Journal of Science & Cycling
Breakthroughs in Cycling & Triathlon Sciences

OPEN ACCESS

Article

Bypass of Respiratory Complex I and its relation to different lactate landmarks – a pilot study

Christoph Triska [1,2,*], Christoph Soukup [1], Johannes Ernst [1], and Astrid Reif [1,2]

[1] Leistungssport Austria, Brunn am Gebirge, Austria.
[2] Institute of Sport Science, Centre for Sport Science and University Sports, University of Vienna, Vienna, Austria.

* Correspondence: Christoph Triska (CT) c.triska@leistungssport.at

Received: date; Accepted: date; Published: date

1. Introduction

The controversy about a valid demarcation of different exercise intensity domains is an ongoing discussion in sports and exercise physiology. To-date, thresholds are mostly determined by concentration changes of molecules and biomarkers determining energy-yielding pathways in the blood (i.e., lactate) or by exchange of pulmonary gases (Poole, Rossiter, Brooks, & Gladden, 2020). Besides that, critical power has recently been demonstrated to more accurately reflect a maximal metabolic steady-state than other measures using blood lactate concentration or respiratory gases (Jones, Burnley, Black, Poole, & Vanhatalo, 2019). However, none of these aforementioned estimates of thresholds intensity takes into account what perturbations occur inside a muscle cell or a mitochondrion where ATP (i.e., the energy currency of the human body) are re-phosphorylated using oxidative pathways.

Lately, Nilsson, Bjornson, Flockhart, Larsen, and Nielsen (2019) demonstrated in a model that respiratory Complex I is bypassed during high intensity exercise using oxygen uptake ($\dot{V}O_2$) data derived from an incremental exercise test. Complex I is one of four enzyme complexes that is involved in the electron transport chain that transport protons across the inner mitochondrial membrane in order to create a proton motive force that is used to generate ATP from ADP and inorganic phosphate in Complex V (also known as the enzyme ATPase). The bypass of Complex I is suggested to be based on a trade-off between maximizing power output (i.e., higher flow rate) and maximizing substrate efficiency (i.e., lower flow rate). Complex I max (CI_{max}) refers to this threshold where Complex I is bypassed.

The aim of this study is therefore to provide a potential study design for a physiological validation of CI_{max}, i.e., the relation of CI_{max} to the intensity associated with lactate threshold (LT) and the onset of blood lactate accumulation (OBLA).

2. Materials and Methods

In this pilot work five male and well-trained cyclists and triathletes volunteered to participate. Participants were required to visit the laboratory once to determine (a) CI_{max}, (b) LT, and (c) OBLA during a high-resolution graded exercise test (GXT). Tests were conducted on an electromagnetically braked cycle ergometer (Lode Excalibur Sport, Groningen, The Netherlands). During the GXT respiratory gases were measured breath-by-breath using a portable gas analyser (MetaMax3B, Cortex Biophysik GmbH, Leipzig, Germany). To determine blood lactate (BLa^-) concentration capillary blood sample were obtained from the earlobe, diluted in 1000 µL glucose solution and were subsequently analysed using an automated analyser (Biosen C_Line; EKF-diagnostic GmbH, Barleben, Germany).

The GXT commenced at 40 W and work rate was increased by 5 W according to the recommendations of Nilsson et al. (2019). When [BLa-] reached a concentration of >4.0 mmol/L the GXT was terminated. The mean duration ± standard deviation (SD) of the GXT was 83.3 ± 18.3 min.

CI_{max} was determined using a Matlab code provided in Nilsson et al. (2019) using $\dot{V}O_2$ and $\dot{V}CO_2$ data that were averaged to 30-s intervals. LT was determined as the first increase of [BLa-] above baseline (Yoshida, Chida, Ichioka, & Suda, 1987) and OBLA was set at a fixed 4 mmol/L BLa- concentration (Sjödin & Jacobs, 1981).

A paired-samples *t*-test was conducted to assess differences between CI_{max} and LT, and between CI_{max} and OBLA. The strength of an association between parameters was assessed using Pearson product moment correlation. Data is presented as mean ± SD. Statistical significance was accepted at $P < 0.05$.

3. Results

Average power output associated with CI_{max}, LT, and OBLA were 151 ± 43 W, 231 ± 71 W, and 290 ± 64 W, respectively (Figure 1). CI_{max} was significantly lower compared to LT ($t_4 = 3.73$; $P = 0.020$) as well as OBLA ($t_4 = 7.73$; $P = 0.002$) and both lactate landmarks were not significantly correlated with CI_{max} (LT: $r = 0.749$, $P = 0.146$; OBLA: $r = 0.780$; $P = 0.120$; Figure 2 and 3).

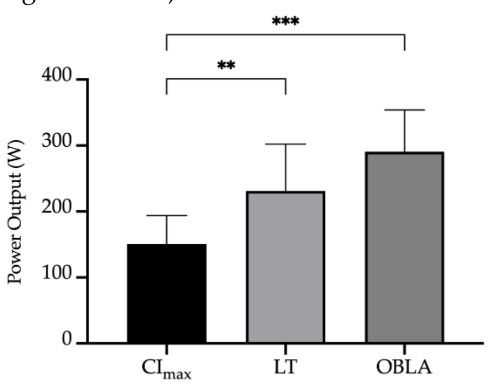

Figure 1. Mean ± SD for the power outputs associated with CI_{max}, LT and OBLA.

4. Discussion

The findings of this pilot work suggest that CI_{max} is significantly lower than commonly used lactate landmarks like LT or OBLA. This suggests that CI_{max} cannot be used as a surrogate for LT that mostly serves as a boundary between the moderate and heavy exercise intensity domain. Therefore, the physiological underpinnings for a bypass of Complex I are not similar to those of LT since CI_{max} is occurring at a significantly lower power output. Moreover, results suggest that CI_{max} occurs at [BLa-] that are generally lower than 4 mmol/L. It is commonly accepted that LT as well as OBLA serve as an indicator of aerobic fitness. A tendency towards a strong relation between CI_{max} and both lactate landmarks suggests that power output at CI_{max} is positively associated with the aerobic capacity of an athlete.

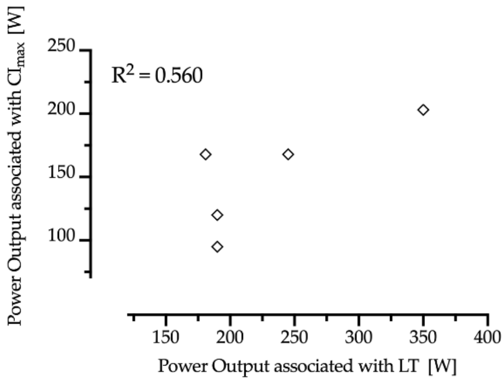

Figure 2. Scatter plot of LT and CI_{max}.

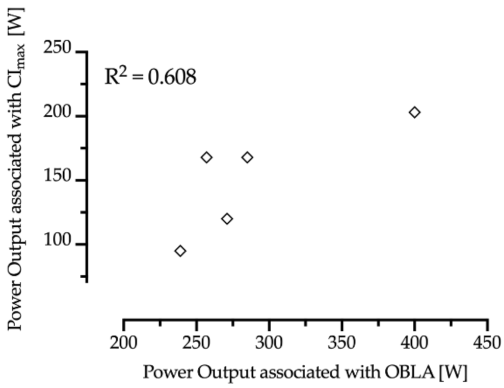

Figure 3. Scatter plot of OBLA and CI_{max}.

5. Practical Applications.

CI_{max} might have the potential to serve as a new (low intensity) parameter assessing aerobic fitness as well as reflecting an 'efficient' substrate usage of the mitochondrion which might be related to gross efficiency during cycling and running economy. Moreover, CI_{max} has probably a usefulness as a new indicator of assessing aerobic fitness. Future studies should focus on reliability of CI_{max} determination as well as a physiological validation of CI_{max}.

References

Jones, A. M., Burnley, M., Black, M. I., Poole, D. C., & Vanhatalo, A. (2019). The maximal metabolic steady state: redefining the 'gold standard'. *Physiological Reports, 7*(10), e14098. doi:10.14814/phy2.14098

Nilsson, A., Bjornson, E., Flockhart, M., Larsen, F. J., & Nielsen, J. (2019). Complex I is bypassed during high intensity exercise. *Nature Communications, 10*(1), 5072. doi:10.1038/s41467-019-12934-8

Poole, D. C., Rossiter, H. B., Brooks, G. A., & Gladden, L. B. (2020). The anaerobic threshold: 50+ years of controversy. *Journal of Physiology*. doi:10.1113/JP279963

Sjödin, B., & Jacobs, I. (1981). Onset of blood lactate accumulation and marathon running performance. *International Journal of Sports Medicine, 2*(1), 23-26. doi:10.1055/s-2008-1034579

Yoshida, T., Chida, M., Ichioka, M., & Suda, Y. (1987). Blood lactate parameters related to aerobic capacity and endurance performance. *European Journal of Applied Physiology and Occupational Physiology, 56*(1), 7-11. doi:10.1007/bf00696368