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Abstract

Can Critical Power be Estimated from Training and Racing Data using Mean Maximal Power Outputs?

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1. Background

Critical Power (CP) represents an important threshold in exercise physiology [1]. CP defines the border between the heavy and severe exercise domains [2] and thus separates power outputs for which a physiological steady state can, and cannot, be achieved. It has been shown to have applicability to both stochastic and non-stochastic efforts within the severe exercise domain [3]. CP is mathematically defined as the asymptote of the power-duration curve[4]. Traditionally, CP was estimated from 3-5 performance trials conducted on successive days [5] but it has recently been shown that CP can be estimated from a single exercise session [6]. However, even this condensed approach may not always be feasible in-season in a professional cycling population due to the required volume of training [7]. Previous research 8 has shown that record power outputs (MMP) from training and racing can be used to derive a hyperbolic power-duration curve. If the asymptote of the MMP curve could be used to derive an accurate estimate of CP (mCP) and W' (mW') it may negate the need for formal CP testing.

2. Aim

The aim of this current study was two-fold:

1, To assess the accuracy of mCP and mW' derived from MMP values.

2, To assess the accuracy of mCP derived from MMP values achieved exclusively in training.

3. Methods

Power meter data was collected from 11 professional U23 Cyclists (mean ± SD, age 21.3 ± 1.1y, body mass 70.8 ± 7kg, height 182.1 ± 5.4cm, VO2 max 74.2 ± 3.1 ml·kg·min^{-1}) during a competitive cycling season.

The season was split into 4 periods. 'pre' (1st November – 31st Jan), 'early' (1st February – 30th April), 'mid' (1st May – 31st July) and 'late' (1st Aug – 31st Oct).

Power meter data from each period was sub-divided by mode of exercise: training or racing.

Power meter data was collected using a using a standardized crank – system (SRAM Red, Quarq, Spearfish, South Dakota, USA) with a 1 Hz sampling rate and monitored on a portable head unit device (Garmin Edge 520, Schaffhausen, Switzerland). A static calibration of each power meter was applied, according to the manufacturer's recommendations, at the start of the data collection period (November

2017). Participants were instructed to perform a 'zero-offset' before each activity.

During a team training camp, in the 'pre' period, participants performed 3 performance trials (2, 5 and 12 minutes) on 3 successive days on a climb with an average gradient of 5.5%. One performance trial was performed per day in a randomized order. Prior to each performance test participants were encouraged to produce the highest possible power output during the performance trial. Participants were asked to maintain a cadence between 80 and 100 revolutions per minute (rev ·min-1). CP (CPtest) and W′ (W′test) were interpolated from these performance trials using the linear 1/time method.

MMP values for the duration of 120-720s were collected from both racing and training during each period, mCP and estimates mW′ were interpolated from a least sum of squares linear regression analysis of MMP using the 1/time method. The y-axis intercept of the regression line was used to interpolate mCP. The slope of the regression line was used to interpolate mW′

For the purpose of analysis mCP and mW′ values from pre were estimated using MMP that included (mCPinc, mW′inc) and excluded (mCPexc and mW′exc) data from the formal testing.

4. Results

Accuracy of mCP derived from MMP values:

CPtest and mCPinc were normally distributed ($p > 0.05$) and not significantly different ($p > 0.05$). Correlation between CPtest and mCPinc was strong ($R = 0.982$, $p < 0.001$) (figure 1), mean bias was 9w (95% CI 6 – 25w) (figure 2), percentage error 2.34% ± 1.95.

W′test was normally distributed ($p>0.05$) however mW′inc was not ($p < 0.05$). W′test and mW′inc were not significantly different ($p > 0.05$). Correlation between W′test and mW′inc was strong ($R = 0.728$, $p < 0.05$) (figure 3), mean bias was 3Kj (95% CI -4 – 10 Kj) (figure 4), percentage error 14.53% ± 17.02.

Accuracy of mCP derived from MMP values achieved exclusively in training only:

There was a significant difference between CPtest and mCPexc values ($p < 0.01$) (figure 5). Correlation between CPtest and mCPexc was strong ($R = 0.904$, $p < 0.001$) mean bias was 60w (95% CI 27 – 92w) (figure 6), percentage error 15.2% ± 3.39.

A repeated measures ANOVA showed significant differences between mCP derived from MMP values achieved exclusively in training and mCP derived from MMP values achieved exclusively in racing for early and mid ($p < 0.05$) but not for late ($p > 0.05$).

There was no significant difference between mCP derived from MMP values achieved exclusively in racing and mCPinc across all periods ($p > 0.05$) nor CPtest ($p > 0.05$).

5. Conclusions

These findings reveal that, provided either MMP values from racing or formal testing are included, mCP is a valid way to estimate CP. mW′ estimates were not significantly different from W′ however the large percentage error means mW′ values should be used with caution.

Accurate estimates for CP and W′ cannot be derived from MMP values achieved exclusively in training. mCP derived from MMP values achieved exclusively in training does not predict mCP derived from MMP values achieved in racing. Coaches should therefore refrain from using mCP values derived from MMP values achieved exclusively in training to predict race performances. These findings also reveal that formal pre-season CP testing is an accurate way to predict mCP values in racing for the subsequent season.

Keywords: Critical Power, Power Duration, Racing, Training.

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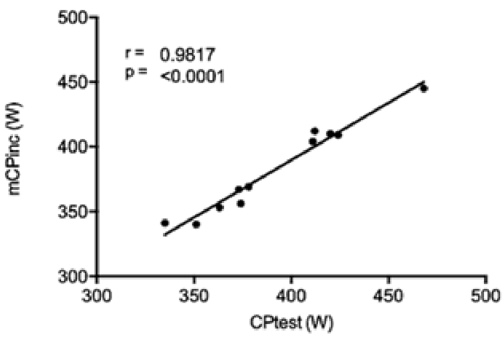

Figure 1. Regression Analysis CPtest & mCPinc.

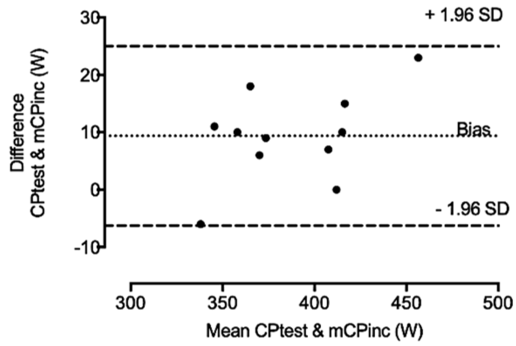

Figure 2. Bland-Altman plot for CPtest & mCPinc.

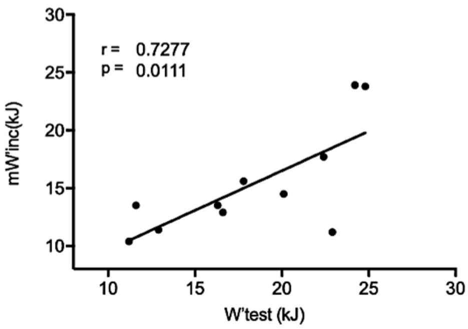

Figure 3. Regression analysis W'test & mW'inc.

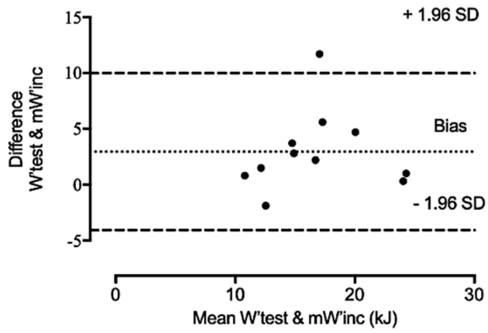

Figure 4. Bland – Altman plot for W'test & mW'inc.

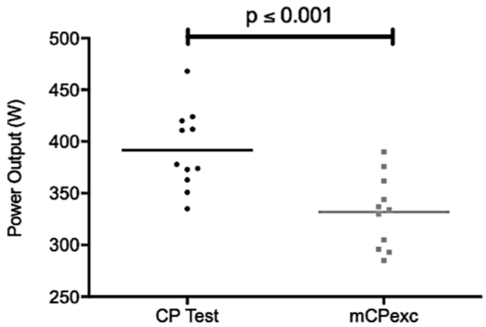

Figure 5. CPtest and mCPexc values.

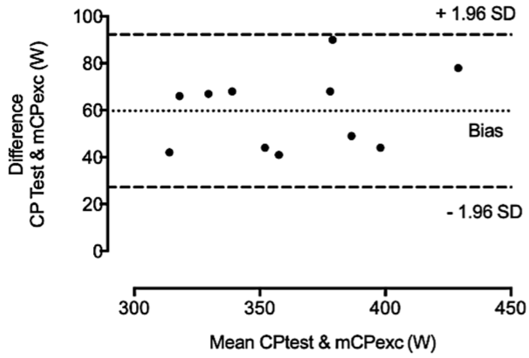

Figure 6. Bland – Altman plot for CPtest &mCPexc.