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## **The reliability of a 30 second sprint test on the Wattbike cycle ergometer**

Submission Type: Original Investigation

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## ABSTRACT

**Purpose:** The purpose of the present study was to determine the reliability of a 30s sprint cycle test on the Wattbike cycle ergometer. **Methods:** Over three consecutive weeks, 11 highly-trained cyclists (mean  $\pm$  SD; age =  $31 \pm 6$  years; mass =  $74.6 \pm 10.6$  kg; height =  $180.5 \pm 8.1$ cm) completed four 30s maximal sprints on the Wattbike ergometer following a standardised warm up. The sprint test implemented a ‘rolling start’ which consisted of a 60 s pre-load (at an intensity of 4.5W/kg) prior to the 30s maximal sprint. Variables determined across the duration of the sprint were peak power ( $W_{\text{peak}}$ ), mean power ( $W_{\text{mean}}$ ), Watts/kg, mean cadence (rpm), maximum heart rate (n=10) and post-exercise blood lactate. **Results:** The average intraclass correlation coefficients between trials (2v1, 3v2, 4v3, 4v1) were  $W_{\text{peak}}$ :0.97 (90%CI 0.94-0.99),  $W_{\text{mean}}$ :0.99 (90%CI 0.97-1.00), Watts/kg: 0.96 (90%CI 0.91-0.98), mean cadence: 0.96 (90%CI 0.92-0.99), maximum heart rate: 0.99 (90%CI 0.97-0.99) and post-exercise blood lactate: 0.94 (90%CI 0.87-0.98). The average typical error of measurement (expressed as a CV% and absolute value between trials - 2v1, 3v2, 4v3, 4v1) was:  $W_{\text{peak}}$ : 4.9%, 52.7 W;  $W_{\text{mean}}$ : 2.4%, 19.2 W; Watts/kg: 2.3%, 0.18 W/kg; mean cadence: 1.4%, 1.6 rpm; maximum heart rate: 0.9%, 1.6 bpm; and post-exercise blood lactate: 4.6%, 0.48 mmol/L. **Conclusion:** A 30s sprint test on the Wattbike cycle ergometer is highly reproducible in trained cyclists.

**KEY WORDS** power output, lactic acid, cycling, reproducibility of results, exercise test, athletic performance

## INTRODUCTION

Sprint performance in the laboratory has been closely related to field sprint performance in elite cyclists<sup>1</sup> highlighting that laboratory assessment of variables such as anaerobic peak power and mean power provide meaningful data for assessing and monitoring performance. When monitoring exercise performance in the laboratory, field knowledge of test-retest reliability provides valuable information to determine what changes in performance may be detected with the test. The knowledge of test-retest reliability may also help in the calculation of sample size and determine precision of measurement between different ergometers.<sup>2</sup> This is of particular importance when working with athletes where improvements in performance are small, but may still be considered worthwhile in a competitive sport setting.<sup>3</sup>

A number of ergometers have been used to assess anaerobic cycling performance including mechanically-braked<sup>4, 5</sup> and electromagnetically-braked ergometers.<sup>6</sup> Geometry and lower limb kinematics that most closely replicate a cyclist's position on their own bike are associated with improved economy<sup>7</sup> and for that reason an ergometer that closely reflects the feel of cycling may provide a superior means of assessing exercise performance, when compared to ergometers that allow minimal adjustments. An ergometer that has been designed to simulate 'real' cycling is the Wattbike cycle ergometer (Wattbike Pro, Nottingham, UK) with a suitable power output range (0 to 3760 Watts) for short duration, high-intensity testing and training.

The Wattbike cycle ergometer is currently used in numerous sporting facilities and University laboratories to assess and monitor cycling performance, however, to date only one study has investigated the accuracy and reproducibility of the ergometer. The validity and reliability of the Wattbike has been determined under constant load cycling (in the range of 50-300W) with a reported CV of 2.6% in trained cyclists.<sup>8</sup> While the reliability of constant

load exercise up to 300W has been previously assessed, the reliability of a sprint performance test associated with higher power outputs is yet to be determined on the Wattbike. Determining the coefficient of variation of a sprint test on a Wattbike will provide insight into monitoring performance and assessing meaningful performance changes. The aim of the present study was therefore to determine the reliability of power, cadence and physiological variables during a 30 s sprint cycle test on the Wattbike in trained, competitive cyclists.

## **METHODS**

### **Subjects:**

Eleven highly-trained cyclists (mean  $\pm$  SD; age =  $31 \pm 6$  years; mass =  $74.6 \pm 10.6$  kg; height =  $180.5 \pm 8.1$  cm) volunteered to take part in the current study. All testing took place during the competition phase of the cycling season in Australia where all subjects were racing at either A or B grade level in their State. Subjects provided informed consent prior to any testing taking place. The study was approved by the Australian Institute of Sport Research Ethics Committee.

### **Design:**

To examine the test-retest reliability of a 30 s sprint test on a Wattbike cycle ergometer, subjects attended five separate testing sessions, including an initial familiarization trial, over a three-week period. To minimize any learning effect, the familiarization trial consisted of subjects performing three separate 30 s sprints (including warm-up and warm-down) on a cycle ergometer, each separated by a 30 min passive recovery period. The experimental trials consisted of a standardized warm-up and pre-load, an all-out 30 s sprint, and a standardized cool-down. Following the familiarization trial, subjects performed four trials separated by  $> 48$  h within a maximum of 14 days. In order to control any dietary variables, subjects

completed a 24 h food diary prior to their first trial and were instructed to replicate their diet as closely as possible before the subsequent trials. Training was also controlled for, with subjects keeping all training the same <48 h before testing on all occasions. Subjects were asked to refrain from strenuous exercise (<24 h) and caffeine (<12 h) and to arrive in a fully rested, hydrated state. All testing was performed at the same time of day ( $\pm 1$  h) to minimize diurnal variation, and on the same cycle ergometer.

### **Methodology:**

All cycle testing was performed on an air-braked cycle ergometer (Wattbike Pro, Nottingham, UK). The Wattbike calculates power output by measuring the chain tension over a load cell (sampled at 100 Hz) using the formula:

$$P[W] = (F[N] * l[m])/t[s]$$

Where  $P[W]$  = power output per revolution,  $F[N]$  = average force per crank revolution,  $l[m] = 0.17\text{m}$  as a crank length,  $t[s]$  = time taken to complete a crank revolution. The Wattbike measures angular velocity twice per crank revolution. Prior to the start of the study, the Wattbike ergometer was calibrated on a dynamic calibration rig using a first principles approach by specialists at the Australian Institute of Sport. The reliability of the Wattbike cycle ergometer has been reported previously over a range of power outputs (50-300W), with a CV of 2.6% (95% CI 0.7-2.0%) in trained cyclists.<sup>8</sup>

Each cycle test consisted of an incremental warm-up (three minutes at 2.5 W/kg, 3.0 W/kg, and 4.0 W/kg), followed by 60 s of passive rest, two short sprints (three-second max sprints with 20 seconds of easy pedaling between each) and finished with five minutes at 2.5 W/kg. Following the warm-up, there was a 60 s period of setup time where subjects were instructed to sit passively before proceeding to the sprint test. The sprint test implemented a ‘rolling start’ which consisted of a 60 s pre-load (at an intensity of 4.5 W/kg) prior to the 30 s maximal sprint. During the 30 s sprint, subjects had access to elapsed time and were required

to produce as much work as possible in the timeframe. With the exception of verbal encouragement no other information was provided. During the sub-maximal stages of the warm-up, pre-load and warm-down, subjects were instructed to maintain a target power output relative to their individual body weight (W/kg). The gearing and cadence (rpm) were self-selected by subjects on the Wattbike ergometer during the familiarization trial and then replicated during the pre-load and 30 s sprint in the experimental trials. Saddle height, saddle position, handle bar height and handle bar position were replicated for each trial. Subjects wore their own cycling shoes with toe clips. All subjects were instructed to perform the sprint as a maximal all-out effort and as such they began the 30 s sprint out of the saddle and were typically seated for the final seconds of the sprint.

The computer attached to the cycle ergometer was used to record mean 30 s power output ( $W_{\text{mean}}$ ), peak power output ( $W_{\text{peak}}$ ) and average cadence data (rpm) during the sprint test. Immediately following the sprint test, a standardized cool down (three minutes at 2.0 W/kg) was completed. The sprint test protocol implemented in the current study was designed to closely mimic certain track-cycling events that involve a period of pre-load followed by a maximal sprint effort (e.g Keirin track-cycling event). The protocol may also be applicable to various team sports that require bouts of high-intensity exercise followed by maximal sprints.

Blood lactate concentration was measured via a capillary finger-tip sample and was analyzed with a Lactate-Pro analyzer (Shiga, Japan). Measurements were taken three minutes following the maximal sprint test (end of warm-down). The test-retest reliability of the Lactate Pro has been previously reported, with technical error of measurement results ranging from 0.1-0.4 mmol.L<sup>-1</sup> at blood lactate concentrations of 1.0-18.0 mmol.L<sup>-1</sup>.<sup>9</sup> These values were not corrected for plasma volume changes.

Heart rate was measured continuously (RS800cx, Polar Electro Oy, Finland) during the experimental trials.

### **Statistical Analyses:**

Data were log transformed<sup>8, 10</sup> and analysed using an Excel spreadsheet for reliability.<sup>11</sup> An individual's CV was calculated as the SD of an individual's repeated measurement expressed as a percent of their individual mean test score.<sup>2</sup> The intraclass correlation coefficient (ICC) between trials was determined in combination with the 90% confidence limits (CI). Typical error is expressed as a CV% and as an absolute value along with upper and lower 90% CI

### **RESULTS**

HR data were obtained from 10 of the 11 cyclists. Mean data for sprint performance variables and physiological variables are presented in Table 1.

The highest correlation and lowest typical error (expressed as a CV%) for  $W_{\text{peak}}$ ,  $W_{\text{mean}}$  and mean W/kg were between tests one and two (Table 2). Blood lactate concentration had the highest correlation and lowest typical error between tests three and four and HR between tests two and three. Rpm had the highest ICC between tests one and two and lowest typical error between tests four and one. The average ICC and typical error of measurement between trials (2v1, 3v2, 4v3, 4v1) are presented in Table 2. Difference from the mean of all trials for  $W_{\text{peak}}$ ,  $W_{\text{mean}}$ , blood lactate concentration and maximum heart rate are shown in Figure 1.

### **DISCUSSION**

This is the first investigation to determine reproducibility of sprint performance of trained cyclists on the Wattbike cycle ergometer. Previously, only the reliability of constant load exercise up to 300 W on the Wattbike had been assessed. Our findings suggest that

power outputs, cadence and physiological variables from a 30 s all out sprint performed on the Wattbike are highly reproducible. In addition, the low technical error of measurement and high ICCs between trials one and two suggest that a familiarization session that entails three 30 s sprints is sufficient to minimize any learning effect in trained cyclists for this sprint test.

The average technical error of measurement for  $W_{\text{peak}}$  was 4.9% and for  $W_{\text{mean}}$  2.4%, with the lowest CV reported between trials one and two (4.2% and 2.1%, respectively). In a meta analysis by Hopkins et al.<sup>10</sup> the CV for mean power from a 30 s cycle test has been reported between 2.2 to 5.8%. The CVs for  $W_{\text{peak}}$  and  $W_{\text{mean}}$  on the Wattbike are similar to those reported for trained cyclists tested on their own bicycle fitted to an airbraked ergometer with SRM cranks ( $W_{\text{peak}} = 4.5 \pm 1.6\%$  and  $W_{\text{mean}} = 2.4 \pm 1.2\%$ ).<sup>12</sup> Given the low CV between trial one and trial two we support previous findings that in trained cyclists variability does not extend beyond the second trial,<sup>13, 14</sup> particularly for the key variables of  $W_{\text{peak}}$  and  $W_{\text{mean}}$ . Given the low CV a trained cyclist may only require one familiarization session (consisting of three repeated sprints) if assessing power output during a 30 s sprint on a Wattbike.

The ICC for blood lactate concentration in response to maximal sprint exercise on the Wattbike is similar to that reported by Weinstein et al (ICC=0.93)<sup>15</sup> who conducted a Wingate test on a computerised cycle ergometer in a heterogeneous cohort and Coleman et al.<sup>12</sup> that had a more homogeneous population of trained cyclists but used the cyclists own bicycles attached to an airbraked ergometer. The CV in the present study however (3.6-6.0%) was lower than that reported by Weinstein (17%)<sup>15</sup> and Coleman et al. (12.1%)<sup>12</sup> suggesting that if post-exercise lactate concentration is a key variable of interest, the Wattbike sprint test would be

more sensitive to change in this variable. The low CV of average cadence and HR also make these variables sensitive to small changes.

While validity of the Wattbike was not assessed in the present study, power output values are comparable to those previously reported in cyclists. In the present study  $W_{\text{peak}}$  and  $W_{\text{mean}}$  were higher than those reported in active to moderately trained men from a 30 s test on a Lode Excalibur ergometer ( $945 \pm 165$  W and  $721 \pm 113$  W, respectively)<sup>16</sup> but similar to those reported in endurance trained, nationally competitive track cyclists performing a 30 s Wingate test on a mechanically braked Monark cycle ergometer.<sup>17</sup> The difference in power outputs across studies is likely to be attributable to the training status of the subjects as Micklewright et al.<sup>6</sup> have reported that  $W_{\text{peak}}$  and  $W_{\text{mean}}$  determined from a Wingate test are not significantly different when measured on a Lode Excalibur or Monark ergometer.

## **PRACTICAL APPLICATIONS**

A 30 s all-out sprint test on the Wattbike cycle ergometer is highly reproducible in trained cyclists for peak power, mean power, Watts/kg, mean cadence, maximum heart rate and post-exercise blood lactate. The typical error (and other) data presented enables the tester to determine if changes across time in 30 s all-out sprint performance on the Wattbike are ‘true’ improvements or reductions in sprint performance variables. A minimum of nine, highly-trained cyclists would be required to detect a smallest worthwhile change of 0.2 of the between-subject standard deviation in  $W_{\text{peak}}$ . A familiarization session that entails three 30 s sprints is sufficient to minimize any learning effect in trained cyclists for the reported 30 s sprint test on the Wattbike.

## **CONCLUSION**

A 30 s all out sprint performed on the Wattbike is reliable for  $W_{\text{peak}}$ ,  $W_{\text{mean}}$ , average cadence, maximum heart rate and post-exercise blood lactate concentration. Our data provide an indication of variability in these measures across four trials and as such can be used to

determine worthwhile changes in 30 s cycle sprint performance variables. When a standardized warm up is employed, the Wattbike sprint test is reproducible.

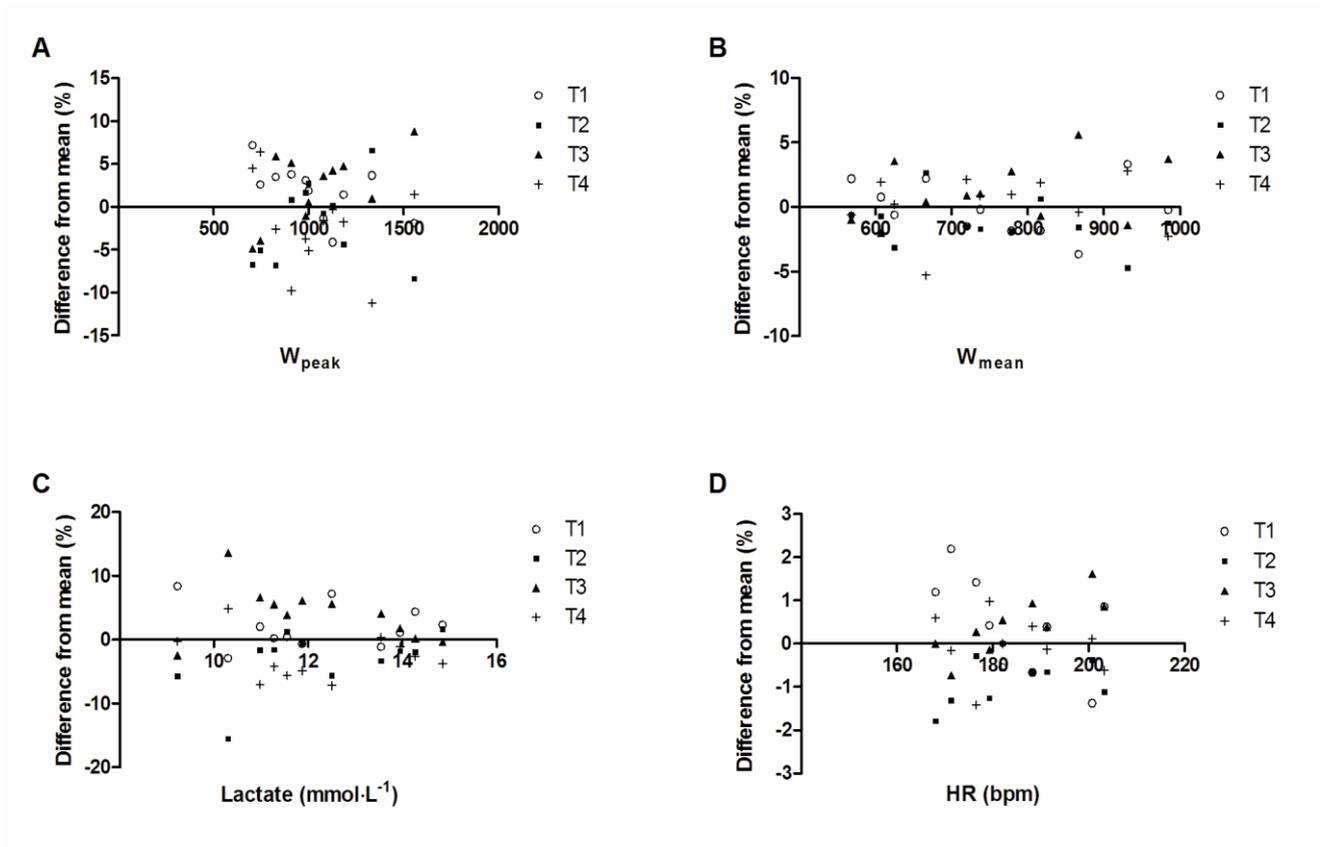
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**Figure 1.** Difference (%) of each individual trial from the mean of four trials for each individual for A) peak power,  $W_{peak}$  (W), B) mean power,  $W_{mean}$  (W), C) blood lactate (mmol/L) and D) HR (bpm).

**Table 1.** Mean performance and physiological variables from competitive cyclists during and following a 30 s sprint on a Wattbike cycle ergometer over four separate testing sessions. Data are presented as mean  $\pm$  SD.

	Test 1	Test 2	Test 3	Test 4	Average
$W_{\text{peak}}$ (W)	1054 $\pm$ 241	1023 $\pm$ 256	1069 $\pm$ 293	1014 $\pm$ 245	1040 $\pm$ 259
$W_{\text{mean}}$ (W)	753 $\pm$ 134	744 $\pm$ 129	765 $\pm$ 145	756 $\pm$ 138	755 $\pm$ 137
rpm	119 $\pm$ 8	118 $\pm$ 7	120 $\pm$ 9	120 $\pm$ 7	119 $\pm$ 8
$W \cdot \text{kg}^{-1}$	10.1 $\pm$ 1.0	10.0 $\pm$ 1.1	10.2 $\pm$ 0.9	10.1 $\pm$ 0.8	10.1 $\pm$ 1.0
Lactate ( $\text{mmol} \cdot \text{L}^{-1}$ )	12.4 $\pm$ 1.8	11.9 $\pm$ 2.0	12.7 $\pm$ 1.7	11.9 $\pm$ 1.7	12.2 $\pm$ 1.8
HR (bpm)	185 $\pm$ 11	183 $\pm$ 12	186 $\pm$ 13	185 $\pm$ 12	185 $\pm$ 12

**Table 2.** Mean within-subject intraclass correlation (ICC) and typical error as a coefficient of variation (CV%) of between test change. Absolute typical error of the measurement (TEM) values are presented as the mean of the four comparisons. Data are presented as mean (90%CI).

	W <sub>peak</sub> (W)	W <sub>mean</sub> (W)	W/kg	rpm	Lactate (mmol/L)	HR (bpm)
ICC <sup>(2to1)</sup>	0.98 (0.94 to 0.99)	0.99 (0.97 to 1.00)	0.98 (0.95 to 0.99)	0.97 (0.91 to 0.99)	0.95 (0.87 to 0.98)	0.98 (0.93 to 0.99)
ICC <sup>(3 to 2)</sup>	0.97 (0.93 to 0.99)	0.99 (0.96 to 1.00)	0.94 (0.83 to 0.98)	0.95 (0.86 to 0.99)	0.90 (0.72 to 0.96)	1.00 (0.99 to 1.00)
ICC <sup>(4 to 3)</sup>	0.96 (0.89 to 0.99)	0.98 (0.95 to 0.99)	0.98 (0.93 to 0.99)	0.96 (0.90 to 0.99)	0.95 (0.87 to 0.98)	0.99 (0.98 to 1.00)
ICC <sup>(4 to 1)</sup>	0.93 (0.81 to 0.98)	0.97 (0.92 to 0.99)	0.84 (0.58 to 0.94)	0.93 (0.82 to 0.98)	0.88 (0.67 to 0.96)	0.95 (0.86 to 0.98)
Mean ICC	0.97 (0.94 to 0.99)	0.99 (0.97 to 1.00)	0.96 (0.91 to 0.98)	0.96 (0.92 to 0.99)	0.94 (0.87 to 0.98)	0.99 (0.97 to 0.99)
CV <sup>(2 to 1)</sup>	4.2 (3.1 to 6.7)	2.1 (1.5 to 3.3)	1.6 (1.2 to 2.6)	1.3 (1.0 to 2.1)	4.1 (3.0 to 6.6)	1.1 (0.8 to 1.8)
CV <sup>(3 to 2)</sup>	4.9 (3.6 to 8.0)	2.4 (1.7 to 3.8)	2.9 (2.2 to 4.7)	1.7 (1.2 to 2.7)	6.0 (4.4 to 9.7)	0.4 (0.3 to 0.7)
CV <sup>(4 to 3)</sup>	5.7 (4.2 to 9.3)	2.8 (2.0 to 4.4)	1.6 (1.1 to 2.5)	1.5 (1.1 to 2.4)	3.6 (2.7 to 5.8)	0.7 (0.5 to 1.1)
CV <sup>(4 to 1)</sup>	4.8 (3.5 to 7.8)	2.5 (1.8 to 3.9)	2.7 (2.0 to 4.4)	1.2 (0.9 to 2.0)	4.2 (3.1 to 6.8)	1.1 (0.8 to 1.8)
Mean CV	4.9 (4.1 to 6.3)	2.4 (2.0 to 3.1)	2.3 (1.9 to 2.9)	1.4 (1.2 to 1.8)	4.6 (3.8 to 5.8)	0.9 (0.7 to 1.1)
Absolute TEM	52.7 W (43.9 to 67.1)	19.2 W (16.0 to 24.4)	0.18 W/kg (0.18 to 0.28)	1.6 rpm (1.4 to 2.1)	0.48 mmol/L (0.40 to 0.61)	1.6 bpm (1.3 to 2.0)