Comparison between Maximal Lactate Steady-State, Critical Power and the Second Ventilatory Threshold detected by a Computer Algorithm

R. Bertschinger[1], P. Thumm[1], M. Gratkowski[2], A. Artiga Gonzalez[2], D. Saupe[2]

[1]Department of Sport Science, raphael.bertschinger@uni-konstanz.de

[2]Department of Computer and Information Science, dietmar.saupe@uni-konstanz.de

Introduction

The exact determination of the anaerobic threshold is indispensable in the analysis and optimization of endurance performance, as it demarcates the bodies' boundary from a predominant aerobic to a predominant anaerobic energy metabolism. In the past, several biological parameters and determination concepts have been proposed to be more or less effective in determining the anaerobic threshold (Peinado, Rojo, Calderon & Maffulli, 2014). Unfortunately most of these concepts are limited by its subjective methodology. In recent years the critical power (CP) concept (Monod & Scherrer, 1965) has received increasing attention and is used alternatively for the anaerobic threshold (Bosquet, Larrouturou, Lheureux & Carter, 2011). However it remains questionable if this concept can be used as an alternative to other lactate threshold concepts. Furthermore it is expected that a more standardised and objective procedure in the determination of the second ventilatory threshold could lead to an improved validity when comparing it to the gold standard method of anaerobic lactate threshold determination.

Therefore, the aim of this study was to determine the second ventilatory threshold (VT_2) by an automated method as well as CP by three cycle ergometer tests and to compare them to the maximal lactate steady-state (MLSS).

Methods

13 recreational cyclists and one sedentary male (age: 41.1 yrs., height: 181 cm, weight: 75.6 kg, VO_{2max}: 57.2 ml/min/kg) completed a series of cycling tests, separated by at least 48h of recovery. The first test consisted of an incremental ramp exercise to exhaustion for the determination of VT_2. The remaining 4-5 tests were performed at different constant work rates (CWR) in order to determine CP and MLSS. Every CWR test lasted up to maximally 30 min or until volitional exhaustion. Lactate probes from the earlobe were taken every five minutes and at test termination. The intensity of each CWR test was related to body weight (range across subjects: 2.75 and 5.5 W/kg) and decreased or increased in steps of 0.25 W/kg. The test phase was completed when all of the following criteria were met:

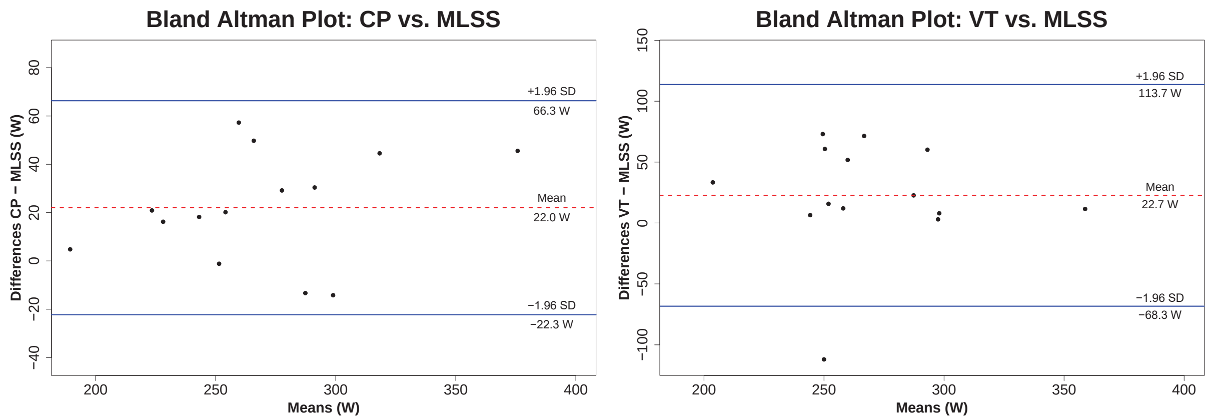
a) Every subject performed three CWR tests to volitional exhaustion before the end of the 30 minute cut-off time.
b) At least one 30 min test that showed a steady-state (< 1mmol/l) in blood lactate concentration from minute 10-30 and a CWR test at an intensity 0.25 W/kg higher than

the previous test that showed an increase in blood lactate concentration of more than 1mmol/l in the last 20 minutes (or less).

The MLSS intensity was defined as the highest intensity in which the lactate concentration did not rise more than 1 mmol/l in the last 20 minutes of the test. The critical power was calculated from the three tests to exhaustion by the 2-parameter critical power model adapted by Moritani, Nagata, deVries und Muro (1981). VT_2 was analysed by a self-programmed computer algorithm based on the determination method proposed by Beaver, Wasserman und Whipp (1986).

Results

Mean work rates were 257.9 ± 43.6 W, 279.9 ± 50.1 W and 280.6 ± 42.5 W (Mean ± SD) for MLSS, CP and VT_2 respectively. Bland Altman analysis between MLSS and CP revealed a mean bias of 22W with limits of agreement (LoA) between -22 and +66W. For MLSS and VT_2 the mean bias was 23W with LoA between -68 and 114W.



A paired t-test showed a significant difference between MLSS and CP (p = .003) but no significant difference for MLSS vs. VT_2 (p=.090). Pearson's Product Moment Correlation revealed a strong correlation between MLSS and CP (r=.893, p=<.001) and a weak correlation between MLSS and VT_2 (r=.419, p=.068).

Discussion

The aim of this study was to determine CP with three constant power tests to volitional exhaustion and VT_2 by a computer algorithm and compare these procedures to the gold standard method of MLSS determination.

Bland Altman analysis represents an adequate tool for demonstrating the amount of agreement between differing methods. In this study the accuracy to identify the MLSS is 18.9 ± 1.4 W. We therefore determined appropriate limits of agreement to lie between ± 20.2W. Bland Altman analyses revealed that an upward bias of 22W (CP) and 23W (VT_2) was evident. Unfortunately, the critical limits were more than two-fold for CP (± 44.3W) and four and a half fold for VT_2 (± 91W). Therefore, both CP and VT_2 determination methods are considered as invalid procedures for the determination of the MLSS.

Although testing for statistical differences and relationships showed partly promising results and are to some extent in line with other studies (Dekerle, Baron, Dupont, Vanvelcenaher und Pelayo (2003) Pringle und Jones (2002). However, they are not considered as appropriate procedures for comparing differing methods and were merely conducted to demonstrate that these approaches can be misleading.

The here proposed computer based method for the detection of the second ventilatory threshold has shown not to be an ideal predictor of the maximal lactate steady-state. Further work has to be put into a new or modified computer algorithm to attain better results in the future. Also the determination of critical power by three laboratory tests seems to be an inadequate method for determining MLSS. However it should be considered that different CP models or field data collected from mobile power meters with more data points for the power time relationship curve could yield different, more reliable results.

Conclusion

In this study we show by the Bland Altman procedure that work rate at critical power and ventilatory threshold determined by a computer algorithm are not adequate methods for determining MLSS. Although significant results and high correlations could have been partly demonstrated, these measures do not account for the agreement between the methods and are considered inappropriate for this kind of research question.

Reference

Beaver, W. L., Wasserman, K. & Whipp, B. J. (1986). A new method for detecting anaerobic threshold by gas exchange. *J Appl Physiol (1985), 60*(6), 2020-2027.

Bosquet, L., Larrouturou, M., Lheureux, O. & Carter, H. (2011). VO2 slow component is independent from critical power. *Int J Sports Med, 32*(9), 693-697. doi:10.1055/s-0031-1275358

Dekerle, J., Baron, B., Dupont, L., Vanvelcenaher, J. & Pelayo, P. (2003). Maximal lactate steady state, respiratory compensation threshold and critical power. *Eur J Appl Physiol, 89*(3-4), 281-288. doi:10.1007/s00421-002-0786-y

Monod, H. & Scherrer, J. (1965). The work capacity of a synergic muscular group. *Ergonomics, 8*(3).

Moritani, T., Nagata, A., deVries, H. A. & Muro, M. (1981). Critical power as a measure of physical work capacity and anaerobic threshold. *Ergonomics, 24*(5), 339-350. doi:10.1080/00140138108924856

Peinado, A. B., Rojo, J. J., Calderon, F. J. & Maffulli, N. (2014). Responses to increasing exercise upon reaching the anaerobic threshold, and their control by the central nervous system. *BMC Sports Sci Med Rehabil, 6*, 17. doi:10.1186/2052-1847-6-17

Pringle, J. S., Doust, J. H., Carter, H., Tolfrey, K., Campbell, I. T., Sakkas, G. K. & Jones, A. M. (2003). Oxygen uptake kinetics during moderate, heavy and severe intensity "submaximal" exercise in humans: the influence of muscle fibre type and capillarisation. *Eur J Appl Physiol, 89*(3-4), 289-300. doi:10.1007/s00421-003-0799-1

Pringle, J. S. & Jones, A. M. (2002). Maximal lactate steady state, critical power and EMG during cycling. *Eur J Appl Physiol, 88*(3), 214-226. doi:10.1007/s00421-002-0703-4