A critique of “A critical review of critical power”
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Dear Editor,

We read the recent review article by Mr Raffy Dotan entitled “A Critical Review of Critical Power” with much interest. This review examined the critical power (CP) concept according to the original (and what we will argue to be inaccurate) interpretation of the physiological significance of a mathematical parameter. This interpretation was formulated nearly 60 years ago and suggests that exercise performed “at” CP, the power-asymptote of the hyperbolic power–time relationship, should be sustainable “for a very long time without fatigue”. In this response, we will argue that this interpretation is not consistent with the empirical data published within the last 2 decades and thus not consistent with the current understanding of the CP model. It is our contention that in viewing the CP concept through this historical lens, this review does not provide a contemporary critique.

First, we would like to address the idea that exercise “at” CP is sustainable “indefinitely” or “for a very long time without fatigue”. Whilst modelling the power-duration relationship permits the estimation of CP to 1 W, we remind the reader that experimental evidence suggests that CP occurs within a range provided by the 95% confidence limits of the CP estimate. This point is evidenced, rather eloquently, by Pethick et al. (2020) who show that physiological responses indicative of both heavy- and severe-intensity exercise occur at work rates within these statistical limits. Additionally, we would also highlight that CP is not fixed and instead has been shown to decline during endurance exercise (Clark et al. 2019). Thus, exercise “at” CP is inherently ambiguous. However, even if one were theoretically able to exercise “at” CP, as humans are not immortal, it is not possible to maintain even a resting metabolic rate ad infinitum, let alone the elevated metabolic rates associated with exercise. Therefore, we propose that an appraisal of the CP concept based on how long exercise “at” CP can be maintained is a fundamentally flawed endeavour.

This review also highlights that CP differs from the maximal lactate steady state (MLSS) and uses this to support the assertion that CP is therefore not a valid indicator of the maximal metabolic steady state (MMSS). This incongruity was the topic of a recent review, in which Jones et al. (2019) present evidence to explain that: (1) this discrepancy is methodological; (2) as presently defined, MLSS underestimates the maximal metabolic steady state (MMSS); (3) CP defines the boundary between discrete exercise intensity domains within which steady state (namely, heavy exercise intensity domain) and non-steady state (i.e., severe exercise intensity domain) behaviour in skeletal muscle metabolic, blood acid–base and pulmonary O2 uptake responses to exercise can be observed (Black et al. 2017). Resultantly, it is argued that CP, and not the MLSS, should be considered the gold-standard in defining MMSS. Dotan’s review seemingly disagrees with these arguments due to exercise “at” CP being “unsustainable” and, instead, proposes two alternate methodologies for the estimation of MMSS: (1) the modified lactate minimum test; and (2) the reverse lactate threshold test. However, we would caution that these alternatives lack empirical evidence to support their use, as both the validity and sensitivity of these approaches has yet to be adequately

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investigated. Thus, it seems inappropriate to suggest that either of these methodologies “provide comparable or much better estimates of the true heavy-severe exercise boundary than can critical power”.

Where we do agree with Mr. Dotan is that the appropriate selection of prediction trials is of utmost importance for the valid determination of CP (and W’). However, rather than providing evidence to refute the basis of CP (and W’) determination, we consider that the substantial existing work provides the necessary guidance for accurate and valid estimation of these parameters. Briefly, identification of CP (and W’) necessitates a “top-down” approach, in which a series (typically 3–5) of constant work rate (or speed) trials are performed, within the severe-intensity domain, to volitional exhaustion. Alternatively, fixed duration or distance trials may also be performed where individuals complete as much work in the given time, or complete the specified distance as quickly as possible. Importantly, the duration of trials used to construct the power–duration curve are far from arbitrary; rather, they are judiciously selected to ensure the attainment of $\dot{V}O_2$ max and complete utilisation of W’ at task failure; both of which are paramount for the inclusion of any exercise trial within the CP model. To facilitate the attainment of $\dot{V}O_2$ max, exercise work rates eliciting task failure within a range of ~2–3 min to ~12 min are advised (Jones et al. 2019). An alternative to this multi-trial approach is to perform a 3-min all-out test where the individual is required to perform an all-out sprint, resulting in the utilisation of W’ in the early portion of the test, the attainment of $\dot{V}O_2$ max, and power output gradually falling with time until it asymptotes at a power equal to CP (Clark et al. 2019). CP derived with 2-parameter models from both the performance of prediction trials and the 3-min all-out test has been shown to provide valid estimates of the MMSS (Black et al. 2017; Vanhatalo et al. 2016).

Finally, we wish to highlight additional benefits of the CP concept. Not only does the model provide a validated estimate of the MMSS but also the finite work capacity (namely, W’) that can be performed above CP. Thus, unique amongst estimates of MMSS, the CP model enables highly accurate prediction of exercise performance within the severe-intensity domain (~2 to 20 min). The CP model, therefore, provides unique insights into an individual’s high-intensity exercise tolerance, is valuable for designing individually optimised interval training programmes, and for the longitudinal monitoring of an athlete’s progress.

We acknowledge that a key test of any scientific theory is its ability to withstand criticisms from researchers within the field. However, it is vitally important that such criticisms are grounded in sound theory and appreciate both the origins and the development of a research field.

Author contributions All authors have contributed equally to this Letter to the Editor, and approve for its submission to the journal.

References


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