A Comparison of Critical Velocity Estimates to Actual Velocities in Predicting Simulated Rowing Performance

Michael D.J. Kennedy and Gordon J. Bell

Catalog Data

Key words: maximal oxygen consumption, critical power, critical speed
Mots clés: consommation maximale d’oxygène, puissance critique, vélénité critique

Abstract/Résumé
The most accurate critical velocity (CV) estimate for the prediction of velocity during a simulated 2,000-m rowing race and the relationship to aerobic power were studied. Sixteen male rowers completed randomized maximal exertion trials (200, 400, 600, 800, 1,000, and 1,200 m), a maximal oxygen consumption ($\dot{V}O_{\text{max}}$) on a Concept II rowing machine, and an actual 2,000-m simulated rowing race. Three mathematical models were applied to 4 rowing distance combinations producing 12 CV estimates. Seven of the 12 possible CV estimates were not significantly different from actual 2,000-m velocity. Comparison of the 3 CV models using all 6 trial distances revealed that the nonlinear model produced a CV estimate lower than the 2 linear CV models. CV was significantly correlated to $\dot{V}O_{\text{max}}$ ($r = 0.91$) and the mean velocity achieved during the 2,000-m simulated rowing race ($r = 0.97$). $\dot{V}O_{\text{max}}$ was significantly correlated to 2,000-m simulated rowing race velocity ($r = 0.93$).

Le but de cette étude est d'établir l'estimation la plus précise de la vélénité critique (CV) et sa relation avec la puissance aérobie maximale au cours d'une épreuve d'aviron simulée sur une distance de 2,000 mètres. Seize rameurs participent à six épreuves maximales (200,

The authors are with the Faculty of Physical Education and Recreation at the University of Alberta, Edmonton, Alberta T6G 2H9.
400, 600, 800, 1,000 et 1,200 m) dont l'ordre est établi aléatoirement, à un test de consommation maximale d'oxygène sur une machine à ramer de marque Concept II et à une compétition simulée sur 2,000 mètres. Trois modèles mathématiques sont appliqués à quatre combinaisons de distance d'épreuve, ce qui donne douze estimations de CV. Sept des douze estimations ne sont significativement pas différentes de la vitesse observée sur 2,000 mètres. La comparaison de trois modèles d’estimation de CV dans les six épreuves révèle que la valeur de CV dans le modèle non linéaire est plus faible que dans les deux modèles linéaires. CV est significativement corrélée au Vmax (r = 0,91) et à la vitesse moyenne au cours de la compétition simulée sur 2,000 mètres (r = 0,97). La valeur du Vmax est également corrélée à la vitesse de déplacement sur 2,000 mètres (r = 0,93).

Introduction

Critical velocity (CV) has been used as a simple and practical method to predict maximal average velocity in a variety of sports such as swimming (Wakayoshi et al., 1992), running (Kachouri et al., 1996; Kranenburg and Smith, 1994; Pepper et al., 1992), and the triathlon (Zaryski et al., 1994). Previous applications of CV have been based on the linear relationship between total work done and time to exhaustion at that workload (Monod and Scherrer, 1965). McDowell and colleagues (1988) applied the total work-time model to distance and time values by replacing the dependent variable (total work) with total distance (linear distance-time model). Wakayoshi and colleagues (1992) utilized this model for swimming and found a high correlation between distance covered and time to exhaustion.

This type of relationship suggests that CV can be a predictor of time over a predetermined distance. As well, CV has been correlated to physiological parameters including maximal lactate steady state (MLSS) for swimming (Wakayoshi et al., 1993) and maximal oxygen consumption for running (Pepper et al., 1992). However, CV may overestimate the individual anaerobic threshold (IAT; McLellan and Cheung, 1992) or MLSS (Jenkins and Quigley, 1990) when applied to cycle ergometry. Other CV models include the linear distance-1/time model initially proposed by Hughson and colleagues (1984) and the nonlinear velocity-time model initially proposed by Moritani and colleagues (1981) but later modified by Pepper and colleagues (1992) to fit distance and time parameters.

Presently, there has been no CV model applied to the sport of rowing. On-water male rowers (individual sculls to eights) cover a distance of 2,000 m in approximately 5–7 min. However, with the advent of indoor rowing machines, especially Concept II machines (Concept II Inc., Morrisville, VT, U.S.A.), training and racing on such machines has become prevalent for on-land supplementary training, team seat selection for particular crews, and as a coaching tool. Due to the popularity of rowing and the use of indoor rowing machines, an international competition involving a 2,000-m simulated rowing race has evolved. Local, national, and international events now exist for simulated on-land row racing (2,000 m, Concept II, 1998).

Currently, there are few pacing strategies to predict performance in a simulated indoor rowing event. The application of CV models to predict performance in simulated 2,000-m row races would be a useful tool for both coaches and athletes. It could be used to monitor performance and training adaptations as well as be useful for the development of pacing strategies without having to complete the
actual 2,000-m event distance. Therefore, the purpose of this study was to compare 12 CV estimates produced by four different distance trial sets and three models to determine the accuracy of these CV estimates to predict 2,000-m velocity during a simulated rowing race. Models were chosen on their published history and availability (only models to be modified to fit distance – time parameters). Six different distances were decided upon, as a balance between too many trials for each subject to perform, yet enough to create four different sets of trial lengths. The 12 CV estimates are a product of the four different trial sets and the three models used.

Methods

Subjects

Subjects were recruited from the local rowing club and university rowing population. All subjects were male (n = 16) and had a minimum of 1 year to several years rowing experience at a provincial and national level. Subject characteristics (mean ± SD) were age (yr) 22.7 ± 3.9, height (cm) 186.2 ± 6.5, body mass (kg) 83.7 ± 8.4, \( \dot{V}O_2 \) max (L·min\(^{-1}\)) 5.01 ± 0.50, \( \dot{V}O_2 \) max (mL·kg\(^{-1}\)·min\(^{-1}\)) 59.9 ± 6.1. Subject activity was limited to normal training load including both intensity and duration. They were asked not to perform strength or endurance training in the 24 hr prior to a CV trial. As well, normal training volume and intensity were controlled during the study to minimize the effect of residual training fatigue on the exercise testing. The trials were randomized to minimize the effect of previous trials on performance. All subjects signed an informed consent form prior to testing, and the study had ethical approval by the Faculty of Physical Education and Recreation at the University of Alberta.

Critical Velocity Trials

Critical velocity (CV) estimates were limited to no longer than 60% of the predicted distance (2,000 m) for two reasons: the convention is to utilize trials shorter than 50–60% to form the CV estimates, and trials longer than 50% have been associated with metabolic and fatigue factors that reduce the predictive power of the CV estimate (Clingeleffer et al., 1994). The present investigation utilized a series of six distance trials (200, 400, 600, 800, 1,000 and 1,200 m) completed in random order by each subject. A simulated 2,000-m race trial was also completed to determine actual 2,000-m velocity. Time(s), average stroke rates, split time for 500 m, and heart rates were recorded for each trial. All tests were performed on the same Concept II Model C rowing machine (Concept II Inc., Morrisville, VT, U.S.A.). The resistance lever on the Concept II rowing machine flywheel setting was 4 for all testing. All trials were preceded by a 1,000-m warm-up including three maximal 5-s sprints followed by static stretching for 5 min. Each randomized time trial was programmed on the Concept II computer display, and the subject was able to view the following information on the ergometer screen: cumulative meters, time/500 m, stroke rate, and time.

At the completion of the trial, the display recorded time to the nearest 1/10th of a second and mean stroke rate. The importance of providing maximal efforts in the trials was imperative to the validity of CV estimates so each subject was asked
prior to each trial to provide their best effort and treat each trial as a "race." No verbal encouragement was given during the trials in an attempt to minimize external factors known to influence performance. A minimum of 24 hr rest was required between trials. The 2,000-m time trial was performed on a different day after completion of all the CV trials in the same manner as described above.

CRITICAL VELOCITY DETERMINATION

Each subject had 12 CV estimates formed from their trial data. The 12 estimates were determined by the following method: three sets of four distance trials and one set of all distances in combination with three mathematical models to produce 12 different CV estimates (Table 1). The distance sets were

Short (S) = 200, 400, 600, 800 m
Medium (M) = 400, 600, 800, 1,000 m
Long (L) = 600, 800, 1,000, 1,200 m
All Distances (AD) = 200, 400, 600, 800, 1,000, 1,200 m

The following mathematical models were used. Model 1: Linear distance-time model as proposed by McDowell and colleagues (1988). This model relies on the principle that a line of best fit through a series of data points will continue to be linear beyond the area covered by the plotted points. Mathematically, the CV estimate was calculated using the following equation:

\[ d = CV(t) + AWC \]

where \( d \) = the dependent variable of distance (m); \( t \) = the independent or manipulated variable of time (s); \( CV \) = critical velocity, the slope of the relationship between distance and time (m \( \cdot \) s\(^{-1}\)); and \( AWC \) = anaerobic work capacity, the y-intercept (m).

Model 2: Linear velocity-1/time model proposed by Hughson and colleagues (1984). It involves the plot of velocity and the fractional component of time (1/time) to provide values that are sensitive to longer trials used in critical velocity determination. The following equation was used:

\[ v = \frac{AWC + CV}{t} \]

where \( v \) = velocity at which each trial was completed (m \( \cdot \) s\(^{-1}\)); \( t \) = time to complete each trial (s); \( AWC \) = anaerobic work capacity, slope of the relationship indicating (m), and \( CV \) = critical velocity, the y-intercept of the relationship between velocity and 1/time (m \( \cdot \) s\(^{-1}\)).

Model 3: The nonlinear velocity-time model initially proposed by Moritani and colleagues (1981) and later modified by Pepper and colleagues (1992) to fit distance and time parameters. The following equation was used:
Table 1  Experimental Design

<table>
<thead>
<tr>
<th></th>
<th>Linear distance-time model</th>
<th>Linear velocity-time model</th>
<th>Nonlinear velocity-time model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short distance trials</td>
<td>CV estimate 1</td>
<td>CV estimate 2</td>
<td>CV estimate 3</td>
</tr>
<tr>
<td>200, 400, 600, 800 m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium distance trials</td>
<td>CV estimate 4</td>
<td>CV estimate 5</td>
<td>CV estimate 6</td>
</tr>
<tr>
<td>400, 600, 800, 1,000 m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long distance trials</td>
<td>CV estimate 7</td>
<td>CV estimate 8</td>
<td>CV estimate 9</td>
</tr>
<tr>
<td>600, 800, 1,000, 1,200 m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All 6 distances</td>
<td>CV estimate 10</td>
<td>CV estimate 11</td>
<td>CV estimate 12</td>
</tr>
</tbody>
</table>

\[ t = \frac{AWC}{(v-CV)} \]

where \( t \) = time to complete each trial (s); \( v \) = velocity at which each trial was completed (m · s\(^{-1}\)); \( AWC \) = anaerobic work capacity, slope of the relationship between velocity and time (m); and \( CV \) = critical velocity, the power asymptote or y-intercept based on the relationship of time to fatigue at each trial and the velocity at which the trial was completed (m · s\(^{-1}\)).

It is important to note that despite the generation of two different values with each model, \( CV \) and anaerobic work capacity (\( AWC \)), only the \( CV \) estimates were investigated. \( AWC \) has been used as an indicator of anaerobic capacity (Hill and Smith, 1994), but this was not a focus of the present study.

**DETERMINATION OF AEROBIC FITNESS**

Prior to initiating the \( CV \) trials, all subjects were required to undergo an incremental maximal oxygen consumption (\( VO_{2,\text{max}} \)) test to volitional exhaustion on a Concept II Model C rowing machine. The test began at a power output (PO) of 100 W for 2 min followed by increments in PO by 50 W every 2 min until the \( V_{\text{L}}/\overline{VCO}_{2} \) ratio reached a minimum and began to increase. Subsequently, the PO was increased by 50 W every minute until the respiratory exchange ratio (RER) reached \( \geq 1.10 \), after which time the subject performed a maximum stroke rate until volitional exhaustion (< 2 min; Bell et al., 1998; Haykowsky et al., 1998). The criterion for \( VO_{2,\text{max}} \) was a peak and plateau in \( VO_{2} \), with increasing exercise time with secondary criteria of an RER > 1.15 and attainment of known or age predicted maximum heart rate (HR max; Bell et al., 1998; Haykowsky et al., 1998). Expired air was collected into a calibrated Horizon metabolic measurement cart (Sensor
Medics, CA, U.S.A.) for analysis of ventilation and respiratory gases (15 s average). All subjects wore a heart rate monitor (Polar Electro Canada, Quebec) that was preset to record heart rate to memory every 5 s. The \( \text{VO}_2 \max \) test was spaced by a minimum of 2 days prior to the initial CV trial.

**Data Analysis**

A one-way ANOVA was used to compare all CV estimates derived by the three different CV models utilizing all four trial distance sets and actual 2,000-m rowing velocity. Secondly, one-way ANOVA was used to determine the differences between the three CV models using all six distances. To determine main effects for models (three models) and trial sets (S, M, L) as well as interaction effects between the nine different CV values, a two-way ANOVA (3 x 3) was used. A Newman Keuls post hoc test was used for any multiple comparisons. Stepwise multiple regression was used to determine the degree of variability accounted for by the most accurate CV estimate and maximal oxygen consumption for prediction of actual 2,000-m velocity. A Pearson’s correlation coefficient was used to determine the relationship between these latter variables. An alpha level of \( p < 0.05 \) was set a priori.

**Results**

Prediction of 2,000-m velocity using the linear distance-time model and all six trial distances (velocity = 4.9 ± 0.2 m · s\(^{-1}\)) was the most accurate estimate of actual 2,000-m velocity (velocity = 4.9 ± 0.2 m · s\(^{-1}\)). Figure 1 shows that seven CV estimates were not significantly different from actual 2,000-m velocity, including the linear distance-time model (all distances), the linear distance-time model (medium distances), linear velocity-1/time model (medium distance), linear velocity-1/time model (long distances), nonlinear velocity-time model (short distances), nonlinear velocity-time model (medium distances), and nonlinear velocity-time model (long distances). Figure 2 compares the three CV models using all six trial distances. Comparison of CV estimates derived from the nonlinear velocity-time model to the linear models shows a significant difference between the nonlinear and linear models CV estimates. There was a significant interaction effect between CV model estimates and distance trials (see Table 2).

Pearson’s correlation coefficients between the CV estimate using the linear distance-time model, actual 2,000-m velocity, and maximal oxygen consumption revealed that CV was significantly correlated to both 2,000-m velocity (\( r = 0.97, p < .05 \)) and \( \text{VO}_2 \max \) (\( r = 0.91, p < .05 \)). Actual 2,000-m velocity was also significantly correlated to \( \text{VO}_2 \max \) (\( r = 0.91, p < .05 \)). CV value with the smallest absolute difference (the linear distance-time model, all distances) accounted for the majority of the total variance associated with predicting actual 2,000-m velocity (\( R^2 = 0.948, p < .05 \)). The addition of \( \text{VO}_2 \max \) (\( r = 0.97 \)) to the CV estimated produced an \( R^2 \) of 0.962 (\( p < .05 \)).
**Figure 1.** A comparison of all 12 critical velocity estimates and actual 2,000-m simulated rowing velocity. Values are velocity (m·s⁻¹) ± standard deviation. M1 = linear distance-time model; M2 = linear velocity-1/time model; and M3 = nonlinear velocity-time model. S = short distances of 200, 400, 600, 800 m; M = medium distances of 400, 600, 800, 1,000 m; L = long distances of 600, 800, 1,000, 1,200 m; and All = all distances of 200, 400, 600, 800, 1,000, 1,200 m. *Not significantly different from actual 2,000-m rowing velocity, P < .05.

**Figure 2.** A comparison of three different critical velocity models using six distance trials. M1 = linear distance-time model; M2 = linear velocity-1/time model; and M3 = nonlinear velocity-time model. *Significantly different from both other CV models, P < .05.
Table 2  Critical Velocity Estimates

<table>
<thead>
<tr>
<th></th>
<th>Short distance</th>
<th>Medium distance</th>
<th>Long distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear distance-time model</td>
<td>5.1 ± 0.2 m · s⁻¹</td>
<td>4.9 ± 0.3 m · s⁻¹</td>
<td>4.8 ± 0.3 m · s⁻¹</td>
</tr>
<tr>
<td>Linear velocity-1/time model</td>
<td>5.3 ± 0.2 m · s⁻¹</td>
<td>5.0 ± 0.3 m · s⁻¹</td>
<td>4.8 ± 0.3 m · s⁻¹</td>
</tr>
<tr>
<td>Nonlinear velocity-time model</td>
<td>5.0 ± 0.3 m · s⁻¹</td>
<td>4.8 ± 0.2 m · s⁻¹</td>
<td>4.7 ± 0.2 m · s⁻¹</td>
</tr>
</tbody>
</table>

Notes. Values are Means ± SD. Paired letters denote not significantly different from one another, P > 0.05.

Discussion

The present study investigated the application of three mathematical models to produce critical velocity estimates using different combinations of distance trial lengths in an attempt to predict actual velocity during a 2,000-m simulated rowing race. Our findings showed that there were 7 out of a total of 12 CV estimates that were not significantly different from actual velocity obtained during the 2,000-m simulated rowing race. This latter finding attests to the general accuracy of all three CV models using a variety of combined distances. The nonlinear model produced the two most conservative estimates of actual 2,000-m simulated rowing velocity in comparison to the two linear critical velocity models resulting in a consistent underprediction of actual rowing velocity. Previous research (Gaesser et al., 1990; Gaesser et al., 1995; Hill et al., 1995) substantiates the conservative nature of nonlinear models when compared to linear model estimates.

In regard to the appropriate combination of trial distances used in each critical velocity model, it seems that the medium trial lengths produced the most accurate estimate. The relationship between VO₂max and actual 2,000-m simulated rowing velocity was similar to the relationship between the CV estimate and actual 2,000-m simulated rowing velocity. Critical velocity (CV) calculated using the linear distance-time model incorporating all the trial distances provided the most accurate prediction of actual 2,000-m simulated rowing velocity. This was justified since the predicted velocity using the above model resulted in the identical mean and standard deviation to the actual velocity of the 2,000-m rowing race.

Previous research has utilized critical velocity estimates to accurately predict maximal average velocity in a variety of sports such as swimming (Wakayoshi et al., 1992), running (Kachouri et al., 1996; Kranenburg and Smith, 1994; Pepper et al., 1992), and the triathlon (Zaryski et al., 1994). It was observed in our study that 7 out of a possible 12 critical velocity estimates were not significantly different.
from actual 2,000-m simulated rowing velocity. This finding suggests a robustness of predicting actual rowing velocity using different critical velocity models and a variety of trial lengths. Hill and colleagues (1995) stated that there was no main effect for regression models (same mathematical CV models as this investigation) but that there was a significant difference between the linear models and the nonlinear model at two of the three different cadence methodologies examined in that research, which were similar to the distance trial variables used in this investigation.

It is also worthy to note that Hill and colleagues (1995) found the nonlinear estimates to be the most conservative regardless of the cadence methodology used. Gaesser and colleagues (1995) showed that the nonlinear model produced the most conservative critical power (CP) estimate and that nonlinear regression provided the best goodness of fit for the trial data. Our findings also suggest a bias in the critical velocity estimates produced by the nonlinear critical velocity model in regard to the conservativeness of the values and accuracy of the prediction of 2,000-m velocity. The nonlinear model produced a significantly slower critical velocity estimate compared to the two linear models when the distance of trials was kept constant. In fact, the nonlinear model produced the slowest critical velocity estimate regardless of which distance trial set was used. Despite the conservative nature of the nonlinear CV estimates, it is important to recognize that the nonlinear parameter estimates in this investigation as well as others (Hill et al., 1995) were still found to be most accurate regardless of trial set used (nonlinear with S, M, L were all not different compared to actual 2,000-m velocity).

The selection of the distance for the trials and the number of trials used is important when determining critical velocity. Numerous research investigations have utilized four trials (Carnevale and Gaesser, 1991; Florence and Weir, 1997; Housh et al., 1990) or less than four trials (Bishop and Jenkins, 1996; Clingeleffer, 1994) to determine critical velocity or critical power estimates. The six trials in our investigation were performed for two reasons: to determine whether 6 data points improved the accuracy of the prediction and to manipulate the trials into different length sets of equal number (i.e., short, medium, and long). This allowed for an evaluation of the effect of different trial lengths on the critical velocity estimate.

In defense of the six trial methodologies, the linear-distance time model in conjunction with all six trials provided the most accurate prediction of actual 2,000-m simulated rowing velocity. Analysis of the trials in the different length sets (short, medium, and long) determined that the medium set of distances (400, 600, 800, and 1,000 m) with any of the three critical velocity models provided estimates that did not differ significantly from actual 2,000-m velocity. It was concluded that the medium combination of distances was also an accurate set of distances for prediction of actual 2,000-m simulated rowing velocity. It is important to note that the addition of the 2 extra data points to form the all distance trial set did significantly differ from the medium distance trial set in predicting actual 2,000-m velocity using the linear-distance time model. Certainly, performing two less maximal effort trials would be less stressful and better tolerated by most individuals.
Maximal oxygen consumption is arguably the single best measure of aerobic fitness and has been used to evaluate the cardiorespiratory fitness of many different athletes (Jousselin et al., 1984). Characteristically, rowers have a high absolute (l·min⁻¹) maximal oxygen consumption in comparison with other endurance athletes, and it has been stated that the demands of rowing require a high maximum rate of oxygen consumption for successful performance (Secher, 1993). Thus, it was of interest to examine the relationship of maximal oxygen consumption to critical velocity and actual 2,000-m simulated rowing velocity. Our results show that maximal oxygen consumption was significantly correlated to both estimated maximal simulated rowing velocity using the linear distance-time CV model and all trial distances. This suggests that the measurement of maximal oxygen consumption can also be a useful indicator of actual 2,000-m simulated rowing velocity. However, the CV estimate accounted for the majority of the total variance associated with predicting actual simulated 2,000-m velocity when regressed with maximal oxygen consumption in the stepwise multiple regression analysis. Thus, critical velocity estimation may be a better method of predicting actual performance velocity in simulated rowing.

PRACTICAL RECOMMENDATIONS

Based on our findings, the medium set of distances involving four trials of 400 to 1,000 m was the most consistent predictor of actual 2,000-m rowing velocity in comparison to the short or long trial distance combinations. Furthermore, the medium distance trial set did not differ significantly from using all six trials (200 to 1,200 m) regardless of what CV estimate was used. Anecdotally, it was reported by a number of subjects that the ability to perform maximally at distances greater than the 1,000-m trial (3 min) was difficult. Therefore, a pacing strategy may have been used by the subjects in an attempt to produce the best time for the longer trial distances. This would indicate that trial distances that are too long may influence the reliability of the CV estimate. Clingeleffer and colleagues (1994) showed that that 2 data points gave similarly accurate CV estimates as 4 data points with a linear distance-time model. Previous research (Gaesser et al., 1995) has also suggested that if fewer data points are used to form the CV estimate, then the linear models may provide a more accurate CV estimate than the mathematically equivalent nonlinear model. Our results suggest that the medium distance trial set (400 to 1,000 m) would be reliable, not as demanding on the subjects, and accurate in predicting actual 2,000-m rowing velocity regardless of which CV model is used.

The present study revealed that the nonlinear CV model had the fewest significantly different estimates from actual 2,000-m rowing velocity. It has been suggested previously that linear models will produce different parameter estimates than a nonlinear model on the basis of how the data is calculated in each respective model (Colquhoun cited in Gaesser et al., 1995). However, it is important to note that in the present study, both linear models produced many CV estimates that were not significantly different from actual 2,000-m rowing velocity. Because of this and the fact that the nonlinear CV model requires extensive calculations and
data analysis to produce an asymptote value based on the plot of velocity versus time, the use of the linear models may be recommended for coaches, athletes, and applied exercise physiologists. This is because it may be difficult for these latter interest groups to access a complicated mathematical program to derive nonlinear CV estimates in a field setting. On the other hand, the linear models may be computed with a calculator and drawn on graph paper.

Conclusion

Our results indicate that critical velocity estimation was an accurate method of predicting actual 2,000-m simulated rowing performance. In comparison of all three critical models and trial distance sets, it was discovered that the nonlinear model had the fewest significantly different estimates from actual 2,000-m rowing velocity. However, the nonlinear velocity-time model produced the most conservative critical velocity estimate in comparison to either linear distance-time model or linear velocity -1/time model, which suggests that the nonlinear model may underpredict actual performance velocity.

It was also found that the medium trial distance set of 400, 600, 800, and 1,000 m (≤50% of the final race distance of 2,000 m) was the preferred set for the determination of critical velocity regardless of the model used. As well, the CV estimate and maximal oxygen consumption were significantly correlated to actual 2,000-m simulated rowing velocity and each other. Despite the overall accuracy of the nonlinear CV model, this model may not be favored in practice due to the relatively difficult mathematical calculation required to produce the CV estimate. It is interesting to note that the linear distance-time model using all six trial distances resulted in a critical velocity estimate with the same mean and standard deviation as actual 2,000-m rowing velocity. Future research in the validation of CV estimation during actual on-water rowing would be prudent.

References


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