A Comparison of the Physiological Demands of Two Commercially Available Cycle Ergometers In Trained Cyclists

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Abstract

Cycling ergometers are routinely used in a laboratory setting to evaluate physiological function and monitor changes in training status. One limitation of many cycle ergometers, in relation to the performance testing, is their inability to replicate the cyclist own specific cycling position thereby bringing the validity of the ergometer used into question. **Purpose**: The purpose of this study was to compare the aerobic and anaerobic energy demands of two commercially available cycle ergometers in trained cyclists. The first ergometer allowed full adjustment of cycling position and was electromagnetically braked (EB). The second ergometer allowed for saddle height adjustment only and was resistance braked (RB). **Methods**: Ten trained male cyclists were tested on 2 separate occasions within a 14 day period under the same conditions. Subjects performed a 30 second Wingate maximal sprint test followed 60 minutes later by a continuous maximal incremental step test on either the EB or RB cycle ergometer, in a random order. The Wingate test was performed at 9% of body mass and for 30 seconds with a 5 second speed up period. The incremental test started at 100W and increased in resistance by 50W every 3 minutes until volitional exhaustion. Heart rate, VO_2, power output and blood lactate were measured during the maximal incremental test. **Results**: The results showed a significant difference ($p<0.01$) for the Wingate test between the RB and EB both in terms of peak power output (POmax) and mean power output (POmean) with subjects generating greater power outputs on the EB. During the maximal incremental test, significant differences ($p<0.01$) were found between EB and RB for submaximal power output, heart rate, and VO_2 at both lactate threshold 1 ($1mmol \cdot l^{-1}$ rise above baseline, LT1) and onset of blood lactate accumulation ($4mmol \cdot l^{-1}$ blood lactate reference point, OBLA), as well as peak power output at VO_2max (PVO_2max). **Conclusions**: Overall it was shown that significant differences in physiological demands were present between the two ergometers under both anaerobic and aerobic conditions. This is may in part be explained by the different positions that the cyclists adopted on either ergometer. Further research is required to compare the findings of the current study with actual cycling performance.

Introduction

In modern competitive cycling considerable emphasis is placed on the physiological assessment of cyclists in a laboratory setting. This allows physiological testing to be performed in controlled conditions without the variability of the external environment associated with field-based monitoring. The question remains as to the specificity and validity of laboratory testing and its relationship with actual cycling performance. Over the years a number of cycling ergometers have been developed and used for the laboratory assessment of physiological function in cyclists. In this regard it is generally accepted that testing in a laboratory is both easier to accomplish and more repeatable than testing on the road (Jeukendrup, 2002). Furthermore, it has been shown that testing in a velodrome, where all weather conditions can be reasonably controlled, comparative results with those attained in a laboratory setting have been achieved for physiological variables such as VO_2max (Padilla et al., 1996). A number of ergometers have been developed which use a variety of methods in an attempt accurately simulate actual cycling. One system, the Monark has traditionally been regarded as the gold standard when conducting maximal testing (Paton & Hopkins, 2001). Despite this, the Monark ergometer has been criticized due to its failure accurately mimic the cyclists optimal cycling position (Zavorsky et al.,2006) and due to the fact that for riders over 96kg tests such as the Wingate test cannot be utilized (Nieman, 2003). For many cycle ergometers therefore, it remains to be established how closely they replicate the physiological demands of actual cycling or determine the specific critical factors affecting cycling performance. The purpose of this study was to compare the energy demands of an ergometer which mimics a cyclists own race position, with a system which uses a standardised position during a maximal aerobic and anaerobic testing.

Methods

Ten trained male club level road cyclists were recruited for the purpose of the study. The main descriptive data are included in Table 1. Subjects attended the Human Performance Laboratory located at the School of Health and Human Performance at DCU on two separate occasions. 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. When each subject was using the Velotron ergometer (Racermate Inc., Seattle, U.S.A) (EB), the ergometer was set up to replicate their preferred riding position by taking specific measurements from their own bicycle. EB is adjustable along each of its major axes. For the trial using the Monark bicycle ergometer (Monark Exercise AB, Vansbro, Sweden) (RB), 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 EB, and in any hand position on the RB. Subjects performed a 30 second Wingate maximal sprint test followed 60 minutes later by a continuous maximal incremental step test on either the EB or RB cycle ergometer, in a random order. The Wingate test was performed at 9% of body mass and for 30 seconds with a 5 second speed up period. The incremental test started at 100W and increased in resistance by 50W every 3 minutes until volitional exhaustion. Heart rate (HR) was measured continuously using a wireless Polar HR monitor (Polar Electro, Finland), blood lactate (BL) measurements were taken at rest and at the end of each increment using a Lactate Pro analyser (Arkray, Japan);. Gas analysis was continuously measured using open circuit spirometry with an Innovision InnocorTM (Innovision, Denmark) metabolic cart. During the maximal incremental test cyclists had to maintain a cadence of 80-100RPM. Recovery blood lactate levels were also measured at 1, 3 and 5 minutes post test.

Results

Descriptive and Anthropometric Data

Table 1. Subject Characteristics and Anthropometric Variables

Variable	Subjects
Age (yrs)	25.70 (5.77)
Mass (kg)	68.93 (5.48)
Height (m)	1.75 (0.05)
BMI (kg/m^2)	22.39 (1.57)
Body Fat (%)	10.38 (3.96)

Data presented as means $\pm$ SD

Anaerobic test

Table 2. Mean Power Output Data from Wingate Tests

	Monark	Velotron
POmax (W)	773.27 (102.79)	828.25 (86.21)**
POmean (W)	674.15 (80.12)	676.30 (61.30)
POmax (W/kg)	10.58 (0.96)	11.71 (0.94)**
POmax (W/RPM)	1.64 (0.22)	2.45 (0.28)**

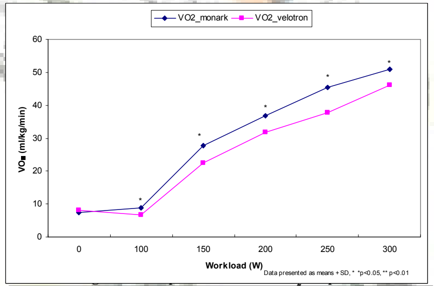
Data presented as means $\pm$ SD, * $p<0.05$, ** $p<0.01$.

Aerobic Test

Table 3. Differences Submaximal and Maximal Parameters

	Monark	Velotron
PO@LT1 (W)	198 (21)	242 (45)**
PO@OBLA (W)	262 (34)	322 (47)**
HR@LT1 (bpm^{-1})	147 (13)	157 (12)
HR@OBLA (bpm^{-1})	163 (11)	181 (16)**
VO_2@LT1 ($ml \cdot kg \cdot min^{-1}$)	34 (6)	37 (5)*
VO_2@OBLA ($ml \cdot kg \cdot min^{-1}$)	46 (6)	49 (5)*
VO_2max ($ml \cdot kg \cdot min^{-1}$)	59.3(5.9)	58.7 (6.2)
POmax (W)	318.7 (35)	353.1 (16)**
T.T.E (min)	16.23 (2.11)	18.19 (0.47)*

Data presented as means $\pm$ SD, * $p<0.05$, ** $p<0.01$.



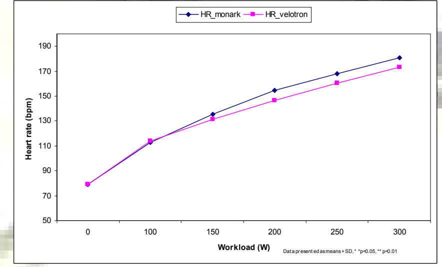


Figure 2 Comparison of Mean Heart Rate Responses

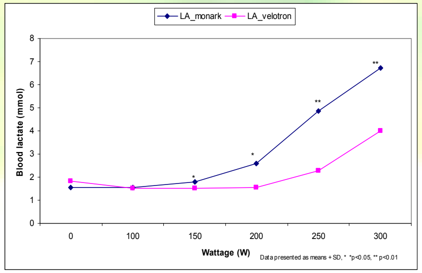


Figure 3 Comparison of Mean Blood Lactate responses

Discussion

During the anaerobic test it appeared that adoption of a position that the cyclists were more used to allowed them to generate a greater power output. This may be attributed to several factors including muscle recruitment patterns, familiarity with the position, and hip orientation. However as the test itself is applied with the cyclist seated it can only be considered a measure of peak power output under anaerobic conditions and not a measure of sprint performance. This is due to the fact that most cycle sprinting is performed out of the saddle. Analysis of the data during the maximal incremental tests revealed no significant differences were found for VO_2max. This may in part be explained by the virtue that the subjects were trained cyclists. In contrast significant differences were observed for maximal performance variables such as POmax and time to exhaustion. Similarly, significant differences were observed for submaximal indices including blood lactate levels and VO_2 at LT1 and OBLA. This would suggest that the preferential cycling position adopted on the Velotron resulted in an enhanced cycling economy and lower anaerobic energy yield during submaximal intensities whilst at the same time facilitating a higher peak power output during maximal exercise. One possible explanation for the significant differences in submaximal variables is that the non specific cycling position adopted on the Monark ergometer may place a possible greater emphasis on the use fast glycolytic fibres leading the elevated blood lactate levels and significantly lower PO at LT1 and OBLA. 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, 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.

Conclusions

Overall, although both ergometers may be valid for assessment of maximal aerobic capacity in cyclists, significant differences were observed for other maximal indices including PVO_2max, time to exhaustion and POmax. Similarly a number of sub maximal parameters were also shown to be significantly different between the two ergometers indicating differences in the physiological demands, which may in part be explained by the variability of cycling position adopted and the ergometer itself. Further research is required to compare the findings of this study with actual cycling performance.

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