

Conference Abstract

The effect of reducing work rate on total work done, and exercise tolerance, during severe intensity exercise.

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1. Introduction

The hyperbolic relationship between power output and time to exhaustion during high-intensity exercise can be described by a power asymptote, critical power (CP), and curvature constant, W' . CP demarcates the heavy and severe intensity domains. W' is considered a fixed and finite amount of work that can be completed above CP which when depleted exhaustion will occur, or work rate has to be reduced below CP (Fukuba et al. 2003; Morton 2006; Poole et al. 1988)

The assumption that W' is a fixed parameter has been challenged. Although Fukuba et al. (2003) originally demonstrated that after initially depleting 50% of W' during severe intensity exercise, subsequently increasing or decreasing the work rate, did not result in any changes to the total work done. In contrast, Dekerle et al. (2015) showed that when work rate was reduced (from 140% to 105% of CP), 20% more work above CP was done than predicted. This observation leads to the possibility that W' may not be fixed which will have implications for predicting exercise tolerance during variable efforts (i.e., pacing), as well as the modelling of W' depletion/reconstruction.

Therefore, the aim of this study is to (i) assess changes in total work done above CP when the work rate is reduced during severe intensity exercise (ii) assess if reducing the work rate just prior to exhaustion allows work to continue above CP.

2. Materials and Methods

Twelve healthy participants (8 males, 3 females; age: 21 [2] y, height: 1.80 [0.10] m, body mass; 68.2 [7.6] kg, $\dot{V}O_{2max}$; 56.1 [11.07] mL·min⁻¹·kg⁻¹, maximal aerobic power (MAP); 361 [76] W, CP; 253 [56] W, W' 22.15 [7.57] kJ, mean [SD]) were recruited for this laboratory-based investigation. Participants attended the laboratory on seven separate occasions for the determination of $\dot{V}O_{2max}$, MAP, CP, W' and three severe domain exercise trials involving stepwise reductions in work rate. All tests were performed on an electronically braked ergometer (Lode Excalibur Sport).

The first two trials consisted of exercising at a fixed work rate which would result in the depletion of 70% of W' in 90 sec and 180 sec. At this point the work rate was reduced to CP + 20 W and the exercise continued until volitional exhaustion. The third trial consisted of exercising at a fixed work rate to achieve volitional exhaustion in 5 minutes (P_{5TTE}). At this point, when pedal cadence began to reduce (by approximately ~5 rpm which is a typical indication of exhaustion), the work rate was rapidly reduced by a work rate equal to 25% of the difference between CP and P_{5TTE} . This reduction in work rate was repeated a further two times (three work rate reductions in total) after which exercise continued until volitional exhaustion. In each trial, the total work was predicted based on



CP/W' (PRED_{WORK}) which was the same for each condition. Total work above CP was measured during each trial (WORK_{90s}, WORK_{180s}, WORK_{P5TTE}).

A one-way repeated measures ANOVA were used to compare differences between predicted and total work during the three trials. Where a significant effect was observed, Bonferroni-corrected post hoc t-tests were used to locate differences. Statistical significance was accepted at $p < 0.05$ and data are presented as mean [SD].

Results

In all three trials, more work done was completed than predicted. There were no differences in the amount of work done between the three trials

Table 1. Predicted and measure work above CP in the three experimental trials.

Depletion Trial	PRED _{WORK} (kJ)	Measured WORK (KJ)	Increase in work (kJ)	Increase in work (%)	p-value
WORK _{90s}	22.15 [7.57]	26.92 [7.84]	4.75 [1.44]	25%	<0.001
WORK _{180s}	22.15 [7.57]	27.64 [10.54]	5.49 [4.34]	22%	<0.01
WORK _{P5TTE}	22.15 [7.57]	24.90 [8.02]	2.75 [1.4]	12%	<0.001

P value is Measured vs. Predicted work

4. Discussion

W' has more flexibility than originally conceptualised. Regardless of the initial work rate (~150% and 134% of CP), after 70% of W' has been depleted and work rate is reduced, approximately 25% (WORK_{90s}) and 22% (WORK_{180s}) more work can be performed than predicted from the CP model. It is also demonstrated that work above CP is possible (~12%) past predicted volitional exhaustion when reductions in work rate are implement as exhaustion is reached. We term this 'residual capacity'.

In conclusion, W' is not a fixed parameter of the power-duration relationship. If the work rate is reduced but still above CP, work can be continued for longer than predicted. It is also possible to continue performing work (above CP) even when theoretically depleted

(i.e., W' reaches 0 kJ) provided the work rate continues to decline.

Implications for applied practitioners

These findings may have implications for pacing strategies, as it appears a positive pacing strategy leads to a greater amount of work above CP. This also may have implications for W' modelling as work can continue above CP with rapid drops which theoretically means W'_{bal} can become negative.

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References

1. Dekerle, Jeanne, Kristopher Mendes De Souza, Ricardo Dantas De Lucas, Luiz Guilherme Antonacci Guglielmo, Camila Coelho Greco, and Benedito Sérgio Denadai. 2015. 'Exercise Tolerance Can Be Enhanced through a Change in Work Rate within the Severe Intensity Domain: Work above Critical Power Is Not Constant'. PLoS ONE 10(9). doi: 10.1371/journal.pone.0138428.
2. Fukuba, Yoshiyuki, Akira Miura, Masako Endoi, Akira Kan, Kazumasa Yanagawa, and Brian J. Whipp. 2003. 'The Curvature Constant Parameter of the Power-Duration Curve for Varied-Power Exercise'. Medicine and Science in Sports and Exercise 35(8):1413–18. doi: 10.1249/01.MSS.0000079047.84364.70.
3. Hill, David W. 1993. 'The Critical Power Concept A Review'. Sports Medicine 16(4):237–54. doi: 10.2165/00007256-199316040-00003.
4. Morton, R. Hugh. 2006. 'The Critical Power and Related Whole-Body Bioenergetic Models'. European Journal of Applied Physiology 96(4):339–54.
5. Poole, David C., Susan A. Ward, Gerald W. Gardner, and Brian J. Whipp. 1988. 'Metabolic and Respiratory Profile of the Upper Limit for Prolonged Exercise in Man'. Ergonomics 31(9):1265–79. doi: 10.1080/00140138808966766.

