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

Aitor Altuna[1], James Hopker[1]

[1] School of Sport and Exercise Sciences, University of Kent, Kent, United Kingdom

Abstract: It has been advocated that critical power (CP) should be considered the gold standard to determine the maximal metabolic steady state (MMSS) (Jones *et al.* 2019). However, the choice of the model affects the estimation of CP (Mattioni Maturana *et al.* 2018). The purpose of this study was to investigate which of the models, exponential (CP_{exp}), 3-parameter hyperbolic ($CP_{3\text{-}hyp}$), 2-parameter hyperbolic ($CP_{2\text{-}hyp}$), linear (CP_{linear}), and inverse of time ($CP_{1/time}$), estimates MMSS best. Eleven male participants (Age: 31 ± 11 years, Body mass: 70.5 ± 5.6 kg) performed three time-trials (12-, 6-, and 3-min long) to determine CP from the five models. On three subsequent visits, participants cycled for 30-min, or until task failure, at the CP estimated by each model. CP_{exp} estimated the highest CP (303 ± 69 W), followed by $CP_{1/time}$ (272 ± 66 W), CP_{linear} (270 ± 64 W), $CP_{2\text{-}hyp}$ (266 ± 65 W) and $CP_{3\text{-}hyp}$ (262 ± 63 W). Oxygen uptake ($\dot{V}O_2$) stabilised at a significantly lower value than peak $\dot{V}O_2$ ($\dot{V}O_{2peak}$) during exercise at CP_{linear}, $CP_{2\text{-}hyp}$, and $CP_{3\text{-}hyp}$ (94 ± 5 %, P=0.041; 87 ± 4 %, P<0.001; 86 ± 4 %, P<0.001, respectively). $\dot{V}O_2$ stabilisation was not significantly different to $\dot{V}O_{2peak}$ during exercise at CP_{exp} and $CP_{1/time}$ (98 ± 2 %, P=1.000; 94 ± 6 %, P=0.130, respectively). For all conditions, $\dot{V}O_2$ did not increase significantly after stabilisation (P=1.000). Rate of perceived exertion significantly increased over time during exercise at $CP_{1/time}$ (P<0.001) and CP_{linear} (P=0.006) but was unchanged between minute 15 and end-exercise during $CP_{2\text{-}hyp}$ (P=0.762) and $CP_{3\text{-}hyp}$ (P=0.569). Lactate increased significantly in the last 10, 15, and 20 minutes of the exercise for all models. No model had an increase of ≤ 1 mmol · L^{-1} from minute 10 to 30. These results suggest that $CP_{2\text{-}hyp}$ or $CP_{3\text{-}hyp}$ should be favoured when CP is used to assess MMSS.

Keywords: threshold; oxygen uptake; lactate; endurance

References:

Jones, A.M. *et al.* (2019). The maximal metabolic steady state: redefining the 'gold standard'. *Physiological Reports* **7**:1–16.

Mattioni Maturana, F. *et al.* (2018). Critical power: How different protocols and models affect its determination. *Journal of Science and Medicine in Sport* [Online] **21**:742–747. Available at: https://doi.org/10.1016/j.jsams.2017.11.015.