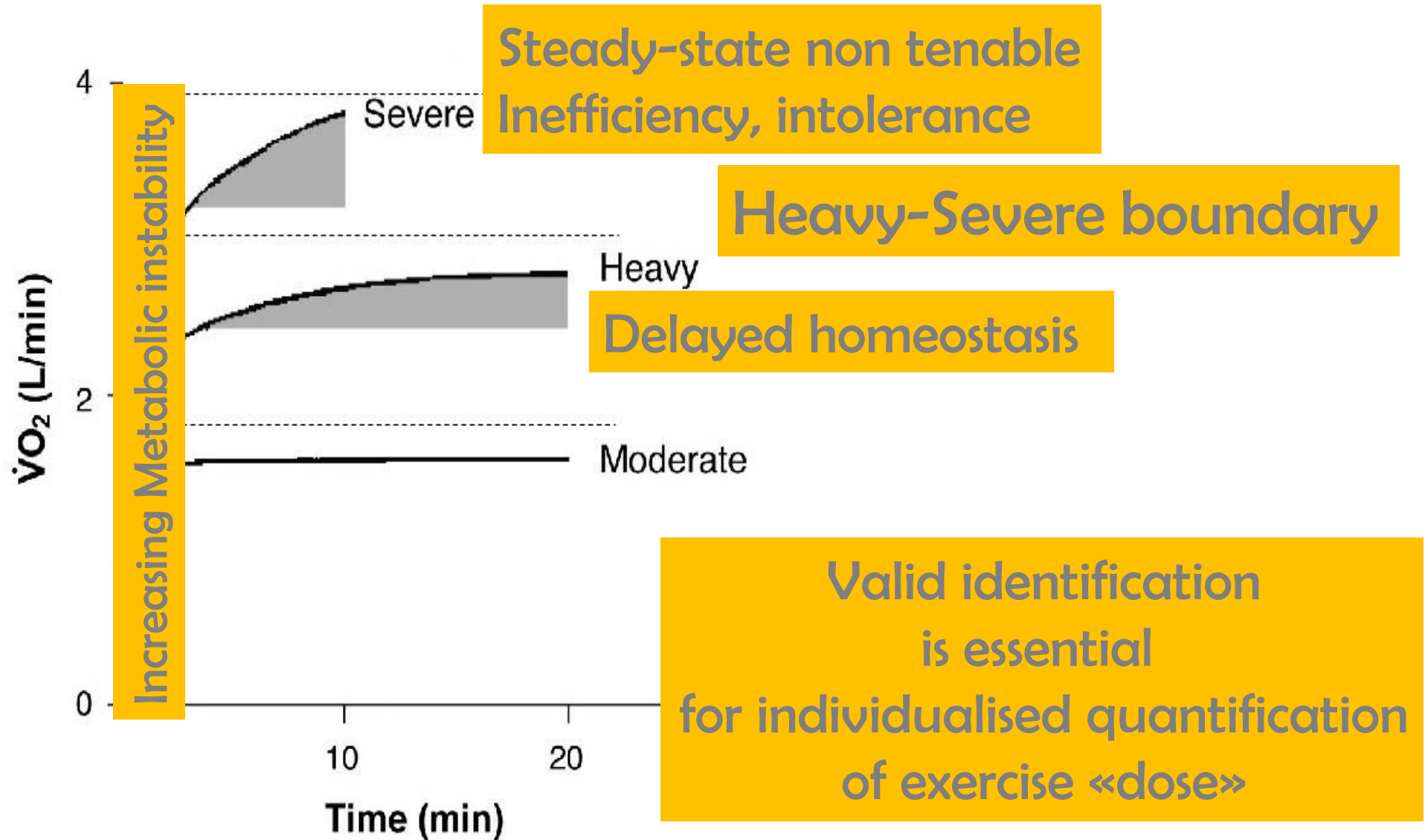


UNIVERSITÀ  
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DIPARTIMENTO DI NEUROSCIENZE,  
BIOMEDICINA E MOVIMENTO

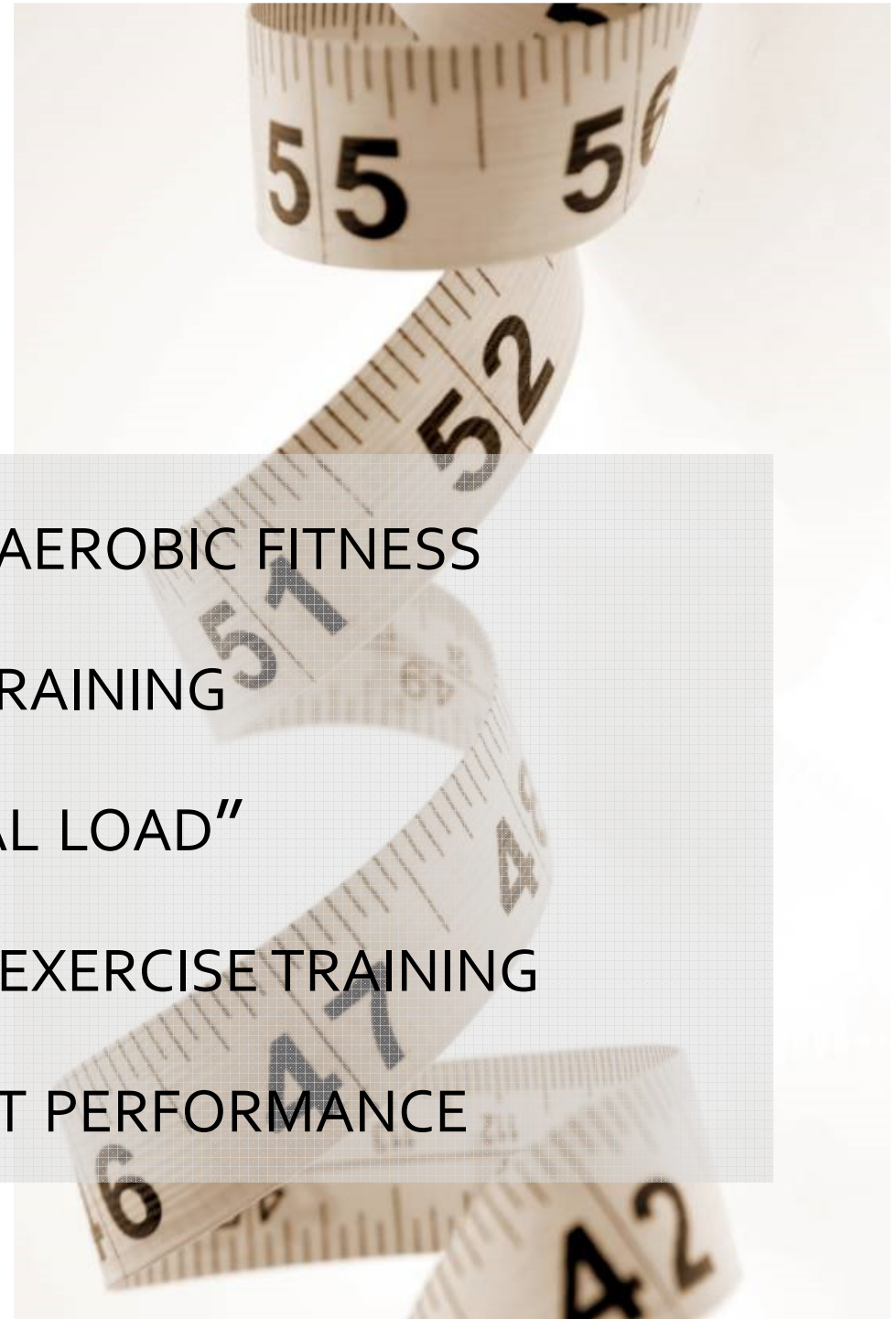
# Exercise-intensity domains:

Exercise duration,  $\dot{V}O_2$  profile, change in intracellular composition

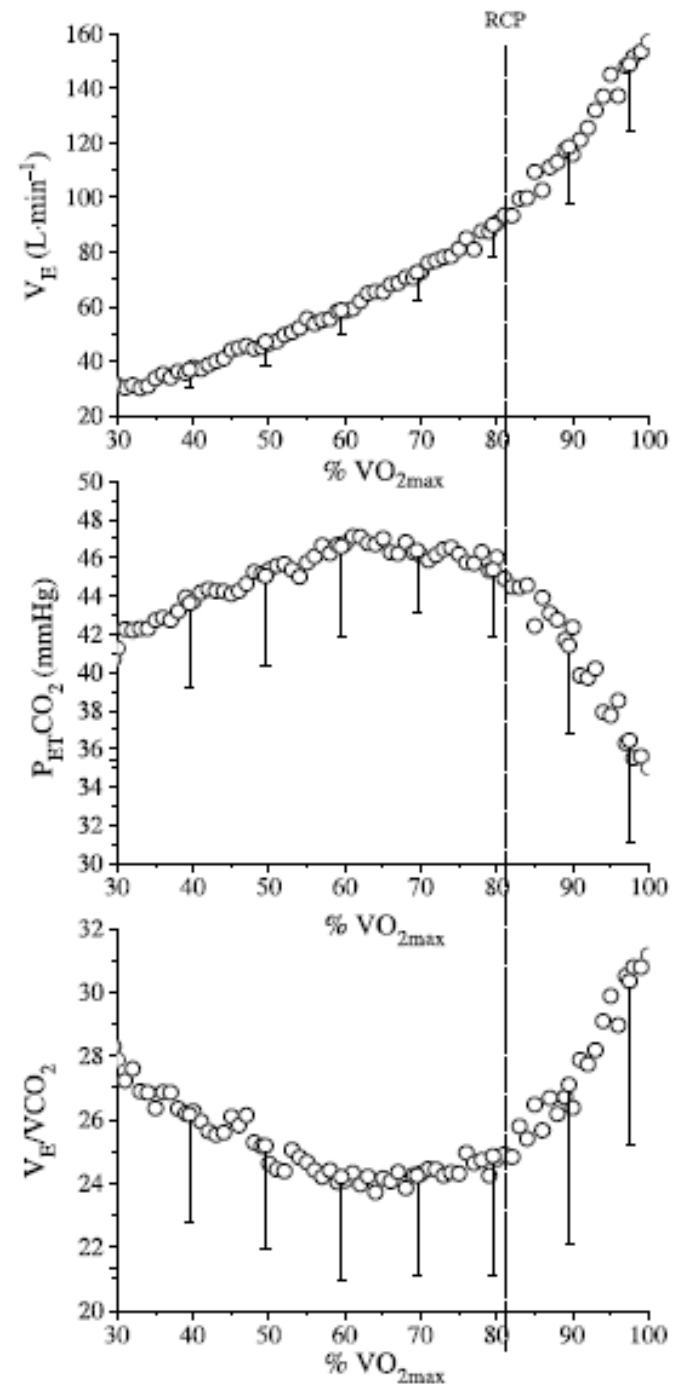
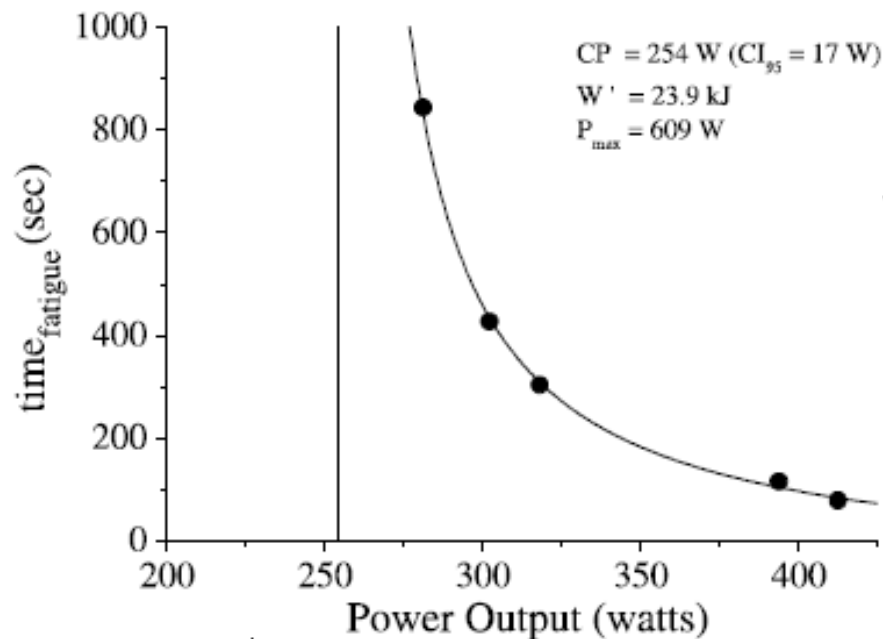
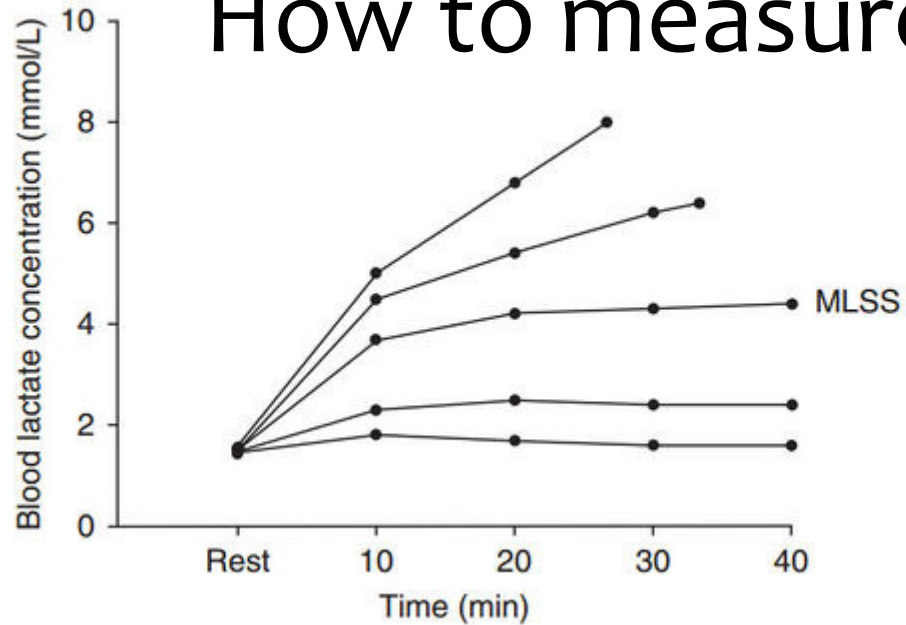


# Why measure heavy- severe boundary?

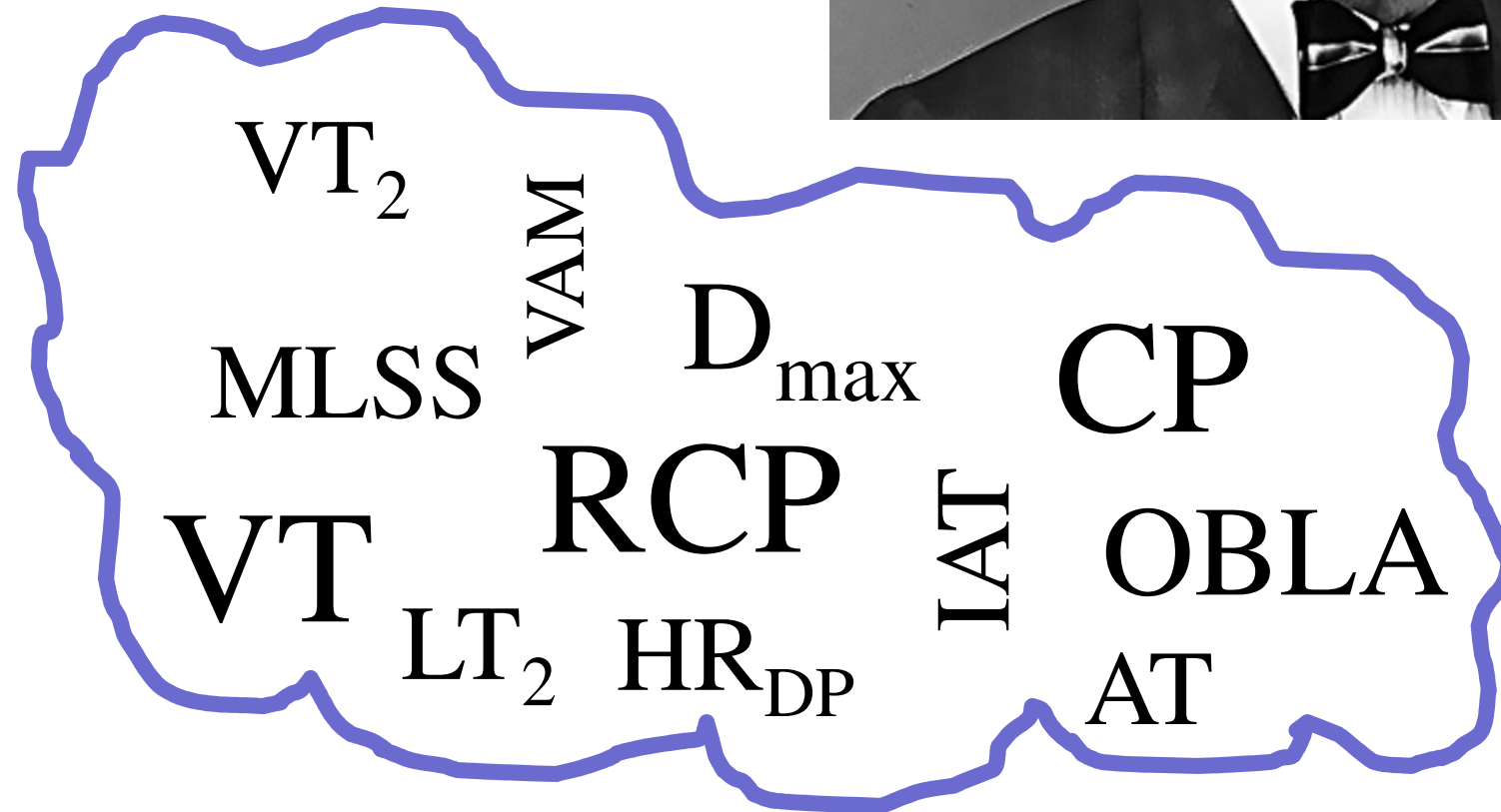
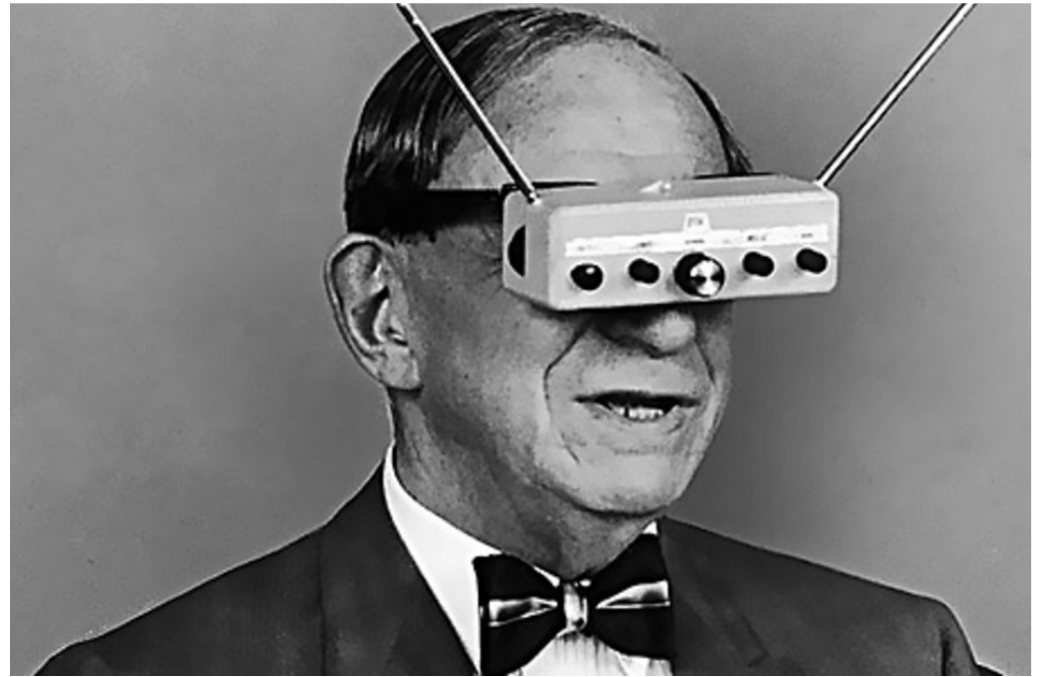
- ✓ SUBMAXIMAL INDEX OF AEROBIC FITNESS
- ✓ SENSITIVE TO AEROBIC TRAINING
- ✓ INDICATOR OF "INTERNAL LOAD"
- ✓ TARGET INTENSITY FOR EXERCISE TRAINING
- ✓ DETERMINANT OF SPORT PERFORMANCE



# How to measure?



# How to measure?

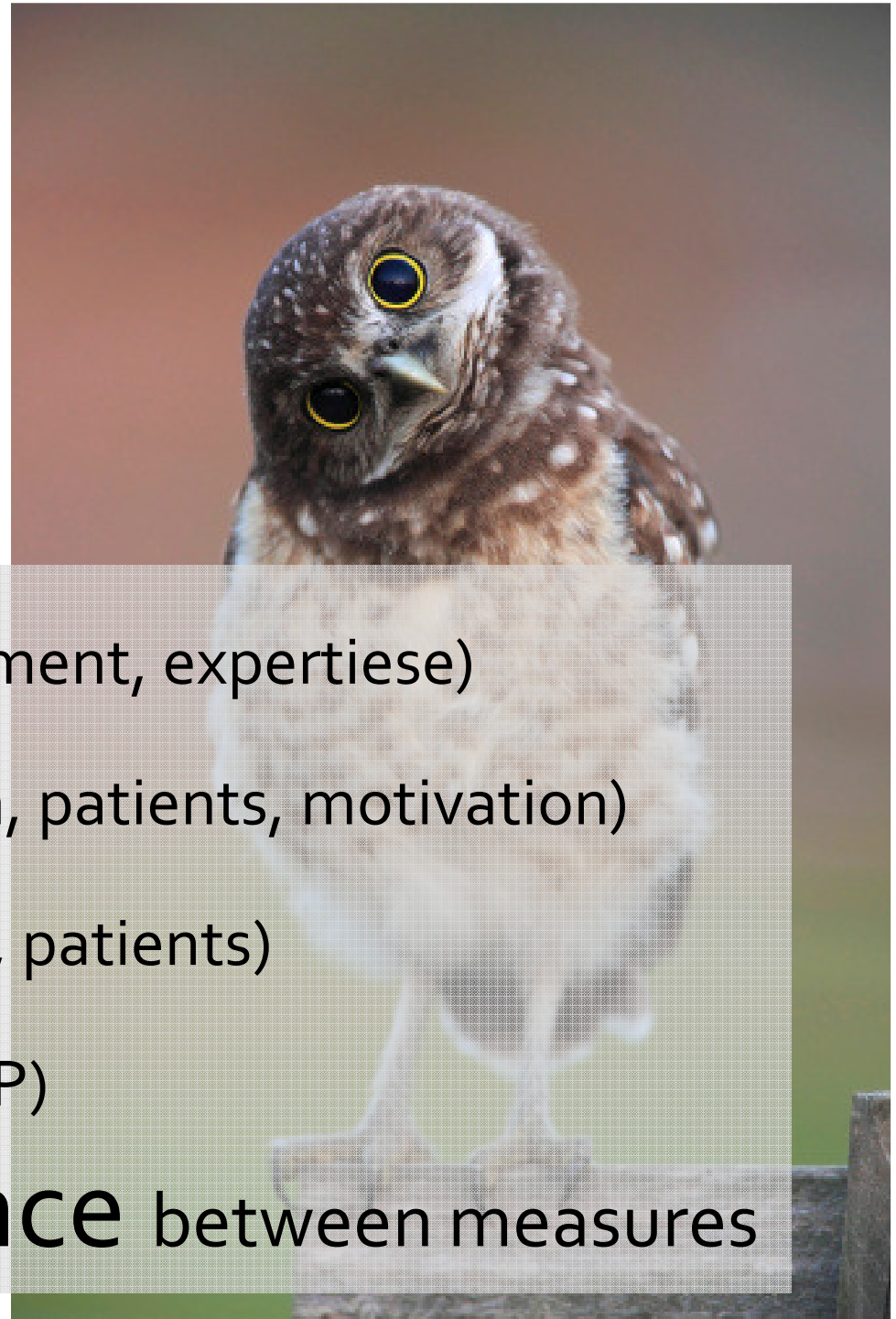




# Alternatives?

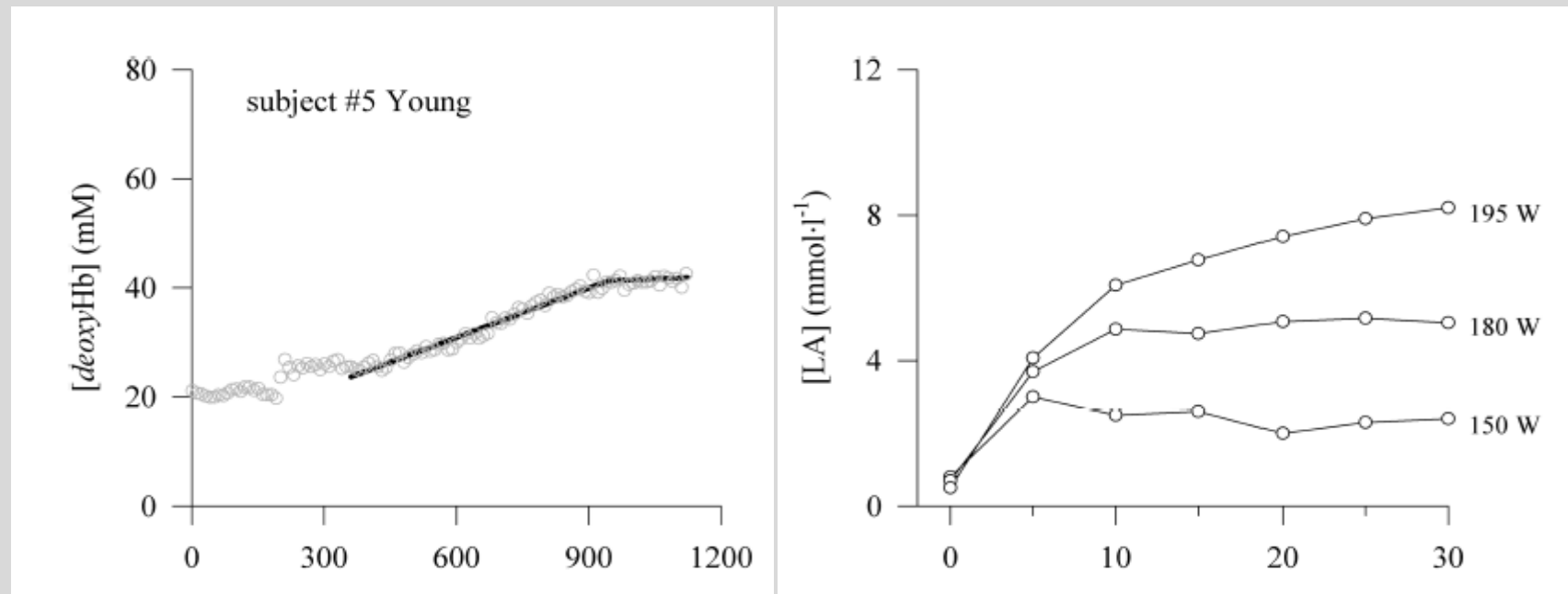
## What's new?

- ✓ **COST** (time, equipment, expertise)
- ✓ **EFFORT** (children, patients, motivation)
- ✓ **RISK** (older adults, patients)
- ✓ **Objectivity** (RCP)
- ✓ **Correspondance** between measures

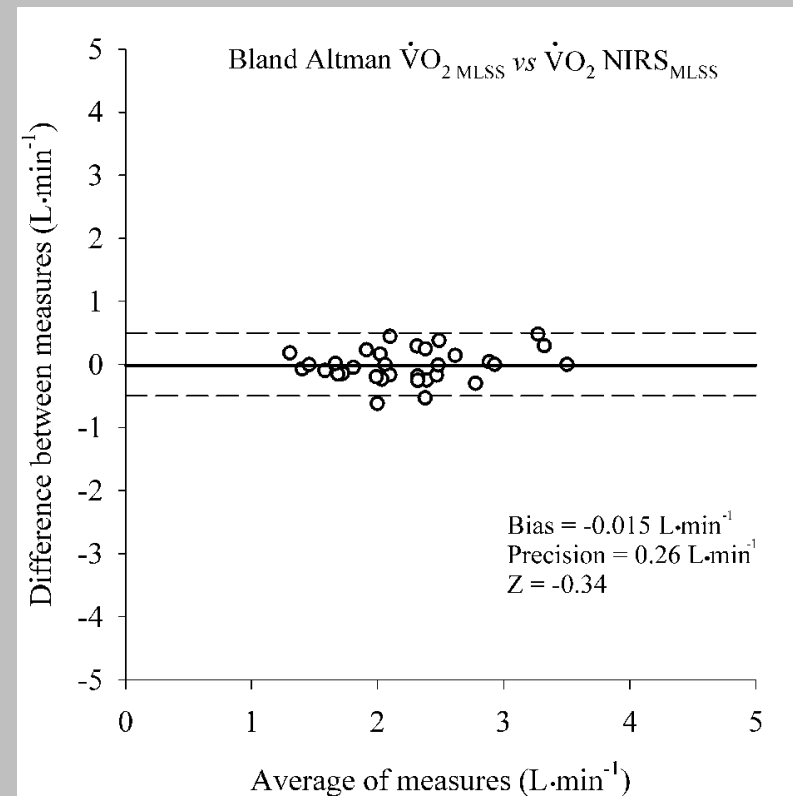
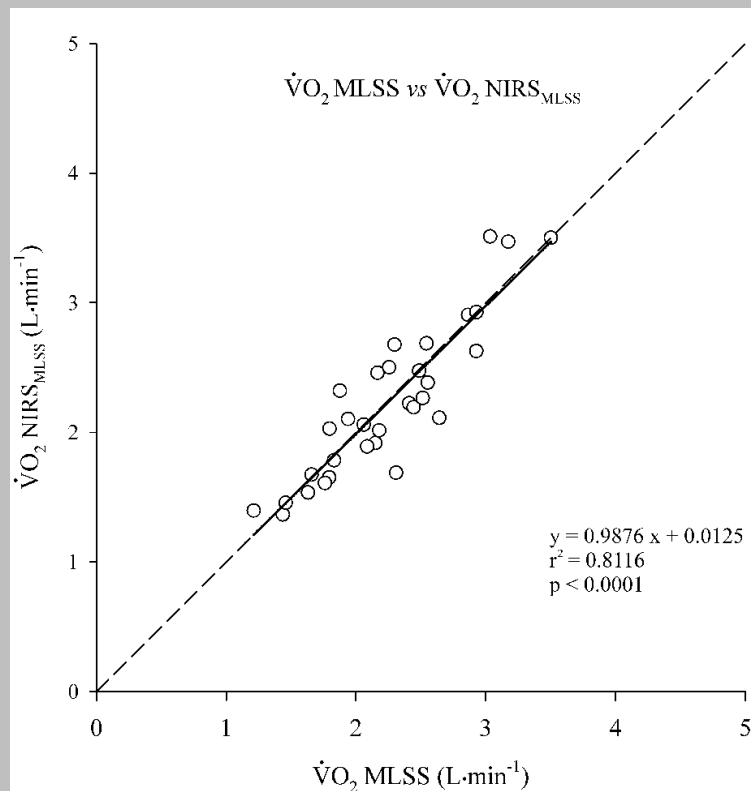


	#	Age (yrs)	Weight (kg)	Stature (m)	BMI	VO <sub>2max</sub> (mL·kg <sup>-1</sup> ·min <sup>-1</sup> )
Mean ± SD	32	48±17	76 ± 8	1.75±0.09	25±3	39.4 ± 11.4
Range		23-74	62-98	1.56-1.90	20-31	21.8-59.8

Can we determine critical intensity  
from deoxyHb profile?  
Correspondence with gold standard



	MLSS	deoxyHb <sub>BP</sub>
$\dot{V}O_2$ (L·min <sup>-1</sup> )	$2.25 \pm 0.54$	$2.23 \pm 0.59$





# deoxyHb<sub>BP</sub> and RCP

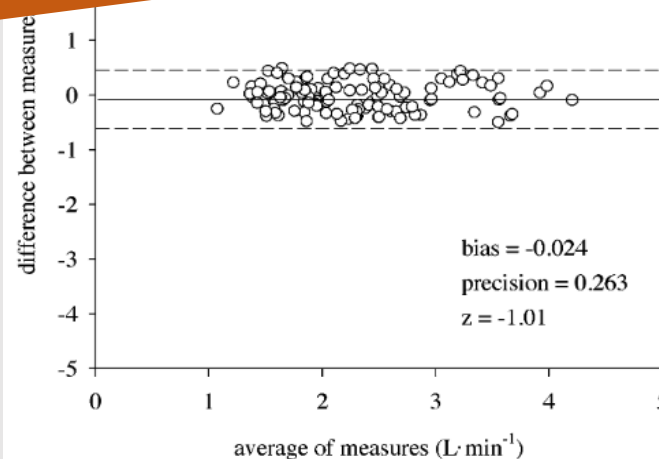
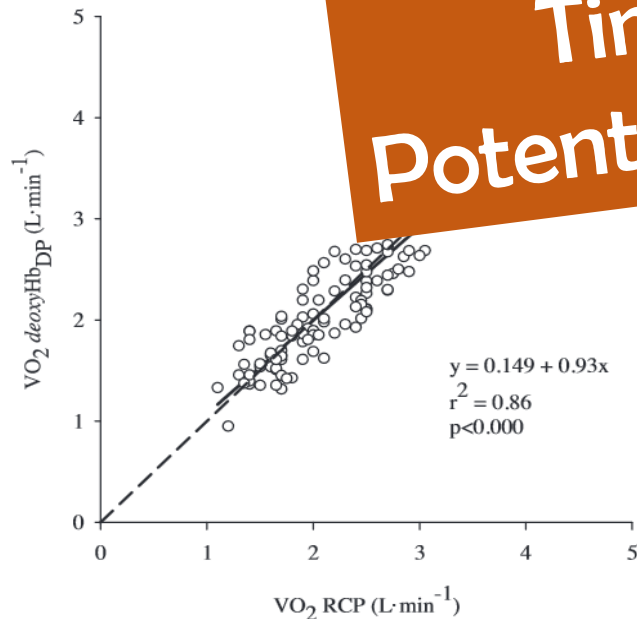
**Table 1**

Ramp incremental test

Urias JM, RPNB 2013

	Women
RCP	2.6 ± 0.4*
Δ[HHb]-BP	2.4 ± 0.4*

Accurate and precise  
Non-invasive  
Objective  
Time-efficient  
Potentially inexpensive

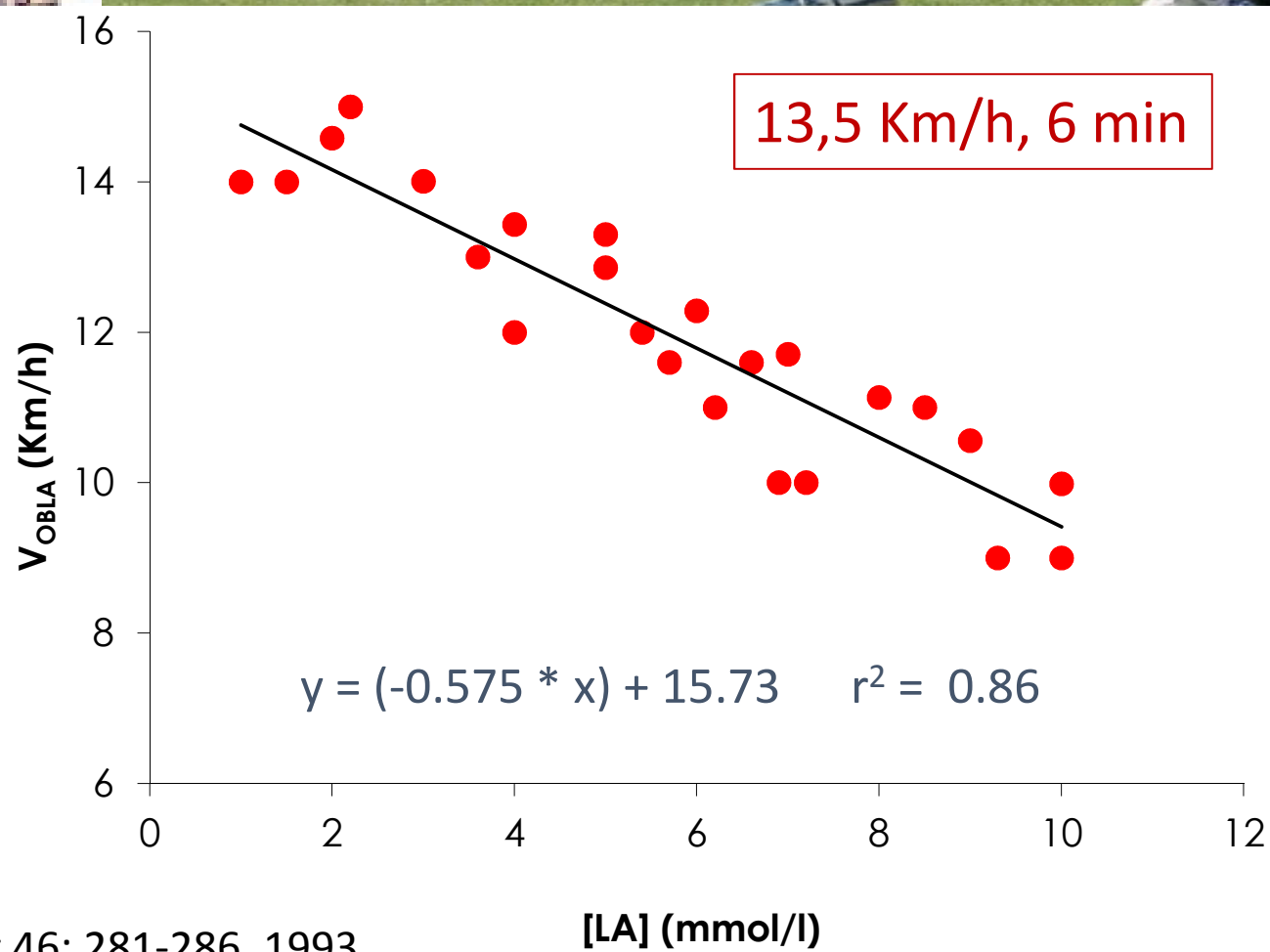


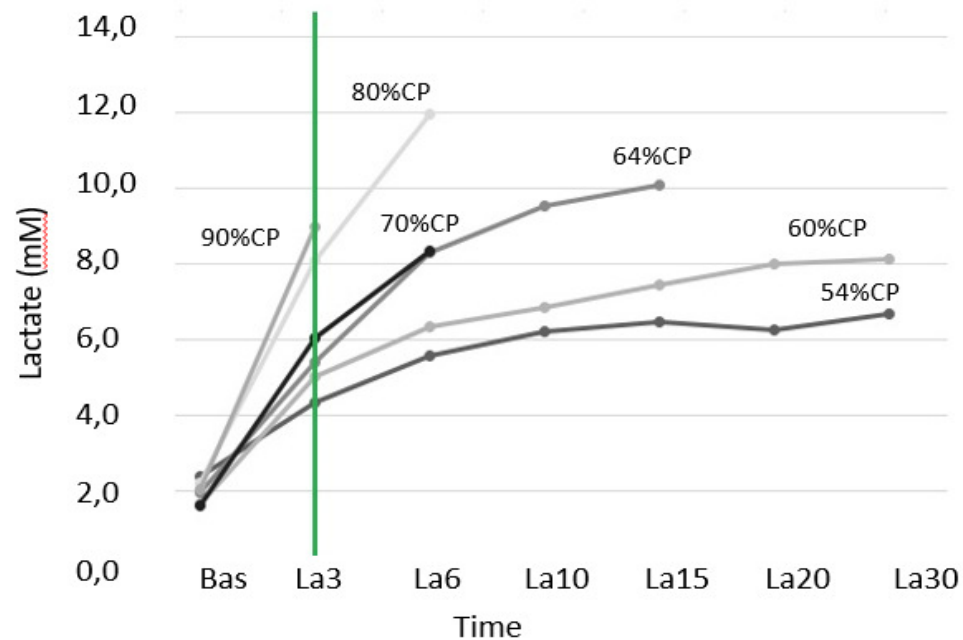
N=118

Can maximal  
effort be  
spared?

✓ EFFORT  
✓ RISK  
✓ COST



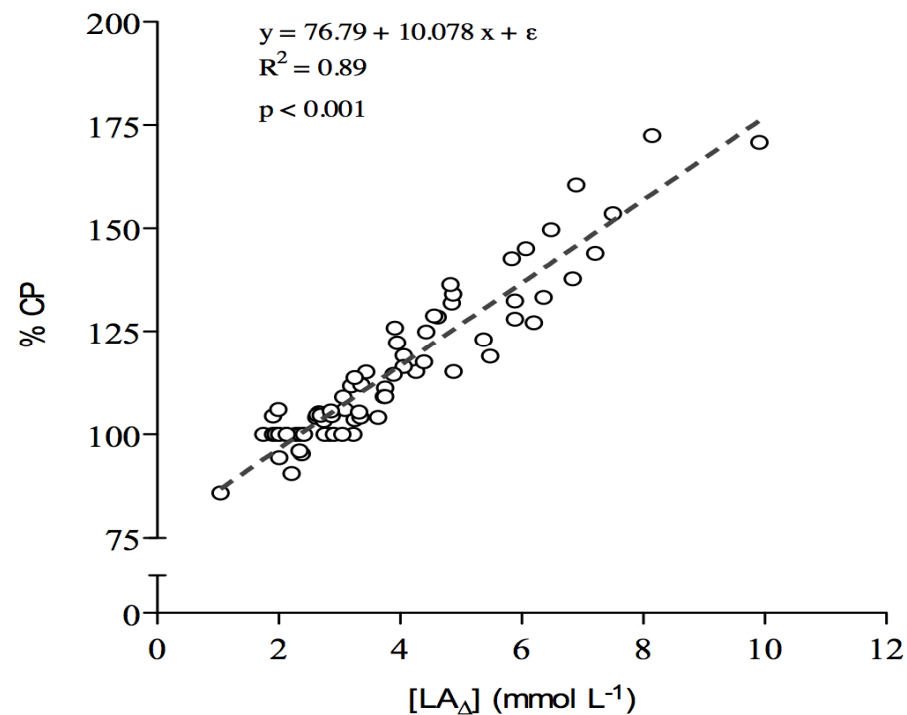


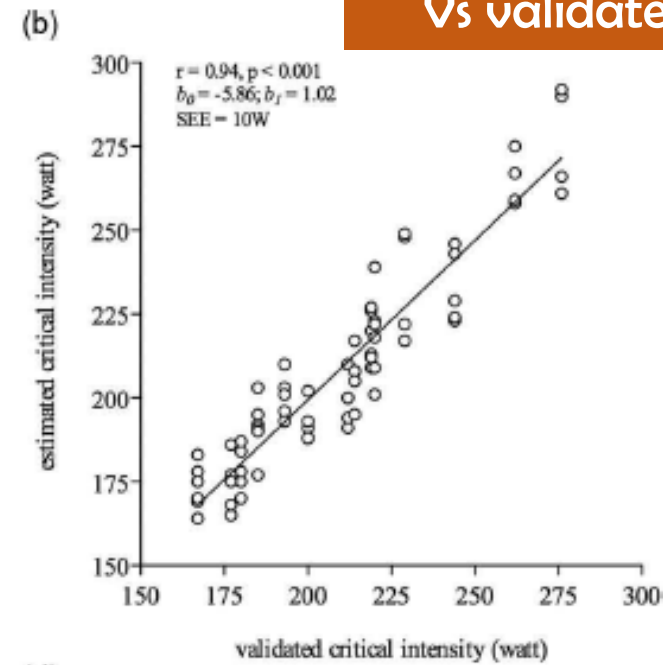
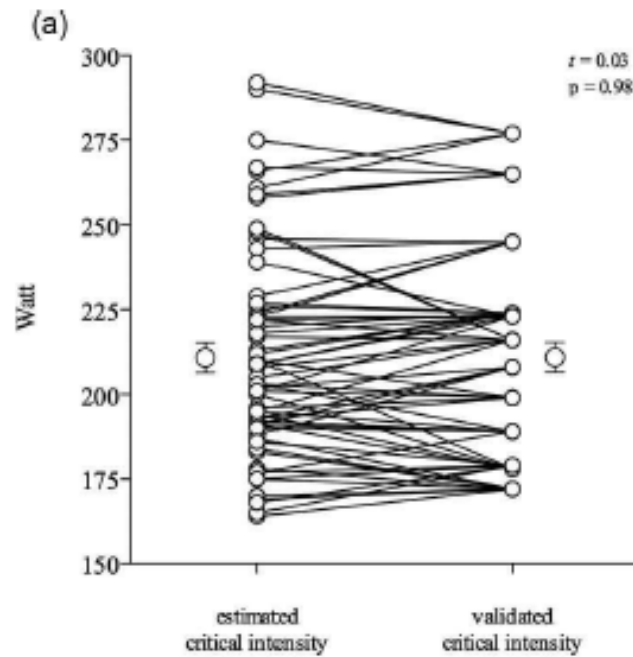


14 ♂

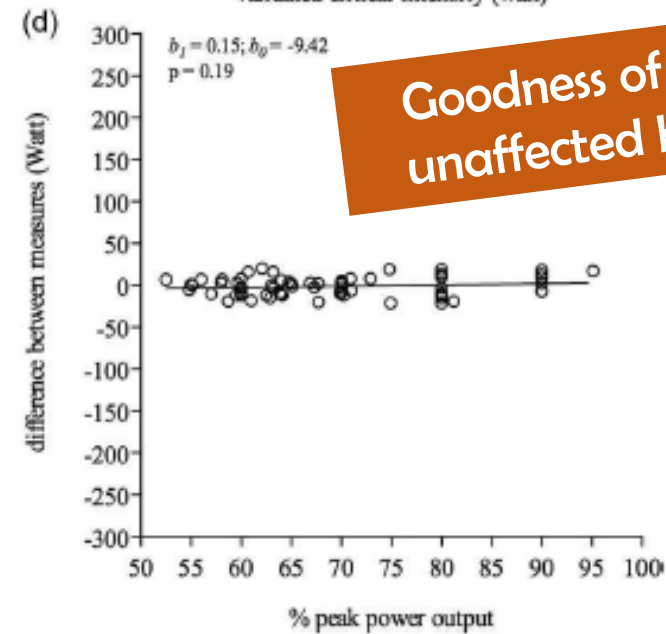
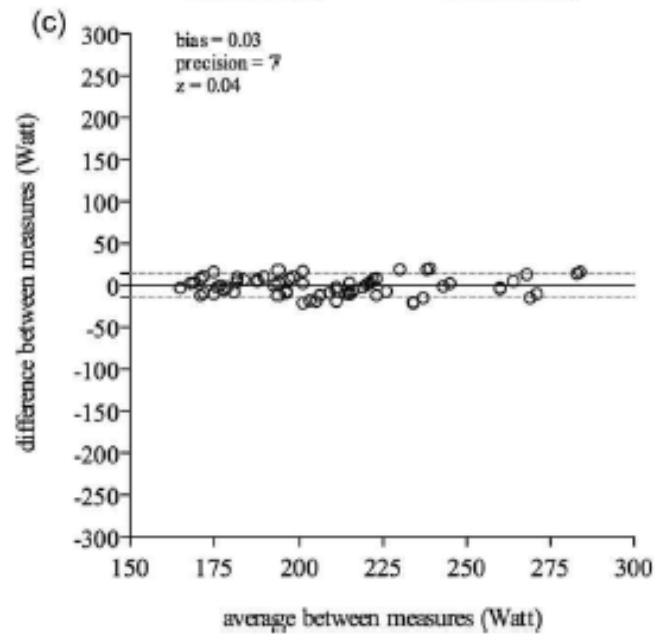
$31 \pm 7$  yrs  
(range 23-44)

$49 \pm 7$  ml\* $\text{Kg}^{-1}$ \*min $^{-1}$   
(range 44-65)





Vs validated intensity



Goodness of prediction  
unaffected by intensity



40 healthy ♂: 42±18 years (range 22-78), 48±8 ml Kg<sup>-1</sup> min<sup>-1</sup> (range 25-68)



## Validation of a single 3-min submaximal test to predict Critical Power



## ABSTRACT

[illegible]

INTRODUCTION:

Critical power (CP) demarcates the heavy/severe intensity boundary and is used for evaluation and monitoring of exercise capacity and for training design and exercise prescription.

The standard measuring technique requires either a physically demanding and time-consuming protocol (3-5 constant-load trials to exhaustion) or a maximal all out test, neither of which are applicable in all contexts and populations.

A recent pilot study demonstrated that CP is accurately and precisely predicted based on blood lactate [LA] accumulation at the third minute of a single submaximal non-exhaustive cycle ergometer exercise<sup>2</sup>.

We tested the hypothesis that CP can be accurately estimated in a large and heterogeneous population based on a single sub-maximal non-exhausting cycle ergometer trial and blood lactate accumulation.



**METHODS:**

- **SUBJECTS:** 40 healthy men: 42±18 years (age range 20-70), 48±8 mL·kg<sup>-1</sup>·min<sup>-1</sup> (age range 20-48)
- **PROTOCOL:** Performed 3-5 constant-power trials on a cycle ergometer, for CP determination (linear model based on three trials) and validation (stability of [La] and VCO<sub>2</sub> over time)
- **MEASUREMENTS:** capillary blood lactate concentration [La] was measured:
  - at baseline ([La]<sub>0</sub>)
  - at 3 min from exercise onset ([La]<sub>3</sub>)
- **CALCULATIONS:**
  - [La]<sub>3</sub> = [La]<sub>0</sub> + [ΔLa]<sub>3</sub> was calculated
  - [La]<sub>3</sub> was plotted as a function of exercise intensity (expressed as % of CP) and a linear relationship was obtained (Figure 1)
  - CP<sub>calc</sub> was computed based on the [La]<sub>3</sub> - %CP linear regression as:
 
$$\text{CP}_{\text{calc}} = \frac{[\text{La}]_3 - [\text{La}]_0}{\text{slope}} \times \frac{100}{\text{CP}_{\text{max}}}$$
 (where slope is the PD in not used for the individual test)
  - to account for the significant effect of age on the  $\text{CP}_{\text{calc}}$  (Figure 2 D), the following multiple linear equation was developed:
 
$$\text{age-adjustedCP}_{\text{calc}} = 63.191 + (0.796 \times \text{age}) + (0.551 \times \text{subject's age})$$
- **STATS:**
  - Validated CP<sub>calc</sub> and age-adjustedCP<sub>calc</sub> were compared by correlation and Bland-Altman analysis. Statistical significance was set at p < .05

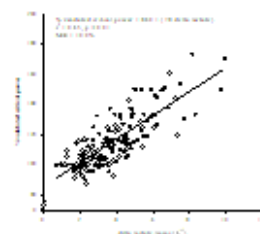


Figure 1: Linear regression between the individual values of blood lactate accumulation measured at the 3<sup>rd</sup> minute during a constant work exercise and the value of power output of the test expressed as % of validated CP. The regression line is displayed along with the regression equation parameters.

RESULTS:

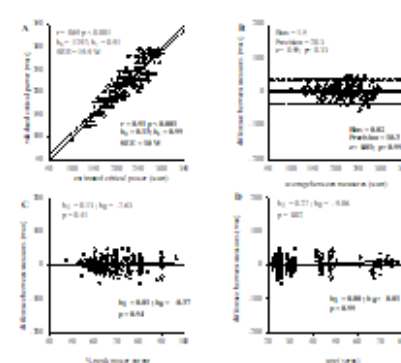


Figure 2:

A. Individual validated CP values are plotted as a function of *acCP* (○) and *supernovCP* (●). The identity (dashed) and the regression (solid) line are displayed along with the coefficient of determination.

B. Individual differences between the values of validated critical power ( $CP$ ) and  $uCP$  ( $\Delta$ ) and  $u_{predicted}CP$  ( $\bullet$ ) are plotted as a function of the average of the two measures. The solid line corresponds to the average difference between measures (i.e.  $\Delta uCP$ ) while the dashed line corresponds to the limits of agreement.

C. Individual differences between CP and reCP (○) and nonreCP (●) are plotted as a function of the  $\beta_{0,CP}$  used to generate the t-distribution tests. The dashed and solid lines represent the average  $\beta_{0,CP}$  as a function of exercise intensity, with a slope not different from zero ( $p < 0.05$ ).

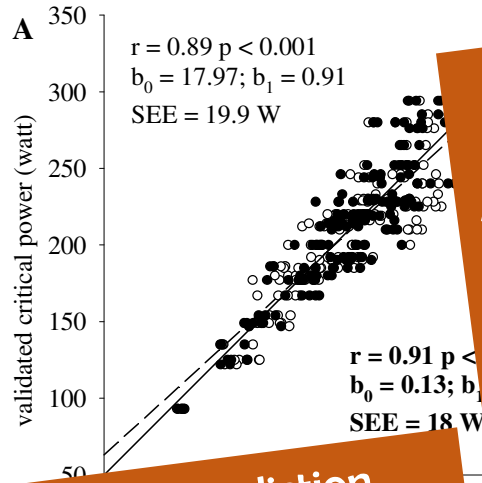
D. Individual differences between CP and *acCP* [●] and *apromotedCP* [■] are plotted as a function of age. The dashed line, representing the average bias for *acCP* [●] values as a function of the subject's age, presents a significant slope. However, when *apromotedCP* [■] values are used, the slope of the average bias is not different from zero ( $p < 0.05$ ).

### CONCLUSIONS:

This newly developed method offers a practical and valid alternative to traditional, time consuming and physically demanding CP determination protocols.

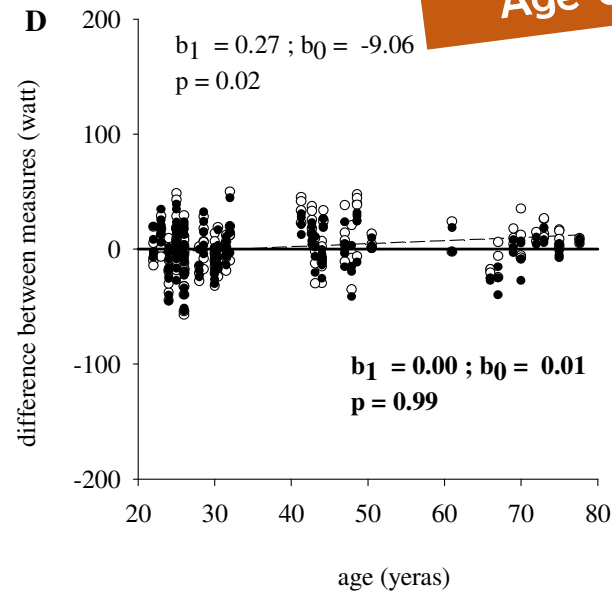
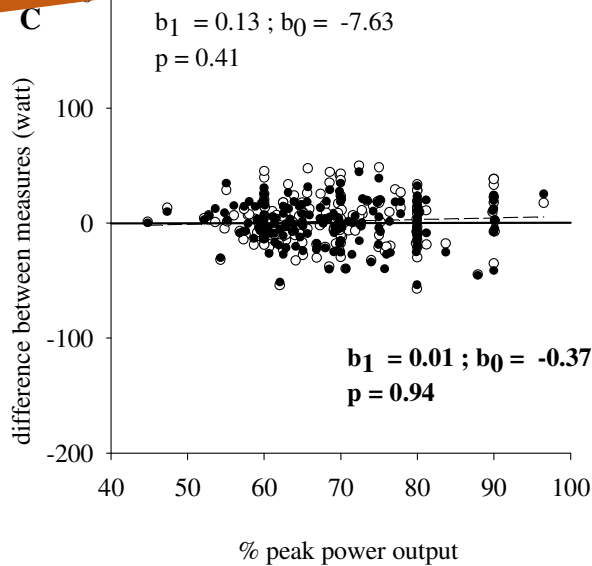
#### REFERENCES

1. Geir DA, Fontana PT, Robertson TC, Munkin JA, Patterson CH, Goodrich JM, Puglisi S. Exercise Intensity Thresholds: Identifying the Boundaries of Sustainable Performance. *Med Sci Sports Exerc*. 43(10):1810-20, 2011
2. Fontana PT, Calozi AM, Geir DA, Munkin JA, Puglisi S. Identification of critical intensity from a single lactate measure during a 3-min, submaximal cycle-ergometer test. *Journal of Sports Sciences*. 2012;30:1-3



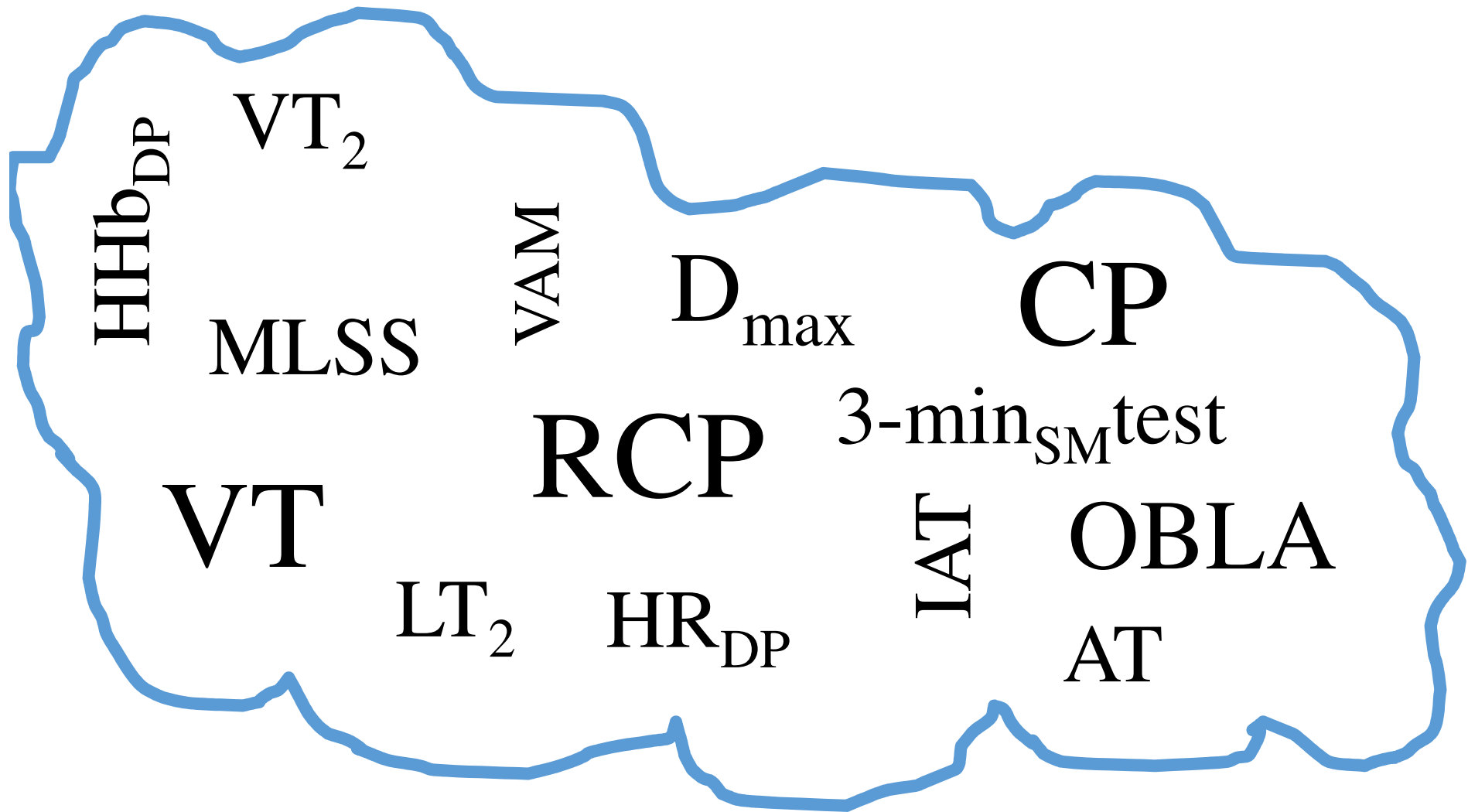
**Sub-maximal!**  
**Accurate and precise**  
**Non-invasive**  
**Objective**  
**Time-efficient**  
**Inexpensive**

**Goodness of prediction  
 unaffected by intensity**

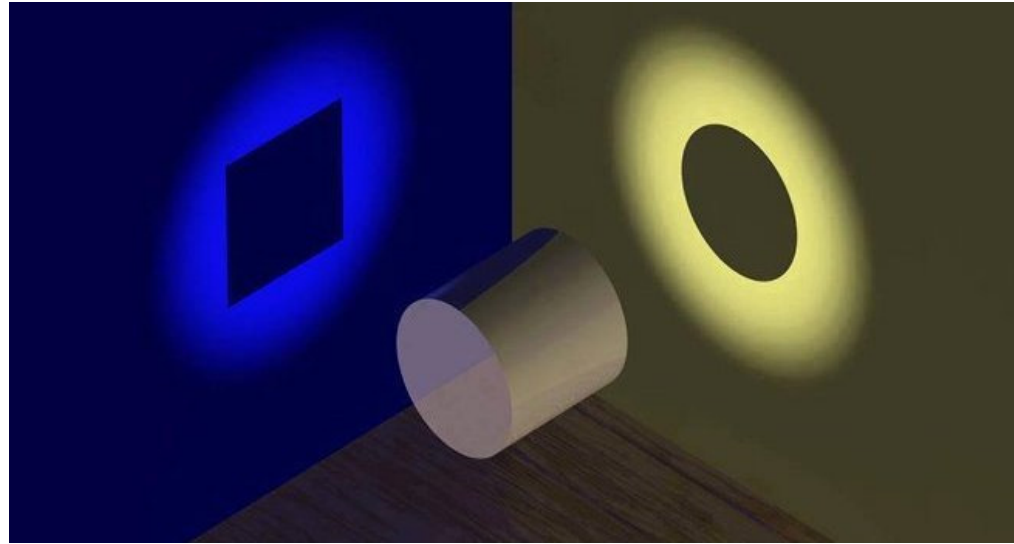


**effect of age on prediction**  
**Age-corrected equation**

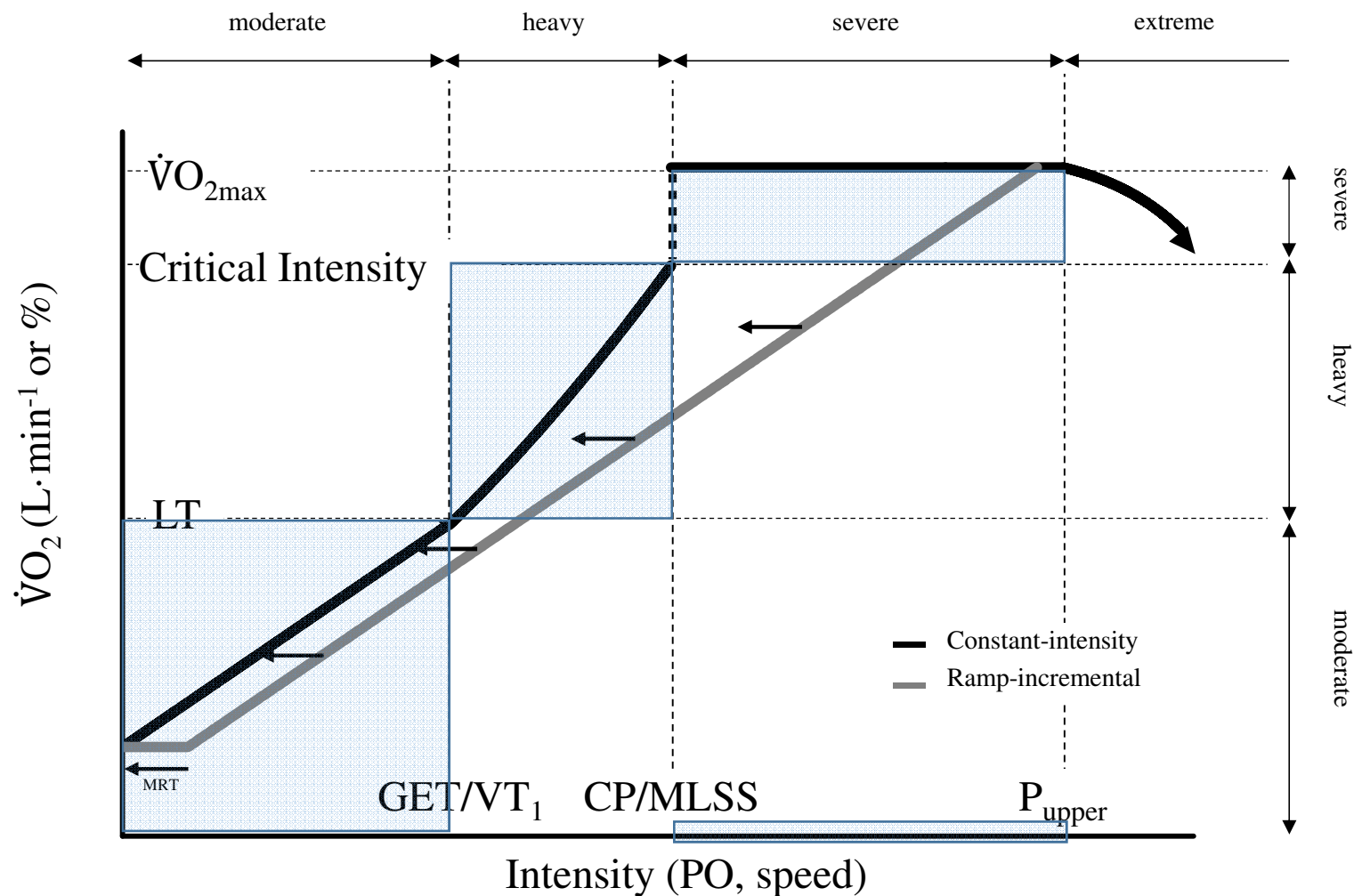
# Correspondance between measures?



Same thing from different angles?

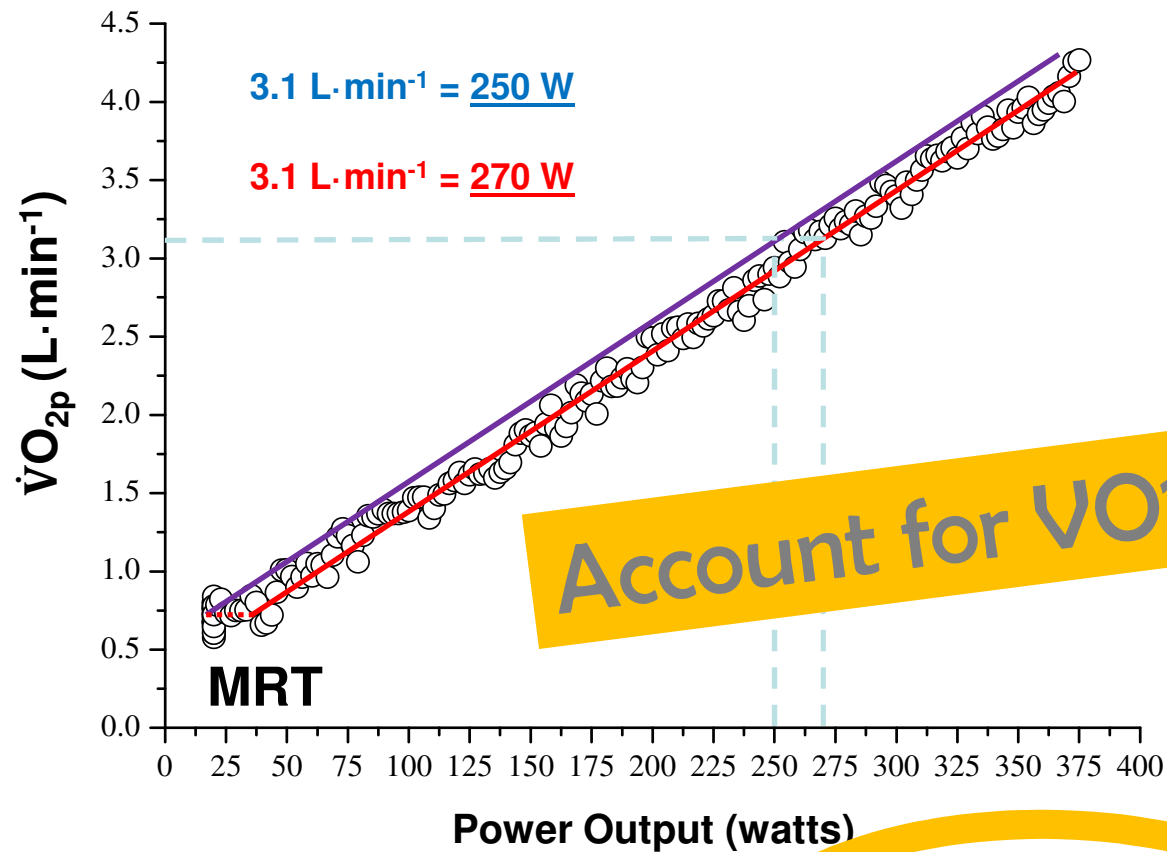


# $\dot{V}O_2$ - exercise intensity in Incremental vs Constant PO exercise The issue of “Translation”



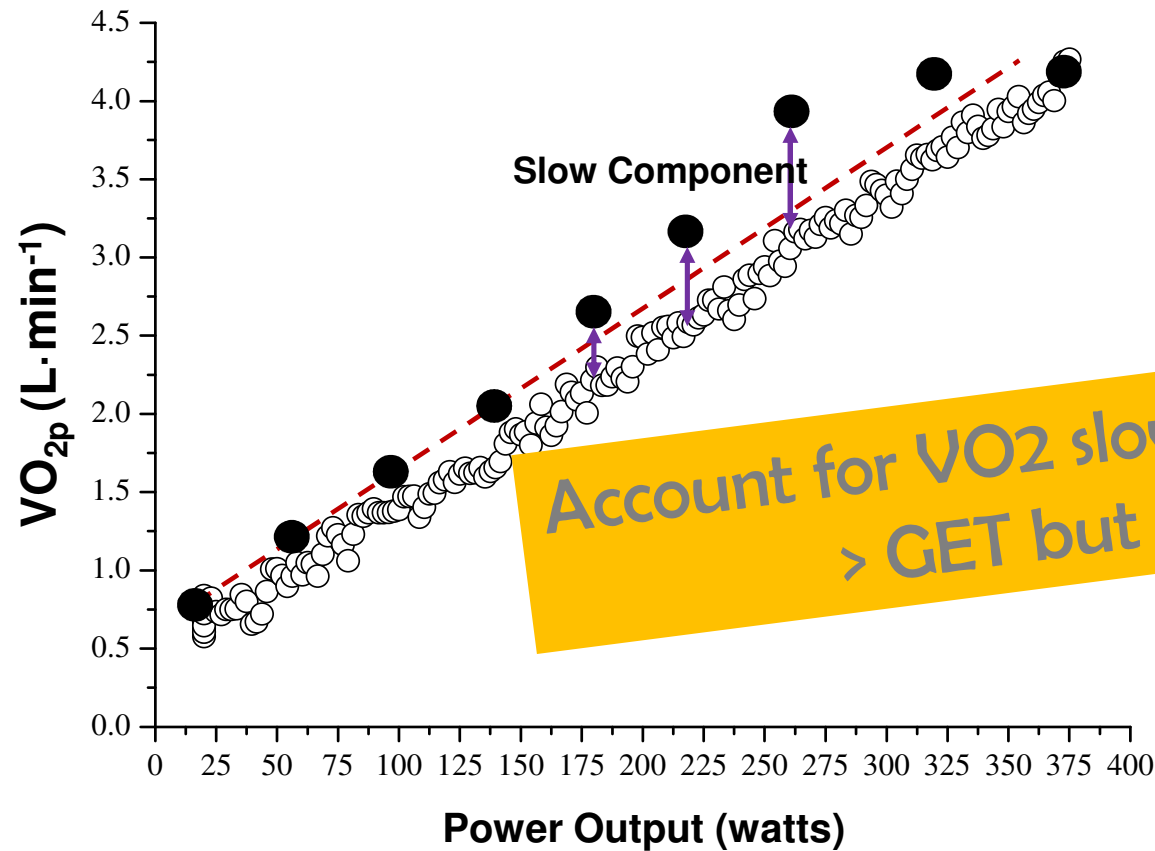


## Incremental exercise → Constant PO



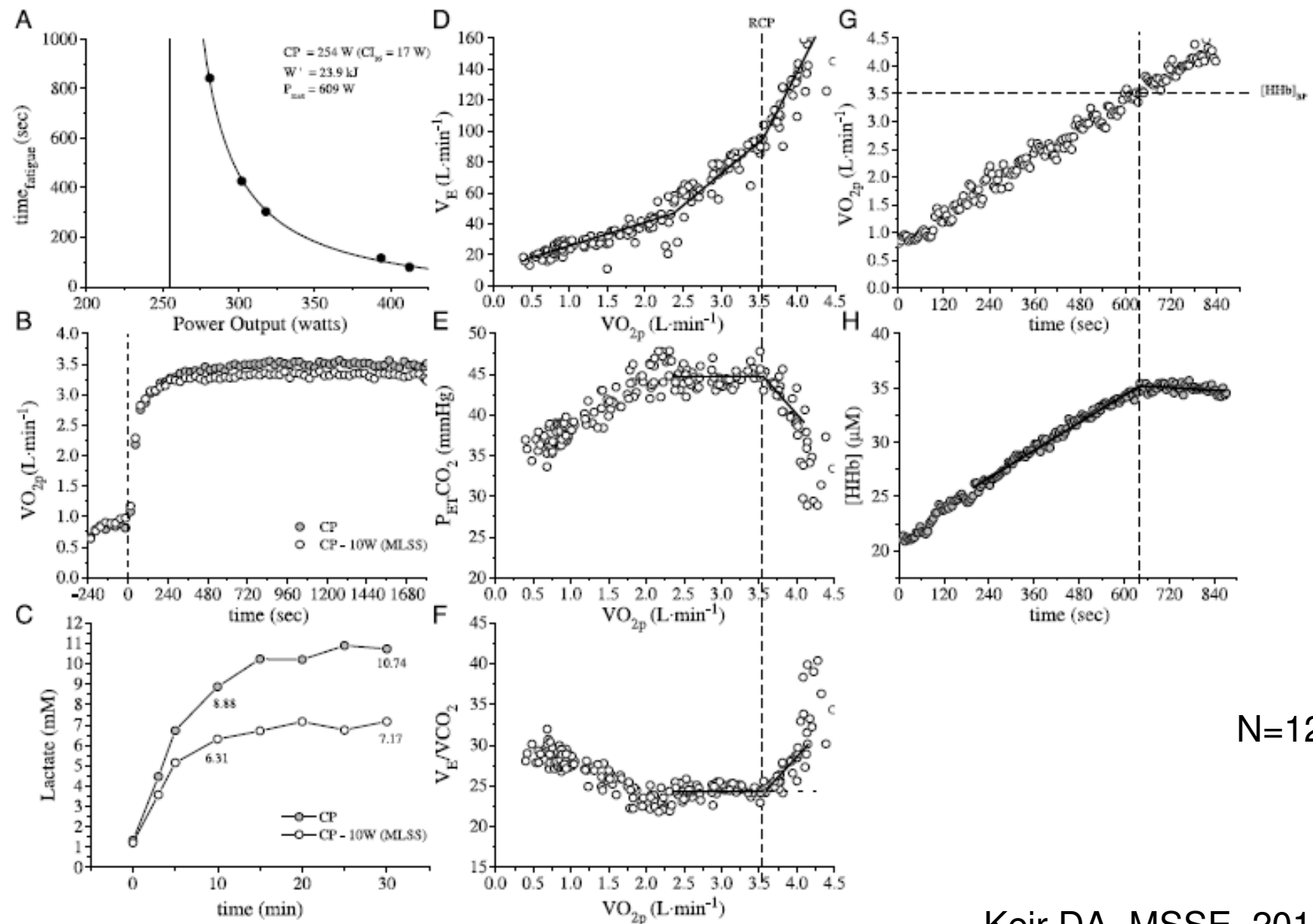
corrected  $W = \frac{(\dot{V}O_2\text{-intercept})}{\text{slope}} - \frac{\Delta W}{\Delta \text{time}} * \text{MRT}$

## Incremental exercise → Constant PO



$$\text{corrected } W = - (\text{VO}_2 - \text{VO}_2 @ \text{GET}) * \frac{(\text{slope}_2 - \text{slope}_1)}{(\text{slope}_2 * \text{slope}_1)}$$

# CP, RCP, MLSS and HHB<sub>BP</sub> occur at equivalent VO<sub>2</sub>?



	CP	MLSS	RCP	[HHb] <sub>BP</sub>
$\dot{V}O_{2p}$ (L·min <sup>-1</sup> )	3.29 ± 0.48	3.27 ± 0.44	3.34 ± 0.45	3.41 ± 0.46
PO (W) <sup>a</sup>	226 ± 45	223 ± 39	262 ± 48 <sup>*,**</sup>	273 ± 41 <sup>*,**</sup>
HR (bpm)	162 ± 10	161 ± 10	158 ± 9	160 ± 8

CP, MLSS, RCP and HHB<sub>BP</sub>  
 identify an identical «metabolic boundary»  
 between sustainable and unsustainable exercise

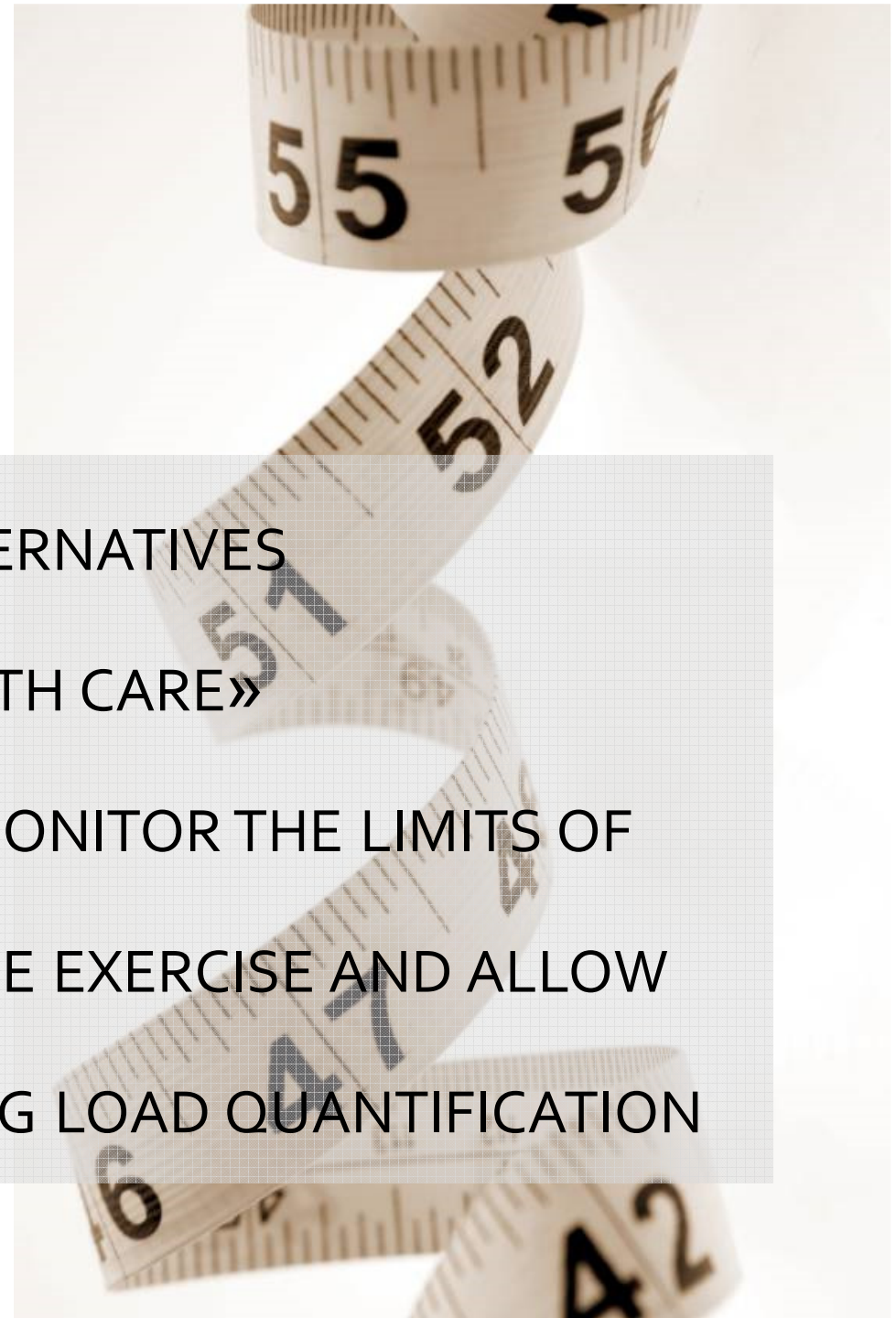
Possible common physiological mechanism  
 Interchangeable «with care»

# How to measure heavy- severe boundary

✓ WE HAVE «SMART» ALTERNATIVES

✓ INTERCHANGEABLE «WITH CARE»

TO DETERMINE AND MONITOR THE LIMITS OF  
TOLERABLE ENDURANCE EXERCISE AND ALLOW  
INDIVIDUALISED TRAINING LOAD QUANTIFICATION





Individual Measure of heavy-severe boundary  
«Translate» it correctly

=

Essential for exercise quantification and  
development of evidence-based,  
individualised exercise prescription to improve  
exercise tolerance





Carlo Capelli  
Enrico Tam  
Luca Dal Sacco  
Paolo Bruseghini  
Federico Fontana  
Giorgia Spigolon  
Alessandro Colosio



Don Paterson  
Juan Murias  
Daniel Keir



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