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## **Discussion: "The efficacy of the self-paced VO<sub>2</sub>max test to measure maximal oxygen uptake in treadmill running"**

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**Re: The efficacy of the self-paced VO<sub>2</sub>max test to measure maximal oxygen uptake in treadmill running by Alexis R. Mauger, Alan J. Metcalfe, Lee Taylor, and Paul C. Castle**

We wish to raise some concerns about the above study published on-line in *Applied Physiology, Nutrition and Metabolism*. Most important is the issue of biased reporting as the authors have failed to acknowledge the findings of a critical paper by Chidnok et al 2013 (first published on-line in the *European Journal of Applied Physiology* in Sept 2012) which provided a rigorous and comprehensive assessment of a self-paced (RPE-guided) test versus two conventional ramp incremental protocols. This study was conducted to test the findings of Mauger and Sculthorpe (2012) which reported that a higher VO<sub>2</sub>max is achieved with a perceptually-regulated maximal test. The protocols used in the study of Chidnok et al (2013) were of similar duration and they observed no differences in VO<sub>2</sub>max. It is therefore both surprising and concerning that Mauger et al. failed to comment on or discuss the findings of Chidnok et al. The latter paper led to correspondence between the lead author of the current paper and an incisive and frank response from Chidnok et al. (2013), both published as letters to the Editor. At first we thought that perhaps the current paper was already in press before the Chidnok et al. (2013) paper was published, but this is obviously not the case. Indeed, there are two references to Mauger (2013) which is the letter to the editor of the *European Journal of Applied Physiology*, concerning the study of Chidnok et al. (2013). However, this citation is used only to reference a speculation about muscle recruitment and to describe an aspect of the methods in their previous study. It would seem that the authors have therefore deliberately avoided citing and discussing the findings of the Chidnok et al (2013) paper in order to reinforce their own findings. This is biased reporting which reflects poorly on the scientific integrity of the authors.

Further biased reporting is evident in the interpretation of the data. Whilst the authors have recognised that their data contained two outliers, they continued to present the data including these two outliers in Table 1, giving the illusion of a greater difference in VO<sub>2</sub>max between the two protocols used in their study. The outliers should have been removed from the data from the outset as there was clearly something out of the ordinary with the participant response, error in measurement or testing environment which affected the variation in scores between the two tests. Importantly, in their own subsequent analysis of data reported in the first paragraph of page 4 which excluded the two outliers, the VO<sub>2</sub>max remained significantly higher by 2.2 ml/kg/min. However, the authors claim that this difference was greater than the coefficient of variation of the graded exercise test (GXT) (i.e., 3.7%) assessed on 5 participants. This is not true. The positive difference of 2.2 ml/kg/min for the self-paced VO<sub>2</sub>max test (SPV) is 3.6% greater than the GXT measurement, i.e., a difference which can be accounted for by the error in reliability of the GXT they used in their study. It appears that the authors have alluded to the larger difference between the means in Table 1 (3.0 ml/kg/min), which includes their two outliers. This leads to a spurious and misleading conclusion.

The authors provide no rationale for why a non-motorized treadmill was used for the SPV. Unfortunately, comparison of the VO<sub>2</sub>max measurements is confounded by the different ergometers used in the study. The internal validity of the study is compromised and this severely limits the extent to which any effect can be generalized to the population. The same ergometer should have been used to reduce the extraneous variance on VO<sub>2</sub>max attributable to the mode of ergometry. Although the authors acknowledge that the difference in VO<sub>2</sub>max may be partly attributable to treadmill-influenced differences in running mechanics and muscle activation, this possibility is dismissed on the basis of a previous study by Davies et al. (1984). However, although Davies et al

(1984) observed no differences in the mean  $\text{VO}_2$  max values between a non-motorized treadmill protocol and several motorized treadmill protocols, it is notable that the level running protocol which most closely resembles the GXT used in the study in question, produced a  $\text{VO}_2$ max which was lower by almost 2 ml/kg/min, compared to the non-motorised treadmill  $\text{VO}_2$ max. Notably, 6 of the 10 subjects in the study of Davies et al (1984) attained a higher value on the non-motorized treadmill and 1 subject attained the same value. Indeed, the rationale for their study was based on previous work where they had observed “..a tendency to achieve higher  $\text{VO}_2$  max and HLA on the non-motorised treadmill.” The positive difference in  $\text{VO}_2$ max with the non-motorized treadmill observed by Davies et al. is remarkably similar to the difference observed in the study by Mauger et al. (2013). When compared statistically on the basis of a unidirectional t-test (on the premise that the non-motorized treadmill leads to a higher  $\text{VO}_2$ max), the difference between the mean values in the study of Davies et al (1984) reveals a t-ratio of 1.869 ( $P < 0.05$ ), indicating a significantly higher mean  $\text{VO}_2$ max produced from the non-motorized treadmill protocol. We therefore believe the small difference in  $\text{VO}_2$ max reported in the study of Mauger et al (2013) can be best explained by the different ergometers.

The results of the GXT, reported in Table 1, would also suggest that the subjects were not at maximum. The RPE of  $18.0 \pm 1.0$  is lower than is typically observed in studies on young and active participants (for example of references see Eston 2012). The standard deviation indicates that some participant RPEs may have been lower than 17. The post-exercise blood lactate concentration ( $5.70 \pm 1.38$ ) for the GXT is also considerably lower than would be expected to occur at  $\text{VO}_2$ max in these subjects. Mean values in the region of 7-8 mmol/l would be expected, as observed in the study by Chidnok et al. (2013). The respiratory exchange ratio, commonly used as one of the criteria for attainment of  $\text{VO}_2$ max, was not reported.

We also have concerns about the accuracy and context of some of the citations. For example, it is misleading to say that the SPV has “...received credit and recognition” from Eston (2012). The latter paper recognised the novelty of extending Eston and colleagues’ well established perceptually-regulated test procedures by including exercise up to RPE 20, but the author (RE) highlighted a serious weakness in the study of Mauger and Sculthorpe (2012) in that their GXT was too long and likely explained the difference in  $\text{VO}_2$ max. Eston (2012) recommended that to evaluate whether the difference in  $\text{VO}_2$ max for self-paced and conventional incremental protocols was real, rather than an artefact of the protocol, a direct comparison was required where the test duration is matched. Indeed, this observation was noted as part of the rationale for the study by Chidnok et al (2012). Also misleading is reference to the study of Parfitt et al. (2000) to support the statement that “...the perceptually regulated nature of the test provides a more palatable form of exercise that could be better tolerated by clinical populations as it allows participants to work according to their own perceived ability”. The study by Parfitt et al (2000) involved aerobically fit individuals, not clinical subjects. Also, they did not use a perceptually-regulated exercise protocol (i.e., guided by the RPE). Instead, they compared the effect of bouts of prescribed and preferred intensity exercise on psychological affect. The concept is quite different to using the RPE to regulate exercise intensity in the SPV described by Mauger et al (2013), in which the subject anticipates working at an absolute maximal intensity in the last two minutes of the test! Although it has been shown that affect is more positive during such a test in young active individuals (Evans et al. 2013), we would never advocate its use in a clinical population.

With regard to the utility of this procedure as a practitioner's tool with clinical populations, we feel that it is quite irresponsible to make this recommendation. It reflects a poor understanding of the risks, ethical issues and legal liabilities involved in working within a clinical setting. Patients with chronic obstructive pulmonary disease (COPD) would certainly not be able to complete the proposed protocol. These patients experience limitations to exercise from a variety of different fronts. Many have multiple co-morbidities such as arthritis, obesity, osteoporosis, and heart failure. We really can't see them "sprinting to the last". In terms of risk with these patients, a clinician would not do even a 6 minute walk test without having full resuscitation equipment available within 10-20 metres of the patient at all times. The main reason for doing an exercise test with these patients is to objectively measure the impact of interventions such as long term oxygen therapy and pulmonary rehabilitation on the quality of life. How would knowing the speed or maximal oxygen uptake at RPE 20 help in this regard?

In summary, the study is confounded and the data are incorrectly interpreted. We suggest that the results and recommendations should be ignored. It is disappointing that these issues were not picked up during the refereeing process, but we do of course understand that ultimately what is written is the responsibility of the authors.

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