Use of the Critical Power Model to Prescribe the Elements of Intermittent Exercise

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Introduction

The relationship between time to exhaustion (t) and work rate (W) during high-intensity exercise can be described by the equation t = W'/(W-Wcp) [eq1], (see Fig 1) where Wcp is the W asymptote, and W' is the curvature of this relationship and represents a finite amount of anaerobic work which can be performed above Wcp (Hill & Smith,1993; Smith, et al., 1998). Wcp has been characterized as that power output that can be sustained "for a very long time without fatigue" (Monod & Scherrer, 1965), and as representing "an inherent characteristic of the aerobic energy supply system" (Gaesser & Wilson, 1988).

Recently, Morton & Billat (2004) attempted to describe the W/t relationship by fitting responses to intermittent exercise into the following equation [eq2]:

$T = n(t_w+t_r) + (W'-n((W_w-Wcp)t_w - (Wcp-W_r)t_r))/(W_w-Wcp)$;

where T is total exercise time, n is the number of work/rest cycles, t_w is the duration of the work interval, t_r is the duration of the recovery interval, W' is anaerobic work capacity, W_w is the work rate of the work interval, Wcp is critical power, and W_r is the work rate of the recovery interval.

Introduction (cont)

Though their efforts met with limited success, it is reasonable that the variables of intermittent exercise programs could be prescribed from this adaptation of the W/t relationship. However, to date no attempt has been made to evaluate the usefulness of the W/t relationship for prescribing elements of intermittent exercise programs.

Purpose

The purpose of this study was to determine if the elements of intermittent exercise could be effectively prescribed from an adaptation of the work rate/time to exhaustion relationship.

Methods

Three women and five men, with mean (sd) age, mass, and height of 21.0 (0.8) yrs, 69.4 (12.5) kg, and 1.76 (0.1) m volunteered to participate in this study. Each volunteer completed the following:

i) Familiarization; 3 bouts of exhaustive exercise were performed at Ws selected to elicit fatigue in 120 to 600 s. These bouts were used to reduce the learning effect associated with this type of exercise and were not used in analyses.

ii) Estimation of individual W/t relationship; 4 bouts of exhaustive exercise were performed at Ws selected to elicit fatigue in 120 to 600 s. W and t from these bouts were fitted to eq1 from which W' and Wcp were estimated.

iii) Intermittent exercise; 3 bouts of intermittent exercise were completed by each participant. The estimates of W' and Wcp, derived from eq1, were fitted to a revision of eq2; $n = W'/((W_w\text{-}Wcp)t_w - (Wcp - W_r)\, t_r)$ [eq3], to allow for the prescription of the variables associated with intermittent exercise. Work/rest intervals of 60/60 s, 120/60 s, and 60/120 s, were prescribed and presented in a randomized order across participants. W for the work portions of the intermittent exercise were calculated by multiplying the Wcp of each volunteer by 1.66, 1.5, and 1.8 for the 60/60, 120/60, and 60/120 conditions, respectively.

Methods (cont)

The predicted number of work/rest cycles (n) was set at 5 for all trials, which then allowed the W for recovery to be solved using eq3.

Paired samples t-tests were used to compare the predicted n to the actual n for each condition. Alpha for these tests was pre-set at $p < 0.02$. A repeated measures ANOVA was used to compare the number of completed cycles across the three interval conditions. A Tukey post-hoc test was done to determine which conditions differed significantly from one another. Alpha for the ANOVA and Tukey analyses were preset at $p < 0.05$.

Results

The mean (sd) completed cycles under the 60/60, 120/60, and 60/120 conditions were 4.8 (1.0), 2.8 (0.7), and 3.1 (0.8), respectively (see Table 1). Paired samples t-tests revealed that the predicted and actual n were not significantly different under condition 60/60 ($t = 0.69$, $p = 0.52$), but were significantly different under conditions 120/60 ($t = 5.75$, $p = 0.001$) and 60/120 ($t = 7.27$, $p < 0.001$). The results of the repeated measures ANOVA suggested that the number of completed cycles was different among the interval conditions ($F = 19.33$, $p < 0.001$). A Tukey post hoc test showed that the number of completed cycles for 60/60 was greater than that under the 120/60 ($p < 0.001$) and 60/120 ($p = 0.002$) conditions. The number of completed cycles were not significantly different between 120/60 and 60/120 ($p = 0.41$).

Conclusion

The results of this study suggest that eq3 may be useful in prescribing the variables of intermittent exercise. However, the precision of this equation appears limited to a narrow range of durations of work/rest cycles.

References

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Table 1: Completed cycles for each volunteer and mean and sd of completed cycles under each condition

Volunteer	60/60	120/60	60/120
1	5.3	4.4	4.3
2	5.4	2.6	2.3
3	4.3	2.6	3.3
4	5.3	2.6	3.3
5	6.1	3.3	4.3
6	3.5	2.2	2.3
7	3.1	2.3	3.2
8	5.3	2.3	2.2
mean	4.8	2.8	3.1
sd	1.0	0.7	0.8