Estimating maximal metabolic steady state using critical power: which model is best?

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Why CP as the MMSS standard?

- CP model: mathematical model of the hyperbolic power-time relationship

- Built from three or more maximal efforts

- Two parameters obtained: CP and W'

- Threshold between steady state and non-steady state intensities

- Discrete metabolic changes in $\dot{V}O_2$ kinetics, PCr, muscle lactate, pH
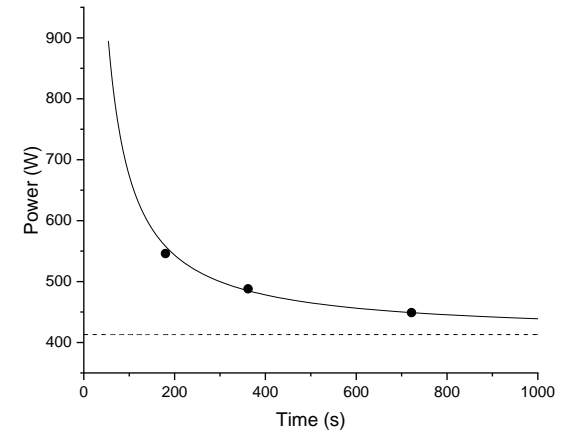
Figure 1 Hyperbolic relationship of time and power obtained from three time-trials (black dots) for CP estimation (dashed line)
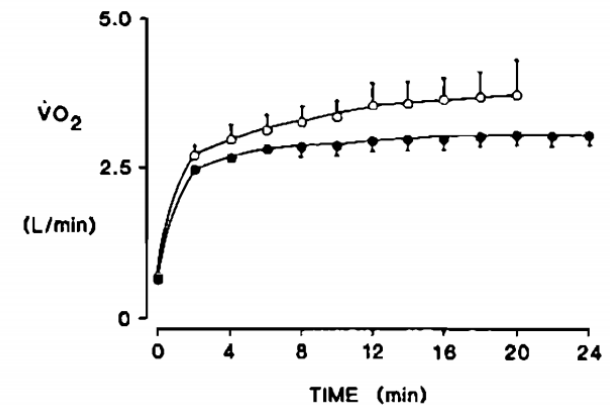
Figure 2 $\dot{V}O_2$ above CP (white circles) and at CP (black circles). From: Poole et al., 1988.

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Differences among CP models

- There are various CP models
- The models provide different CP estimates:

Table 1 CP estimates from different models.
From: Bergstrom *et. al.*, 2014

Model	CP (W)
CP_{exp}	198 ± 41
$CP_{1/time}$	184 ± 43
CP_{linear}	181 ± 42
CP_{2-hyp}	176 ± 40
CP_{3-hyp}	174 ± 41

- Aim: finding which model is best for MMSS estimation

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Methods

- N=11

- 1st visit CP testing (12-, 6- and 3-min TTs); 3 subsequent visits 30-min bouts at each CP estimate

- $\dot{V}O_2$, lactate and RPE measurements

- Two-way repeated measures ANOVA and Bonferroni correction

Results

Table 2 CP and standard error of the estimate expressed as %, W' and the standard error of the estimate expressed as %, and the total error of the model.

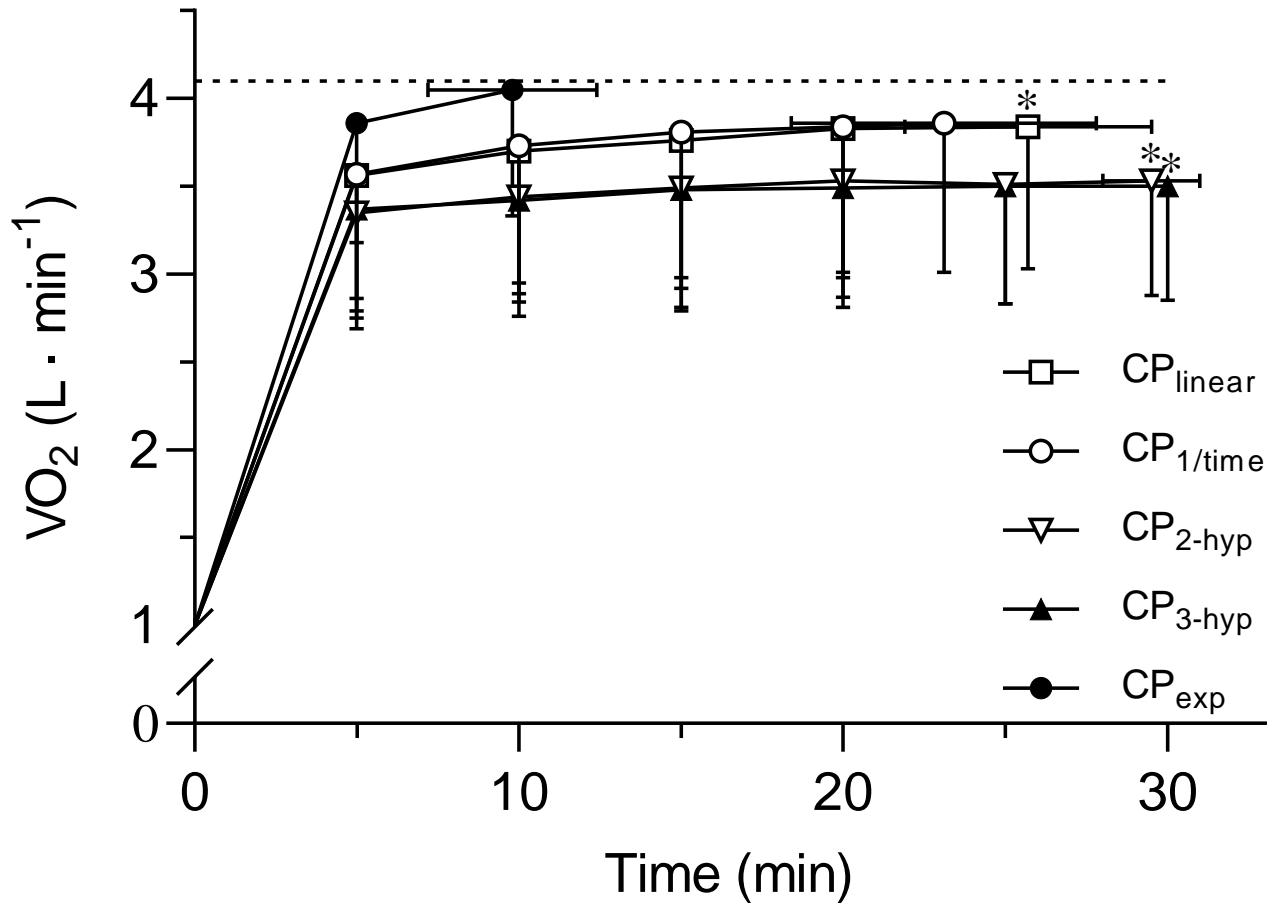|	CP (W)	CoV (%)	W' (kJ)	CoV (%)	Total error (%)
CP$_{linear}$	270 ± 64	1.6 ± 1.2	19.0 ± 1.9	10.11 ± 6.2	11.71 ± 7.4
CP$_{1/time}$	272 ± 66	2.1 ± 1.6	17.9 ± 1.7	8.4 ± 5.5	10.5 ± 7.1
CP$_{2-hyp}$	266 ± 65	1.2 ± 0.9	20.3 ± 2.1	9.5 ± 5.6	10.7 ± 6.5
CP$_{3-hyp}$	262 ± 63	1.0 ± 1.0	24.7 ± 2.3	7.2 ± 5.6	8.2 ± 6.6
CP$_{exp}$	303 ± 69	4.4 ± 1.2	–	–	–

Results

Figure 3 $\dot{V}O_2$ response to exercise at CP_{linear}, $CP_{1/time}$, CP_{2-hyp}, CP_{3-hyp}, and CP_{exp}. $\dot{V}O_2$ did not change significantly after stabilisation. *End-exercise $\dot{V}O_2$ significantly lower than $\dot{V}O_{2peak}$.

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Results

Table 3   Time for $\dot{V}O_2$ to stabilise, percentage of $\dot{V}O_{2peak}$ at which $\dot{V}O_2$ stabilises, slope of $\dot{V}O_2$ after stabilisation, and time to exhaustion (TTE) for each model.

	VO_2 stabilisation time (min)	Percentage of VO_{2peak} (%)	VO_2 slope (mL $\cdot$ min^{-1} $\cdot$ min^{-1})	TTE (min)
CP_{linear}	14.1 ± 4.0	94 ± 5[a]	0.25 ± 1.08	25.7 ± 3.8
$CP_{1/time}$	13.0 ± 3.3	94 ± 6	0.34 ± 0.80	23.1 ± 4.7[b]
CP_{2-hyp}	11.7 ± 2.6	87 ± 4[a]	1.07 ± 1.01	29.5 ± 1.5
CP_{3-hyp}	11.1 ± 4.2	86 ± 4[a]	0.71 ± 1.55	30.0 ± 0.0
CP_{exp}	6.2 ± 1.8	98 ± 2	-0.17 ± 2.10	9.8 ± 2.6[b]

[a] Significantly lower than $\dot{V}O_{2peak}$. [b] Significantly shorter than 30 minutes.
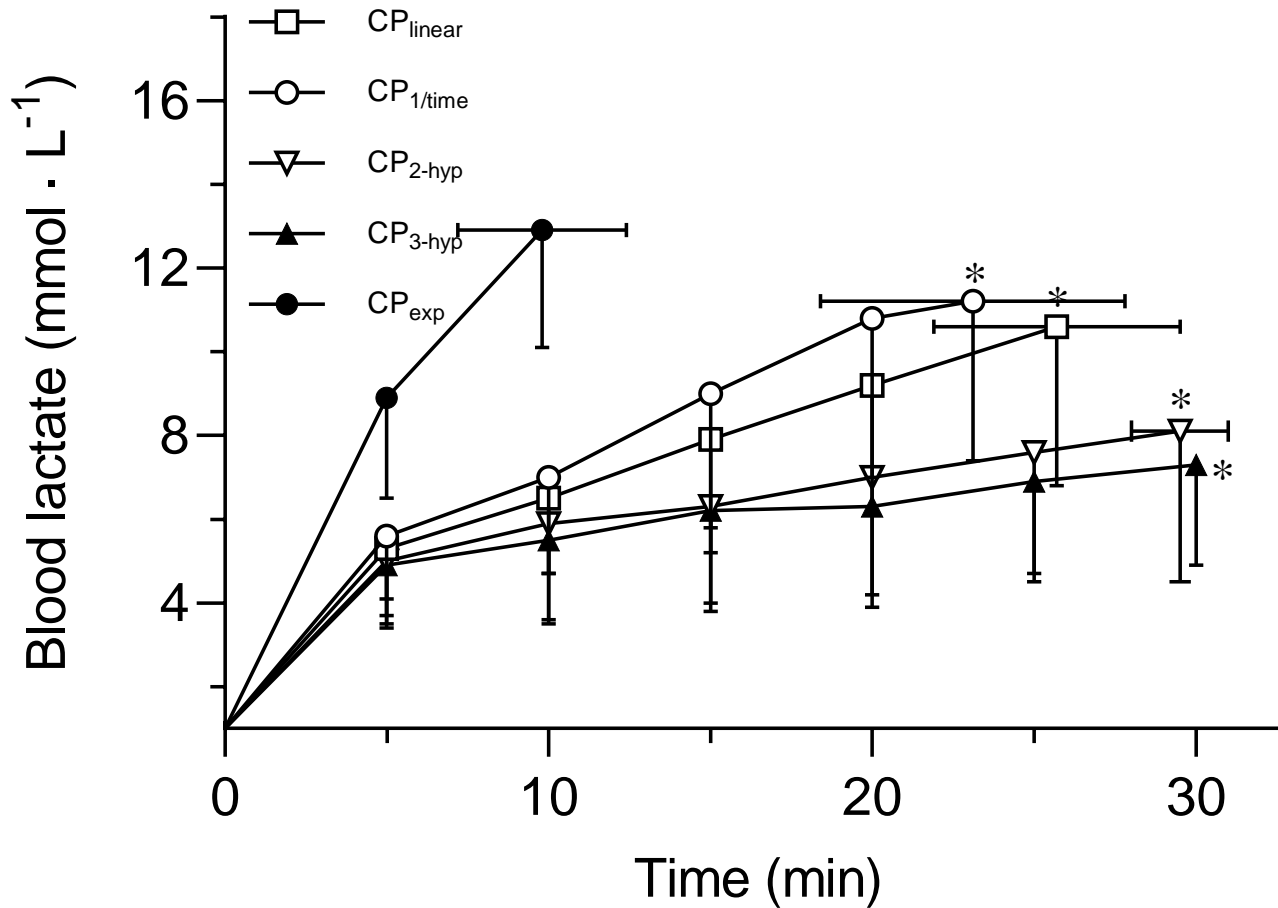
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Results

Figure 4   Blood lactate response to exercise at CP_{linear}, $CP_{1/time}$, CP_{2-hyp}, CP_{3-hyp}, and CP_{exp}. [*]Significant increase in lactate from minute 10 to end of exercise.
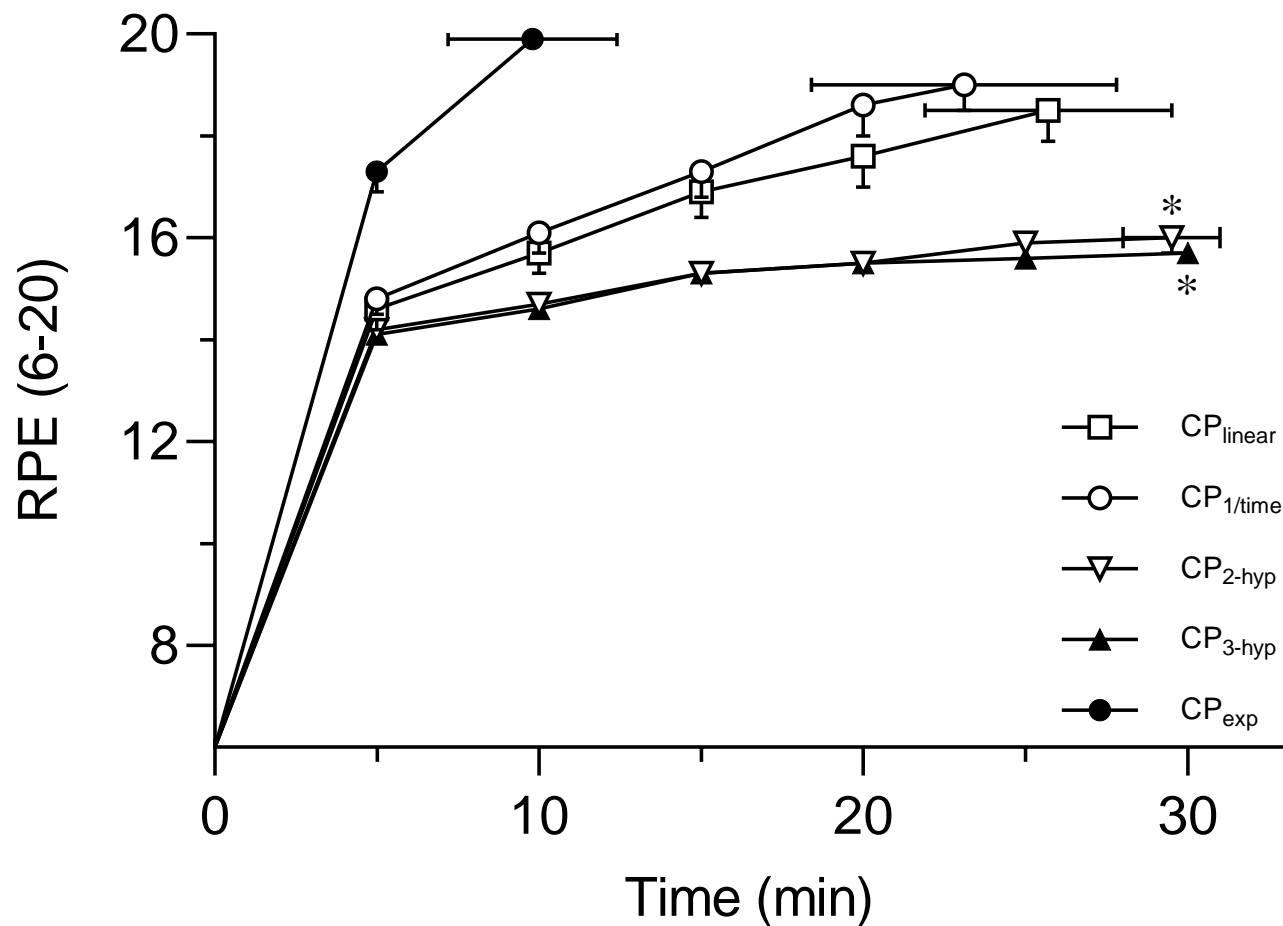
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Results

Figure 5   RPE when exercising at CP_{linear}, $CP_{1/time}$, CP_{2-hyp}, CP_{3-hyp}, and CP_{exp}. *Significantly lower than maximal perceived exertion (20).

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Discussion

- RPE and $\dot{V}O_2$ achieved a steady state at a submaximal level for $CP_{2\text{-hyp}}$ and $CP_{3\text{-hyp}}$

- Lactate was non-steady for every model

- Lactate was not representative of perception nor $\dot{V}O_2$

- There were individual variations in the adequacy of models

- $CP_{2\text{-hyp}}$ and $CP_{3\text{-hyp}}$ provide the best CP calculations for MMSS estimation

THANK YOU