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The Reliability of a 30-s Sprint Test on the Wattbike Cycle Ergometer

Matthew W. Driller, Christos K. Argus, and Cecilia M. Shing

Purpose: To determine the reliability of a 30-s sprint cycle test on the Wattbike cycle ergometer. **Methods:** Over 3 consecutive weeks, 11 highly trained cyclists (mean \pm SD; age 31 ± 6 y, mass 74.6 ± 10.6 kg, height 180.5 ± 8.1 cm) completed four 30-s maximal sprints on a Wattbike ergometer after a standardized warm-up. The sprint test implemented a “rolling start” that consisted of a 60-s preload (at an intensity of 4.5 W/kg) before the 30-s maximal sprint. Variables determined across the duration of the sprint were peak power (W_{peak}), mean power (W_{mean}), W/kg, mean cadence (rpm), maximum heart rate ($n = 10$), and postexercise blood lactate. **Results:** The average intraclass correlation coefficients between trials (2v1, 3v2, 4v3, 4v1) were W_{peak} .97 (90%CI .94–.99), W_{mean} .99 (90%CI .97–1.00), W/kg .96 (90%CI .91–.98), mean cadence .96 (90%CI .92–.99), maximum heart rate .99 (90%CI .97–.99), and postexercise blood lactate .94 (90%CI .87–.98). The average typical error of measurement (expressed as a CV% and absolute value between trials—2v1, 3v2, 4v3, 4v1) was W_{peak} 4.9%, 52.7 W; W_{mean} 2.4%, 19.2 W; W/kg 2.3%, 0.18 W/kg; mean cadence 1.4%, 1.6 rpm; maximum heart rate 0.9%, 1.6 beats/min; and postexercise blood lactate 4.6%, 0.48 mmol/L. **Conclusion:** A 30-s sprint test on the Wattbike cycle ergometer is highly reproducible in trained cyclists.

Keywords: power output, lactic acid, cycling, reproducibility of results, exercise test, athletic performance

Sprint performance in the laboratory has been closely related to field sprint performance in elite cyclists,¹ highlighting that laboratory assessment of variables such as anaerobic peak power and mean power provides 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 determining precision of measurement between different ergometers.² 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.³

A number of ergometers have been used to assess anaerobic cycling performance, including mechanically braked^{4,5} and electromagnetically braked ergometers.⁶ Geometry and lower limb kinematics that most closely replicate a cyclist’s position on his or her own bike are associated with improved economy,⁷ and for that reason an ergometer that closely reflects the feel of cycling may provide a superior means of assessing exercise performance, compared with 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 (0–3760 W) 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 1 study has investigated the accuracy and reproducibility of the ergometer. The validity and reliability of the Wattbike have been determined under constant-load cycling (in the range of 50–300 W) with a reported coefficient of variation (CV) of 2.6% in trained cyclists.⁸ While the reliability of constant-load exercise up to 300 W 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 CV of a sprint test on a Wattbike will provide insight into monitoring performance and assessing meaningful performance changes. The aim of the current study was therefore to determine the reliability of power, cadence, and physiological variables during a 30-second sprint cycle test on the Wattbike in trained, competitive cyclists.

Methods

Subjects

Eleven highly trained cyclists (mean \pm SD; age 31 ± 6 y, mass 74.6 ± 10.6 kg, height 180.5 ± 8.1 cm) volunteered

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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 before any testing taking place. The study was approved by the Australian Institute of Sport research ethics committee.

Design

So that we could examine the test–retest reliability of a 30-second sprint test on a Wattbike cycle ergometer, subjects attended 5 separate testing sessions, including an initial familiarization trial, over a 3-week period. To minimize any learning effect, the familiarization trial consisted of subjects performing 3 separate 30-second sprints (including warm-up and cooldown) on a cycle ergometer, each separated by a 30-minute passive recovery period. The experimental trials consisted of a standardized warm-up and preload, an all-out 30-second sprint, and a standardized cooldown. After the familiarization trial, subjects performed 4 trials separated by >48 hours within a maximum of 14 days. To control any dietary variables, subjects completed a 24-hour food diary before 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 hours 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 (± 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) $\times l$ (m)]/ t (s), where P (W) = power output per revolution, F (N) = average force per crank revolution, l (m) = 0.17 m as a crank length, and t (s) = time taken to complete a crank revolution. The Wattbike measures angular velocity twice per crank revolution. Before 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 (50–300 W), with a CV of 2.6% (95%CI 1.8–5.1%) in trained cyclists.⁸

Each cycle test consisted of an incremental warm-up (3 min at 2.5 W/kg, 3.0 W/kg, and 4.0 W/kg), followed by 60 seconds of passive rest and 2 short sprints (3-s max sprints with 20 s of easy pedaling between), and finished with 5 minutes at 2.5 W/kg. After the warm-up, there

was a 60-second period of setup time where subjects were instructed to sit passively before proceeding to the sprint test. The sprint test implemented a “rolling start” that consisted of a 60-second preload (at an intensity of 4.5 W/kg) before the 30-second maximal sprint. During the 30-second sprint, subjects had access to elapsed time and were required to produce as much work as possible in the time frame. With the exception of verbal encouragement, no other information was provided. During the submaximal stages of the warm-up, preload, and cooldown, 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 preload and 30-second sprint in the experimental trials. Saddle and handlebar height and 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-second 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-second power output (W_{mean}), peak power output (W_{peak}), and average cadence data (rpm) during the sprint test. Immediately after the sprint test, a standardized cooldown (3 min 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 preload followed by a maximal sprint effort (eg, 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 fingertip sample and analyzed with a Lactate-Pro analyzer (Shiga, Japan). Measurements were taken 3 minutes after 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 to 0.4 mmol/L at blood lactate concentrations of 1.0 to 18.0 mmol/L.⁹ 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^{8,10} and analyzed using an Excel spreadsheet for reliability.¹¹ An individual's CV was calculated as the SD of an individual's repeated measurement expressed as a percentage of his or her individual mean test score.² 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

Heart-rate 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_{peak} , W_{mean} , and mean W/kg were between tests 1 and 2 (Table 2). Blood lactate concentration had the highest correlation and lowest typical error between tests 3 and 4, and heart rate, between tests 2 and 3. The highest ICC for rpm was between tests 1 and 2, and the lowest typical error, between tests 4 and 1. The average ICC and typical error of measurement between trials (2v1, 3v2, 4v3, 4v1) are presented in Table 2. Differences from the mean of all trials for W_{peak} , W_{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-second all-out sprint performed on the Wattbike are highly reproducible. In addition, the low technical error of measurement and high ICCs between trials 1 and 2 suggest that a familiarization session that entails three 30-second sprints is sufficient to minimize any learning effect in trained cyclists for this sprint test.

The average technical error of measurement for W_{peak} was 4.9% and for W_{mean} 2.4%, with the lowest CV reported between trials 1 and 2 (4.2% and 2.1%,

Table 1 Mean Performance and Physiological Variables From Competitive Cyclists During and After a 30-Second Sprint on a Wattbike Cycle Ergometer over 4 Separate Testing Sessions, Mean \pm SD

	Test 1	Test 2	Test 3	Test 4	Average
Peak power (W)	1054 \pm 241	1023 \pm 256	1069 \pm 293	1014 \pm 245	1040 \pm 259
Mean power (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/kg	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 (mmol/L)	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
Heart rate (beats/min)	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-Tests Change

	W_{peak} (W)	W_{mean} (W)	W/kg	rpm	Lactate (mmol/L)	HR (beats/min)
ICC ₂₋₁	.98 (.94-.99)	.99 (.97-1.00)	.98 (.95-.99)	.97 (.91-.99)	.95 (.87-.98)	.98 (.93-.99)
ICC ₃₋₂	.97 (.93-.99)	.99 (.96-1.00)	.94 (.83-.98)	.95 (.86-.99)	.90 (.72-.96)	1.00 (.99-1.00)
ICC ₄₋₃	.96 (.89-.99)	.98 (.95-.99)	.98 (.93-.99)	.96 (.90-.99)	.95 (.87-.98)	.99 (.98-1.00)
ICC ₄₋₁	.93 (.81-.98)	.97 (.92-.99)	.84 (.58-.94)	.93 (.82-.98)	.88 (.67-.96)	.95 (.86-.98)
Mean ICC	.97 (.94-.99)	.99 (.97-1.00)	.96 (.91-.98)	.96 (.92-.99)	.94 (.87-.98)	.99 (.97-.99)
CV ₂₋₁	4.2 (3.1-6.7)	2.1 (1.5-3.3)	1.6 (1.2-2.6)	1.3 (1.0-2.1)	4.1 (3.0-6.6)	1.1 (0.8-1.8)
CV ₃₋₂	4.9 (3.6-8.0)	2.4 (1.7-3.8)	2.9 (2.2-4.7)	1.7 (1.2-2.7)	6.0 (4.4-9.7)	0.4 (0.3-0.7)
CV ₄₋₃	5.7 (4.2-9.3)	2.8 (2.0-4.4)	1.6 (1.1-2.5)	1.5 (1.1-2.4)	3.6 (2.7-5.8)	0.7 (0.5-1.1)
CV ₄₋₁	4.8 (3.5-7.8)	2.5 (1.8-3.9)	2.7 (2.0-4.4)	1.2 (0.9-2.0)	4.2 (3.1-6.8)	1.1 (0.8-1.8)
Mean CV	4.9 (4.1-6.3)	2.4 (2.0-3.1)	2.3 (1.9-2.9)	1.4 (1.2-1.8)	4.6 (3.8-5.8)	0.9 (0.7-1.1)
Absolute TEM	52.7 W (43.9-67.1)	19.2 W (16.0-24.4)	0.18 W/kg (0.18-0.28)	1.6 rpm (1.4-2.1)	0.48 mmol/L (0.40-0.61)	1.6 beats/min (1.3-2.0)

Abbreviations: W_{peak} , peak power; W_{mean} , mean power; HR, heart rate; TEM, typical error of the measurement. Absolute values for TEM are presented as the mean of the 4 comparisons, mean (90%CI).

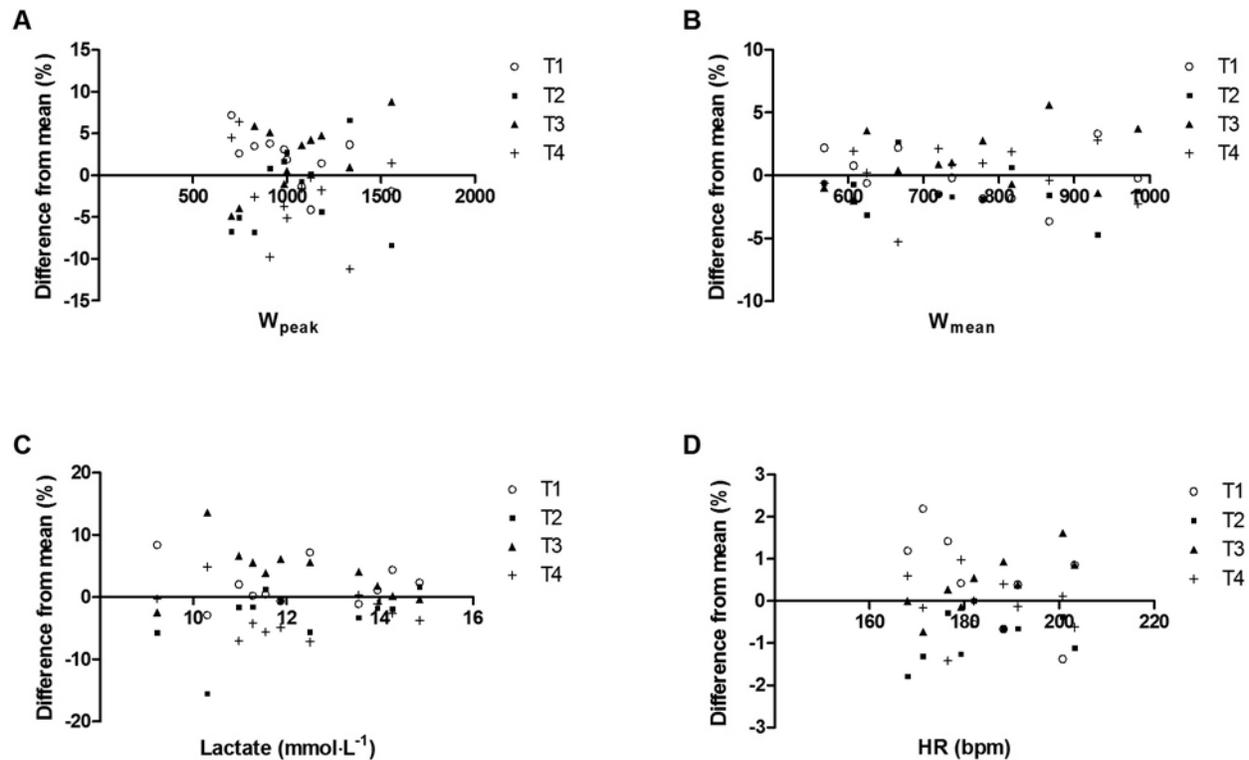


Figure 1 — Difference (%) of each individual trial from the mean of 4 trials for each individual for (A) peak power (W), (B) mean power (W), (C) blood lactate (mmol/L), and (D) heart rate (beats/min).

respectively). In a meta-analysis by Hopkins et al,¹⁰ the CV for mean power from a 30-second cycle test has been reported between 2.2% and 5.8%. The CVs for W_{peak} and W_{mean} on the Wattbike are similar to those reported for trained cyclists tested on their own bicycle fitted to an air-braked ergometer with SRM cranks ($W_{\text{peak}} = 4.5\% \pm 1.6\%$ and $W_{\text{mean}} = 2.4\% \pm 1.2\%$).¹² Given the low CV between trial 1 and trial 2, we support previous findings that in trained cyclists variability does not extend beyond the second trial,^{13,14} particularly for the key variables of W_{peak} and W_{mean} . Given the low CV, a trained cyclist may only require 1 familiarization session (consisting of 3 repeated sprints) if assessing power output during a 30-second 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 al¹⁵ (ICC = .93), who conducted a Wingate test on a computerized cycle ergometer in a heterogeneous cohort, and Coleman et al,¹² who had a more homogeneous population of trained cyclists but used the cyclists' own bicycles attached to an air-braked ergometer. The CV in the current study, however (3.6–6.0%), was lower than that reported by Weinstein et al¹⁵ (17%) and Coleman et al¹² (12.1%), suggesting that if postexercise lactate concentration is a key variable of interest, the Wattbike sprint test would be more sensitive to change in this variable. The low CVs of average

cadence and HR also make these variables sensitive to small changes.

While validity of the Wattbike was not assessed in the current study, power output values are comparable to those previously reported in cyclists. In the current study, W_{peak} and W_{mean} were higher than those reported in active to moderately trained men from a 30-second test on a Lode Excalibur ergometer (945 ± 165 W and 721 ± 113 W, respectively)¹⁶ but similar to those reported in endurance-trained, nationally competitive track cyclists performing a 30-second Wingate test on a mechanically braked Monark cycle ergometer.¹⁷ The difference in power outputs across studies is likely attributable to the training status of the subjects, as Micklewright et al⁶ have reported that W_{peak} and W_{mean} determined from a Wingate test are not significantly different when measured on a Lode Excalibur or Monark ergometer.

Practical Applications

A 30-second all-out sprint test on the Wattbike cycle ergometer is highly reproducible in trained cyclists for peak power, mean power, W/kg , mean cadence, maximum heart rate, and postexercise blood lactate. The typical error (and other) data presented enable the tester to determine if changes across time in 30-second all-out sprint performance on the Wattbike are “true” improvements or

reductions in sprint-performance variables. A minimum of 9 highly trained cyclists would be required to detect a smallest worthwhile change of .2 of the between-subjects standard deviation in W_{peak} . A familiarization session that entails three 30-second sprints is sufficient to minimize any learning effect in trained cyclists for the reported 30-second sprint test on the Wattbike.

Conclusion

A 30-second all-out sprint performed on the Wattbike is reliable for W_{peak} , W_{mean} , average cadence, maximum heart rate, and postexercise blood lactate concentration. Our data provide an indication of variability in these measures across 4 trials and, as such, can be used to determine worthwhile changes in 30-second cycle sprint performance variables. When a standardized warm-up is employed, the Wattbike sprint test is reproducible.

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