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## Over 55 years of critical power: Fact

Dear Editor-in-Chief,

We read with interest the paper by Gorostiaga et al.<sup>1</sup> entitled “Over 55 years of critical power: Fact or artifact?”. It is our opinion, however, that the conclusions drawn by the authors (chiefly that critical power should be considered a mathematical artifact) stem from a grave misunderstanding of the critical power concept and its underlying physiology. The authors’ position is based upon a number of erroneous arguments (i) that critical power fails its own “definition” of being sustainable for “a long time without fatigue” (Monod & Scherrer, p.329<sup>2</sup>), (ii) use of arbitrary exercise durations to establish the power-duration curve (iii), that critical power approaches a high fraction of the speed or power providing the longest exercise duration, and (iv) critical power not residing at a fixed fraction of maximal oxygen uptake ( $\dot{V}O_{2max}$ ) or maximal voluntary contraction (MVC).

- (i) Notwithstanding that “a very long time” is somewhat indefinite, skeletal muscle fatigue occurs during exercise in the moderate exercise intensity domain,<sup>3</sup> and as is rightfully noted, the indefinitely sustainable exercise intensity tends toward zero. However, the authors fail to realize that critical power was never *defined* as such; critical power was defined as the slope of the work–time relationship during muscular work performed to task failure.<sup>2</sup> Notions of the fatiguelessness of exercise at or below critical power were *interpretations*, not definitions.
- (ii) There is unequivocal evidence that critical power represents the upper limit of the metabolic steady state, reflecting the transition point between steady- and non-steady-state system behavior for an array of physiological responses such as whole-body oxygen consumption, intramuscular phosphate metabolism, motor unit recruitment, peripheral fatigue (for review see Poole et al.<sup>4</sup>), and localized muscle oxygen consumption.<sup>5</sup> Accordingly, the range of exercise intensities that form the power–duration curve are far from arbitrary. Rather, they must be judiciously selected such that  $\dot{V}O_{2max}$  is achieved at task failure.
- (iii) Accordingly, in extending their own analysis to the half-marathon and beyond, Gorostiaga et al.<sup>1</sup> overlook

the necessity of including only severe-domain exercise bouts in their analysis. Consequently, it is a mathematical certainty that the apparent critical speed will reduce as ever longer durations/lower speeds are included in the model with the apparent critical speed being a high fraction of the lowest speed included in the model. That this fraction will be relatively fixed in such a homogenous group of participants is unsurprising. The analysis presented by Gorostiaga et al.<sup>1</sup> is thus not evidence that the principle of critical power should be re-evaluated. Rather it reflects the erroneous application of the hyperbolic speed–duration relationship beyond the realms of the severe intensity domain.

- (iv) The authors note that an “issue” with the notion of critical power/critical force is that its expression as a fraction of maximal oxygen uptake ( $\dot{V}O_{2max}$ ) or maximal voluntary contraction (MVC) is not fixed. Of course, since the former is a rate of oxygen uptake and the latter a maximal force, comparison across these different measurements is spurious (though notably  $\dot{V}O_{2max}$  may be achieved with a muscular force of as little as 20% MVC<sup>6</sup>). The calls to authority regarding prior proposals for critical power to reside above  $\dot{V}O_{2max}$  are also not a serious contribution to a debate on how best to determine the upper limit of the metabolic steady state. More importantly, of course, the very point of determining critical power is that the threshold between the heavy and severe domains of exercise intensity cannot be predicted based upon a fixed fraction of  $\dot{V}O_{2max}$ . Hence, criticisms of the measurement of critical power on the basis of it not residing at a fixed fraction of the maximal oxygen uptake miss the entire point of the exercise.

Critical power, and its analogs, is firmly established as a fundamental feature of exercise with a strong theoretical basis.<sup>7</sup> A persistent feature of criticisms of its relevance in exercise science is extending its application outside of the severe exercise intensity domain, which highlights a misconstrual of the intended usage of the power–duration relationship.<sup>4</sup> Correct application of the power–duration relationship within the severe domain yields fundamental

insights into the relationship between exercise tolerance and underlying physiological constructs that extend beyond our species.<sup>4</sup>

#### DATA AVAILABILITY STATEMENT

The present submission is a letter to the editor and is not based upon any original data.

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