A COMPARISON OF THE AEROBIC ENERGY DEMANDS OF TWO COMMERCIALLY AVAILABLE CYCLE ERGOMETERS IN TRAINED CYCLISTS

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The purpose of this study was to compare the energy demands of two cycling ergometers, (Velotron Dynafit Pro and Monark 834E) commonly used in the physiological monitoring of elite athletes. Eight trained male cyclists with a minimum 2 years training and racing experience participated in the study. Each subject completed an exercise trial involving a maximal incremental test. Testing was performed in a random order on either the Velotron or Monark cycle ergometer at the same time of day with no more than 14 days between each testing session. Subjects were requested to maintain their normal training and nutritional practices during the course of the study but to refrain from any intensive training 48 hours prior to each testing session. During the incremental testing significant differences for power output (PO), heart rate (HR), and oxygen uptake (VO_2) were found at both at fixed blood lactate (BL) reference points of; 2.5mmol l^{-1} (REF2.5mM) and at 4mmol·l^{-1} (REF4mM). Overall the Velotron appeared to provide a more specific measure of cycling performance with significantly lower energy demands at fixed submaximal exercise intensities being observed as well as a significantly greater peak power output and time to exhaustion being attained, which may reflect the specific cycling position adopted. Further research is required to compare the findings of this study with actual cycling performance.

KEYWORDS: Ergometry, Cycling, Power, Physiology

INTRODUCTION:

Ergometry is routinely used in a laboratory setting to evaluate physiological function and monitor changes in training status and performance of elite athletes from a range of sports. In road cycling, for laboratory testing to accurately replicate the physiological and biomechanical demands of the activity testing must be accurate, reliable and specific to the event. Traditionally physiological testing of cyclists is undertaken on a standard laboratory ergometer on which the athlete adopts a spurious non-specific riding position. In an attempt to address this issue a number of cycling ergometers have been developed which allow the accurate replication of the riding position that a cyclist adopts on their bicycle and hence measure performance predicting physiological variables with a much higher level of specificity. The purpose of this study therefore was to compare the aerobic energy demands of two commercially available cycle ergometers in trained cyclists.

METHODS:

Eight trained male cyclists aged between 18 and 35 with at least 2 years racing and training experience were recruited to participate in this study. Subjects attended the Human Performance Laboratory located at the School of Health and Human Performance at DCU on two separate occasions. Each visit was separated by no more than 14 days with each test being performed at the same time of day. Prior to participating in each trial, the subjects were advised to maintain their normal training and nutritional practices, and to refrain from any strenuous activity in the preceding 48-hour period. Prior to undertaking any physiological tests, body mass and height were measured and recorded using a digital scales and stadiometer. Body Composition was measured and recorded using repeat skinfold measurements taken at 7 sites using a calibrated Harpenden skinfold calliper to estimate body composition. The Velotron Dynafit Pro (Racermate Inc., Seattle, U.S.A) was the sports specific cycling ergometer selected. It uses a magnetically braked flywheel, which is controlled from a PC. A preset protocol is loaded into the software and resistance is corrected automatically and independent of cadence. The ergometer arrives calibrated from the factory and no extra calibration is needed. It is possible to calibrate the Velotron via the AccuWattTM calibration checking procedure from the PC; this checks the original factory performance to verify that no change has occurred. The Monark 824 E Ergomedic (Monark Exercise AB, Vansbro, Sweden) generates a frictional force about the flywheel by tensioning a cord, which is attached to a hanging basket. This allows for weights to be added increasing the frictional force generated. Due to the nature of the resistive force the resistance is not independent of cadence. The flywheel is graduated to allow the usage of a photo-sensor to measure its rotational speed. This sensor connects to a PC via an ADC-11 data channel logger which, with software provided by Monark allows for calibration of the ergometer, and recording of data during testing. HR was measured continuously using a wireless Polar HR monitor (Polar Electro, Finland), Lactate measurement with a Lactate Pro analyser (Arkray, Japan); data were analysed using SPSS version 14. Significance was set at the $p<0.05$ level. Differences between means were analysed using a paired samples Student's t-test. Differences between ergometers were analysed using One Way ANOVA. Gas analysis was continuously measured using open circuit spirometry using an Innovision Innocor^{TM} (Innovision, Denmark) metabolic cart. The system was calibrated to manufacturer's specification using a 3L syringe and its own calibration procedure.

When each subject was using the Velotron, the ergometer was set up to replicate their preferred riding position by taking specific measurements from their own bicycle. The Velotron is adjustable along each of its major axes. Adjustments can be made to: saddle height; fore/aft position of saddle; vertical height of handle bars; horizontal position of handle bars; rotation of handle bars. Detailed measurements were taken of each subjects own bicycle so as to allow the cyclists own seating position to be replicated as closely as possible for each of the trials. Measurements were taken from: Centre of the stem top - Centre of the front hub; Centre of the bottom bracket – Saddle rails; Centre of handlebars – Centre of saddle rails; Horizontal measurement from centre of bottom bracket – Plum line at 90° dropped from centre of saddle rails. For the trial using the Monark bicycle, being a fixed frame, any adjustments were restricted to setting the saddle height to approximately that of the rider's own saddle. The participant's pedals were removed from their own bicycle and attached to the cranks of both ergometers. Warm-up and test were performed with the subject on the drops of the bars on the Velotron, and in any hand position on the Monark. During the maximal incremental test cyclists had to maintain a cadence of 80 - 100RPM, but not greater than 100RPM. The incremental test was set using 3-minute stages. HR, VO_2, and BL were taken at the end of every stage. The test started at 100W and increased by 50W for each stage until volitional exhaustion. The subject performed a 5-minute recovery at 100W with a self-selected cadence. Recovery BL was measured 1, 3 and 5 minutes post test.

RESULTS:

Table 1: Cardiorespiratoy Evaluation Analysis:

	Monark	SD +/-	Velotron	SD +/-
Power @ 2.5mmol	199.2	54.2	264.9**	33.1
Power @ 4mmol	253.3	33.1	302**	28.7
Heart Rate @ 2.5mmol	150	17.7	163**	14.8
Heart Rate @ 4mmol	167	10.6	173**	15.5
V02 @ 2.5mmol	34	6	37	5
V02 @ 4mmol	44	6	49**	5

= P<0.05, ** = P<0.01

Table 2: Maximal data:

	Monark	SD +/-	Velotron	SD +/-
VO2max ($ml \cdot kg \cdot min^{-1}$)	60.0	6.4	58.7	11.8
Peak Power Output (W)	321.9	33.9	353.1*	31.2

* = P<0.05, ** = P<0.01

Significant differences were found for HR, BL and VO_2 during each stage of the incremental test between the two ergometers. Significant differences were found for PO and HR at both BL marker points; 2.5mmol l^{-1} (REF2.5MM) and 4mmol l^{-1} (REF4MM) respectively. However, corresponding significant changes for measured VO_2 occurred only at REF4MM and not at REF2.5MM.

DISCUSSION:

When undertaking any laboratory based physiological and performance testing for any sport it is essential that the ergometry used, testing procedures and protocols adopted replicate the specific demands of the sport as closely as possible. In cycling the onset of recent technologies such as the development of sports specific ergometers including the Velotron Dynafit Pro and the SRM Cycling Ergometer, allow for a variety of positions to be adopted during testing, which therefore enable a cyclist to adopt their preferred training or racing position.

The age range of subjects in the present study was from 18 – 35 years and was representative of the typical age range of trained competitive cyclists. Results for height (1.75m +/- 0.04m) and body mass (68.9kg +/- 5kg) were very similar to those previously reported for professional road cyclists (Mujika & Padilla, 2001; Faria et al., 2005; Sallet, 2006). This indicates a possible natural propensity for a certain morphotype to become adept at road cycling (Jeunkendrup, 2002). Overall the sample group was in line with reported means, although significant differences exist between VO_{2max} and PO_{max} of the participants and professional riders; this is to be expected as the tested subjects were club level riders as opposed to full time training professional riders, and thus may not have as high a level of conditioning.

As the subjects were all trained road cyclists with a racing background all testing was performed with the cyclists using their own pedals and cycling shoes. Unlike traditional 'rat trap' pedals with straps and toe clips, a set of clipless pedals and shoes allow a cyclist to utilise a much more efficient stroke and increase the level of muscle recruitment during the stroke (De Koning & Van Soest, chapter 11; cited in Jeunkendrup, 2002). The cyclist is effectively able to scoop the pedal backwards while the foot is travelling in a positive vertical motion during the recovery section of the stroke and increase the time over which they are able to apply mechanical force (Burke, 2003). This allows a cyclist to pedal more effectively by eliminating dead spots at the top and bottom of the stroke, and cycle more economically due to greater power output to the same relative demand at sub-maximal intensities (Jeunkendrup, 2001). Testing in the race specific position was performed with the cyclist sitting on the drops of the road bars to further replicate the adopted race position on the Velotron. This position is adopted during racing for its aerodynamic properties which in comparison to the position adopted on the Monark would reduce typical drag area by ~1,000cm^2 and in real terms acts as to reduce the fatiguing effect of wind on a cyclist (Burke, 2003).

Analysis of the maximal data revealed no significant difference were found for VO_{2max}.In contrast significant differences were observed for PO_{max} and time to exhaustion. Perhaps due to a training adaptation trained cyclists are able to produce a higher PO in a position they are used to. The same applies for assessing sub maximal power is scaled to another factor such as cadence or mass. This was shown to vary from ergometer to ergometer and implies that the position adopted on an ergometer will affect these performance determinants. With the length of the incremental test we also started to see the effects of muscle fatigue due to adopted body position during the Monark test. This may explain the increase in both BL and the VO_2 at REF2.5MM and REF4MM. As the body is unable to use the preferred and trained

muscles from its normal cycling position, there may be a greater utilisation of type 2 muscle fibres in an attempt to compensate. A possible greater emphasis on the use fast glycolytic fibres might explain the elevated blood lactate levels at each exercise intensity on the Monark ergometer and significantly lower PO at REF2.5mM and REF4mM.
As cadence was maintained between 80 – 100RPM the effect of cadence on PO during the incremental test was not investigated. Previous studies have shown that increased pedal cadence during maximal trials can reduce the onset of fatigue and result in increase cycling economy (Lucia et al., 2004; Hagan RD, 1992). Furthermore, testing with drop bars on the Monark ergometer may have made more a specific position for the cyclist on the ergometer, due to changes in hip orientation and hence muscular recruitment, but as we were investigating the differences between the ergometers as per manufacturer's specifications it was not utilised. Further investigation into the effect of position on the cyclists ability to develop power at different parts of the cycle stroke could give a better insight into the effect of position on the different cycling ergometers.

CONCLUSION:

Overall both ergometers may be valid for assessment of maximal capacity in cyclists. Both ergometers provided results with no significant differences in maximal physiological values or performance determinants during aerobic exercise. In contrast, sub maximal values were shown to be significantly different between the two ergometers indicating differences in the physiological demands which may in part be explained by the cycling position adopted and the ergometer itself. In conclusion, in order to apply any measures taken in a laboratory to road cycling situations it is essential to make sure all testing is performed in a similar position, repeated in the same manner, and as many factors expressed as either a sub maximal predictor, or as a predictor scaled to another factor. Hence investigation of sub maximal determinants of cycling performance may be as important as maximal predictors for cycling performance. Further research is required to compare the findings of this study with actual cycling performance.

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