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Article Title: Validity of Power Settings of the Wahoo KICKR Power Trainer

Authors: Emma K. Zadow¹, Cecilia M. Kitic¹, Sam S.X. Wu¹, Stuart T. Smith², and James W. Fell¹

Affiliations: ¹School of Health Sciences, University of Tasmania, Launceston, Tasmania, Australia. ²Faculty of Arts and Business, University of the Sunshine Coast, Sippy Downs, QLD, Australia.

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Title
Validity of power settings of the Wahoo KICKR Power Trainer

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Authors:
Emma K. Zadow¹, Cecilia M. Kitic¹, Sam S.X. Wu¹, Stuart T. Smith², James W. Fell¹

Contact Details:
Emma Zadow
University of Tasmania, Locked Bag 1322, Newnham, Launceston, Tasmania, Australia, 7250
+61 430 417 295; Emma.Zadow@utas.edu.au

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ABSTRACT

**Purpose:** The purpose of this study was to assess the validity of power output settings of the Wahoo KICKR Power Trainer (KICKR) using a dynamic calibration rig (CALRIG) over a range of power outputs and cadences. **Methods:** Using the KICKR to set power outputs, powers of 100-999W were assessed at cadences (controlled by the CALRIG) of 80, 90, 100, 110 and 120rpm. **Results:** The KICKR displayed accurate measurements of power between 250-700W at cadences of 80-120rpm with a bias of -1.1% (95%LoA: -3.6-1.4%). A larger mean bias in power were observed across the full range of power tested, 100-999W 4.2% (95%LoA: -20.1-28.6%), due to larger biases between 100-200W and 750-999W (4.5%, 95%LoA:-2.3-11.3% and 13.0%, 95%LoA: -24.4-50.3%), respectively. **Conclusion:** When compared to a CALRIG, the Wahoo KICKR Power Trainer has acceptable accuracy reporting a small mean bias and narrow limits of agreement in the measurement of power output between 250-700W at cadences of 80-120rpm. Caution should be applied by coaches and sports scientists when using the KICKR at power outputs of <200W and >750W due to the greater variability in recorded power.

**Keywords:** cycling, power, ergometry, calibration, training
Introduction

With changes in cycling performance as small as 1% determining the difference between a finish on the podium as opposed to a finish within the peloton, the ability to accurately monitor training and competitive performances in highly-trained cyclists is of high importance.\(^1\) Ergometers that replicate cycling are important pieces of laboratory equipment that can be used to conduct fitness assessments, enable structured training sessions and monitor training responses.\(^2\) With stationary laboratory ergometers, the resistance may be generated through mechanical friction,\(^2\) air resistance,\(^3\) or electromagnetism\(^4\) in order to replicate the physiological demands of cycling. Standard stationary laboratory ergometers have demonstrated various limitations including the inability to precisely replicate the setup of a cyclist’s own bicycle (i.e. same components, dimensions, gearing and joint angles)\(^3,5\) and the dynamic demands associated with cycling on the road.\(^4\) Given that cyclists may ride in excess of 35,000km per year, the ability to replicate individual training and race-specific variables as closely as possible is highly desirable.\(^3\) Indeed, the use of a cyclist’s own bicycle in performance assessment as suggested by Paton and Hopkins,\(^2\) is critical for producing reliable results predictive of competitive performance. When accustomed to the exercise protocol and cyclists’ own bicycles are used, the ability to replicate the physiological demands of cycling\(^6\) and movement economy are improved, enhancing the ecological validity in measures of performance.\(^4,6,7\)

In order to track meaningful changes in competitive performance from an ergogenic or training intervention, Hopkins et al.\(^7,8\) have suggested ergometer error/bias should be less than 2%. As such, the smaller reported coefficients of variation when a cyclist’s own bicycle is used are more likely to meet this stringent requirement within performance assessments. In order to manipulate training techniques and to detect meaningful changes in performance, coaches and
sports scientists need to be confident in the validity and reliability of power outputs of the
cycling ergometers being used.1,9

A recently available mobile cycle ergometer is the Wahoo KICKR Power Trainer
(KICKR: Wahoo Fitness, Atlanta, GA), a Bluetooth 4.0 and ANT + enabled stationary power
trainer allowing for the use of cyclists’ own bicycles attached via a SRAM/Shimano 10-speed
cassette with electronic resistance provided. The KICKR is widely used amongst professional
and recreational cyclists, however, to date, there is no independent scientific investigation
examining the validity of power output generated by the KICKR. Therefore, the aim of the
present study was to assess the validity of power measurements provided by the KICKR using
a dynamic calibration device.

Methods

The validity of the KICKR power output was assessed by comparison with the power
output of a dynamic calibration rig (CALRIG: Flinders University, Dynamic Calibrator 34118,
Adelaide, Australia) at the crank of an attached bicycle, allowing a comparison of power data
with an ecologically valid reference point based on first principles.10 As per manufacturer
requirements to overcome potential frictional losses, the CALRIG and the KICKR was
operated for 30 mins at 100-120rpm4 and 15 mins at 80-100rpm, respectively, immediately
prior to the assessment of power over varying cadences. The assessment of power was
conducted in standard laboratory conditions (18°C and 40% relative humidity).

The CALRIG used within this study has been previously described6,9 and is used to
facilitate the application of a constant cadence to the crank rather than to set a power output.
The CALRIG then quantifies the reaction torque (N.m) produced by the ergometer tested using
a calibrated load cell, 1 m from the fulcrum point with angular velocity (Rad.s−1) recorded via
a crystal-based timing device (10 MHz oscillator)4. A double universal joint connected to the
axis of rotation (i.e. bottom bracket axle) via a spline drive coupling device delivers the
rotational mechanical drive. A bicycle was attached to the KICKR via the SRAM/Shimano Cassette. A range of power outputs (100-999W) were achieved by manually varying the resistance settings to the maximum power achievable (999W) within the Wahoo Fitness Application for the KICKR (Wahoo Fitness, 2014 (version 5.1.1)) using the ‘ergometer mode’ selection. Power output was increased by 50W every 3 mins over 80, 90, 100, 110 and 120rpm. Power produced by the CALRIG was sampled at 200Hz and recorded every second (1Hz), however, only data produced in the final minute of each stage was used for analysis purposes according to the methodology as used by Hopker et al.11 A standardised twenty minute cool down was provided between each cadence tested.

**Statistical Analyses**

Measurements of validity (KICKR) were determined using bias and 95% limits of agreement (LoA) in accordance with the methods of Bland and Altman.12 Data was analysed using GraphPad Prism 5 version 5.03 (La Jolla, CA, USA). The relative error in measurement of power of the KICKR was calculated by subtracting the power measured by the CALRIG from the power settings entered into the Wahoo KICKR. For the purpose of this study, relative measurement bias of <1.5%, 1.5-2.5% and >2.5% were deemed as highly accurate, moderately accurate and inaccurate, respectively.4

**Results**

Overall absolute and relative bias and 95%LoA between the KICKR and the CALRIG over 100-999W and 80-120rpm as determined by Bland-Altman analysis are presented in Table 1.

Absolute mean power (W) differences in measures of power from the KICKR to the CALRIG over 100-999W at 80-120rpm are presented in Figure 1. An increased difference between set and measured power above 750 W was observed for cadences of 80, 90 and 100rpm (Figure 2).
Average relative error (%) in measures of power from the dynamic calibration rig to the Wahoo KICKR Power Trainer over 80-120rpm are presented in Figure 2. Larger differences between the KICKR and CALRIG were observed at higher ranges of power (900-999W) at 80, 90, 100 and 110rpm (Figures 2).

Discussion

The present study is the first to assess the validity of power measurements provided by the Wahoo KICKR Power Trainer using a CALRIG. The results of this investigation show the KICKR has a small mean bias and narrow limits of agreement in the measurement of power output over 250-700W at cadences of 80-120rpm, with larger mean biases and wider limits of agreements observed at lower and higher set power outputs.

The importance of measured power output for detecting changes within performance have been emphasised previously by Hopkins et al.\textsuperscript{7,8} who suggested to detect meaningful changes in performance due to ergogenic or training interventions in elite athletes, ergometer errors of <2% are required.\textsuperscript{7,8} When compared to a CALRIG, the mean bias of the KICKR of -1.1% (95%LoA: -3.5-1.4%, Table 1) over 250-700W at cadences of 80-120rpm, falls within this recommended range for ergometer error. Our findings for the KICKR are consistent with the ergometer errors of the Velotron and SRM power meters of <1% in constant power trials of 250W and 414W in comparison with a CALRIG as reported by Abbiss et al.\textsuperscript{4} Furthermore, an error of <1.3% for incremental power tests performed on the Velotron in comparison to a CALRIG was reported between 400W and 700W, similar to the KICKR’s accepted range of power output (250-700W). Larger mean biases and wider LoAs of 4.5% (95%LoA: -2.3-11.3%) and 13.0% (95%LoA:-24.4-50.3%) were observed for powers of 100-200W and 750-999W (Table 1), falling outside of the acceptable recommended ergometer error.\textsuperscript{7} The KICKR’s mean bias in the power range of 250-700W is better than the reported biases of 2.3% and -2.5% for the SRM and PowerTap between 50-1000W.\textsuperscript{9} Similar to Gardner et al.,\textsuperscript{9} greater
variance in power at the lower and higher ends of measured power was observed across cadences of 80-120rpm.

Despite the overall larger mean biases and limits of agreements observed across cadences at the lower (<250W) and higher (>750W) ranges of power (Table 1), it is clear these values are influenced by cadence selection. When evaluating cadences independently, Figure 2 shows a small mean bias of 0.8% between the KICKR and the CALRIG at the lower ranges of power (150-200W) at a cadence of 80rpm, and a bias of 0.9% can be seen at 120rpm at the higher range of power (750-950W), both falling within the accepted range for ergometer error as recommend by Hopkins. However, due to the stochastic nature of cycling and the constantly changing cadences at varying intensities, the validity of power across combined cadences have been reported for the present study’s findings.

Conclusion

The KICKR provides valid readings of power output over 250-700W at cadences of 80-120rpm. The KICKR appears to be suitable for laboratory training, performance assessments and talent identification purposes. Caution should be applied however at the lower and higher ranges of power (<200 and >750W) with the KICKR recording larger absolute and relative errors in comparison to the CALRIG. With power assessed to the highest operational range of the CALRIG, the validity of power output exceeding 999W (common in sprinting) remains to be investigated.
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References


Figure 1. Bland-Altman plot of the difference in absolute mean power output (W) between the Wahoo KICKR Power Trainer (KICKR) and the dynamic calibration rig (CALRIG) at 80rpm + 90rpm, 100rpm, 110rpm and 120rpm. Dashed lines represent the mean bias and 95% Limits of Agreement.
Figure 2. Relative error (%) of the Wahoo KICKR Power Trainer (KICKR) in comparison to the power produced by the dynamic calibration rig (CALRIG) over 100-999W at cadences of 80-120rpm. Errors of <1.5%, 1.5-2.5% and >2.5% are colour coded as green, yellow and red respectively.
Table 1. Bias and 95%LoA for absolute (W) and relative (%) differences in recordings of power at 100-999W for combined cadences of 80-120rpm.

<table>
<thead>
<tr>
<th>Power (W)</th>
<th>Bias (95%LoA) (W)</th>
<th>Bias (95%LoA) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100-999</td>
<td>30.0 (-158.0-218.1)</td>
<td>4.2 (-20.1-28.6)</td>
</tr>
<tr>
<td>100-200</td>
<td>5.7 (-1.4-12.8)</td>
<td>4.5 (-2.3-11.3)</td>
</tr>
<tr>
<td>250-700</td>
<td>-6.3 (-18.2-5.7)</td>
<td>-1.1 (-3.5-1.4)</td>
</tr>
<tr>
<td>750-999</td>
<td>102.7 (-186.2-391.7)</td>
<td>13.0 (-24.4-50.3)</td>
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