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Research

Effect of a slow ramp rate on exercise testing: a healthy volunteer study

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CONFLICTS OF INTEREST
There are no conflicts of interest for any of the authors.

ABSTRACT:
Ramp rates for incremental ramp rate exercise testing are not fully standardised. The ramp rate may influence the values obtained during exercise testing. We compared a slow ramp rate (SR) (3watts/minute) to a fast ramp rate (FR) (20 watts/minute) in 8 fit non elite cyclists using cycle ergometry. We measured peak power ,oxygen consumption (VO2) at anaerobic threshold (AT) and maximumaerobic capacity (VO2 max). A lower mean peak work (369Watts vs 406 Watts, P=0.004), higher mean AT (42.1 ml/min/kg vs 38.6 ml/min/kg, p=0.16) , lower mean VO2 max (51.7 ml/min/kg vs 54 ml/min/kg p=0.25) and higher ratio of AT to VO2 max (0.82 vs 0.71 p = 0.03) were obtained using the SR protocol. These results suggest that ramp protocols need to be considered when interpreting exercise tests clinically. We suggest that further research is required to allow better standardising of ramp test protocols.

KEY WORDS: anaerobic threshold, exercise testing, ramp rate, maximum aerobic capacity

INTRODUCTION

Submaximal exercise testing is now used routinely to assess aerobic fitness for surgery. The anaerobic threshold determined by expired gas analysis during ramped exercise predicts surgical morbidity and mortality
(1). Cycle ergometry with a ramped protocol is typically used. The American College of Sports Medicine Clinical Exercise Testing Guidelines.
(2) have attempted to standardise protocols. This is based on a pre-test estimate of fitness which may not be reliable. A comparison between 20,30,50 and 100 watts per minute increments (3) showed no difference in anaerobic threshold and VO2 max but lower ramp increments were not tested. In another study comparing 10,30 and 50 watts per minute anaerobic threshold was unchanged but "VO2 peak" was reduced with a 10 watts per minute protocol (4). Using a running treadmill test V Vucetić et al (5) showed differences in peak running speed using different ramp rates but no difference in VO2max or AT. Lower ramp rates have only been compared using arm crank ergometry: 6 watts per minute and 12 watts per minute were studied, yielding higher end exercise lactate and VCO2 (6,7). To date ramp rates below 10 watts per minute have not been compared using cycle ergometry. We hypothesised that at standard ramp rates the anaerobic threshold appeared earlier due to a lag between work rate and cardiovascular changes. We set out to see identify if at very low ramp rates this lag could be reduced or eliminated. We investigated the difference

between a 3 watts per minute and 20 watts per minute in healthy volunteers.

METHODS

Participants

Eight non-elite experienced cyclists were tested on two occasions using cycle ergometry. The participants were all experienced (> 2 years, 50-100 miles / week) non-competitive cyclists with a mean age of 40 years (range 28-44), mean height 180 cm (SD =5.2) and mean weight 77kg (SD=8). The study was approved by the Local Research and Ethics Committee (Frenchay Hospital REC *09/H0107/14)*.The study was performed in accordance with the Declaration ofHelsinki and the Ethical Standards in Sport and Exercise Science Research (8). Subjects were asked to refrain from strenuous exercise in the 24 hours prior to each test. Tests were carried out in random order with a minimum of 3 days interval.Subjects were blinded to the study protocols.

Protocol

Tests were carried out on a Zan 200 cycle ergometer plus metabolic cart (NSpire). Subjects were monitored throughout with continuous ECG and pulse oximetry. Subjects warmed up for 3 minutes at 100 Watts and then started one of two incremental ramp tests. Fast ramp (FR) incremented at 20 watts/ minute and Slow Ramp (SR) incremented at 3 watts/minute. Twenty minutes into the SR subjects were allowed to drink briefly whilst continuing to exercise (breath by breath gas analysis suspended for < 10 seconds). Tests continued until subjects were unable to continue due to exhaustion.

All data were analysed off line by a clinician experienced at interpreting exercise tests, blinded to the study protocol. The "V-slope" method was used to determine anaerobic threshold.

Statistical analysis

The results are expressed as mean (+/- standard deviation). All calculations were carried out in an Excel Spreadsheet (Excel 2010) with internal statistical package. Atwo-tailed paired t test was used to compare differences between means for Power, maximum heart rate (max HR), AT, VO2 max and the ratio of AT to VO2 max. P values are quoted with significance assumed to be a P value less than 0.05.

RESULTS

Maximum power was significantly higher for FR than for SR (369 (9) Watts vs 406 (12) watts, P=0.004).There was no difference in max HR for FR (172 (6.7)) vs SR (175 (5.8). Mean AT was lower for FR (37.6 (7.1) ml/min/kg) than the slow ramp (43.1 (4.2) ml/min/kg () (p= 0.07). Conversely mean VO2 max was higher for the fast ramp (54.6 (3.2) ml/min/kg) than the slow ramp (52.6 (4.3) ml/min/kg) (p=0.28). Mean ratio between AT and VO2 max was significantly lower for the slow ramp (0.82 (0.1) vs 0.71 (0.6), p = 0.03).

DISCUSSION

Our study showed that a slow ramp rate (3 watts/minute) gave significantly different results for peak power and the ratio of anaerobic threshold to VO2max compared to faster ramp (20 watts / minute).

In contrast with the findings of Weston at 10 watts/minute (4) we did no show a significant reduction in VO2 max using the SR. There was no significant difference in AT between SR and FR in agreement withothers(3,4). Our study may have been underpowered to detect small differences in AT or VO2 max. Using arm ergometry there was no difference in VO2 peak but a higher VCO2 at VO2 peak (6,7). We showed a significant difference in the ratio of AT to VO2 using a slow ramp test. We used a very slow ramp (3 watts per minute) which has not been previously tested. This very slow ramp rate has two potential effects which higher ramps may not achieve. Our subjects exercised for 40 minutes allowing them to potentially "warm up" effectively but also allowing them to potentially fatigue by the end of the test. We chose a 100 watt starting power for our warm up phase to minimise the time from start to AT. The very slow ramp rate would potentially reduce the chance of any lag between oxygen delivery and demand. We are undertaking further research to determine if a long sub maximal "warm up" prior to testing accounts for the differences seen. Our subjects were relatively young fit experienced cyclists. Further research would be required to quantify these changes in older less fit subjects. For clinical testing using cardiopulmonary testing the values obtained may be used to guide treatment or surgery. Ramp rates may need to be adjusted further in patients with markedly reduced exercise tolerance (eg heart failure). In the pre-operative setting clinicians may need to consider the ramp rate used before making decisions regarding fitness for surgery.

Summary

Our study showed a possible reduction in AT/VO2 max but may have been underpowered to detect differences in absolute values of AT or VO2 max. A larger study is needed to determine if these differences exist. Clinicians should be cautious using exercise testing for surgical risk prediction in patients with low exercise tolerance as the ramp rate may influence the results.

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