O_2 UPTAKE KINETICS AS A DETERMINANT OF EXERCISE TOLERANCE

Stephen J. Bailey

Submitted by Stephen J. Bailey to the University of Exeter as a thesis for the degree of Doctor of Philosophy by Research in Sport and Health Sciences

February 2010

I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Stephen J Bailey

....

Abstract

Oxygen uptake ($\dot{V}_{O_2}$) kinetics determine the magnitude of the O_2 deficit and the degree of metabolic perturbation and is considered to be an important determinant of exercise tolerance; however, there is limited empirical evidence to demonstrate that $\dot{V}_{O_2}$ kinetics is a direct determinant of exercise tolerance. The purpose of this thesis was to investigate $\dot{V}_{O_2}$ kinetics as a determinant of exercise tolerance and to consider its potential interaction with the maximum $\dot{V}_{O_2}$ ($\dot{V}_{O_2max}$) and the W′ (the curvature constant of the hyperbolic power-duration relationship) in setting the tolerable duration of exercise. Recreationally-active adult humans volunteered to participate in the investigations presented in this thesis. Pulmonary $\dot{V}_{O_2}$ kinetics was assessed on a breath-by-breath basis and exercise tolerance was assessed by a time-to-exhaustion trial, with exhaustion taken as the inability to maintain the required cadence. A period of repeated sprint training (RST) resulted in faster phase II $\dot{V}_{O_2}$ kinetics (Pre: 29 ± 5, Post: 23 ± 5 s), a reduced $\dot{V}_{O_2}$ slow component (Pre: 0.52 ± 0.19, Post: 0.40 ± 0.17 L·min^{-1}), an increased $\dot{V}_{O_2max}$ (Pre: 3.06 ± 0.62, Post: 3.29 ± 0.77 L·min^{-1}) and a 53% improvement in severe exercise tolerance. A reduced $\dot{V}_{O_2}$ slow component and enhanced exercise tolerance was also observed following inspiratory muscle training (Pre: 0.60 ± 0.20, Post: 0.53 ± 0.24 L·min^{-1}; Pre: 765 ± 249, Post: 1061 ± 304 s, respectively), L-arginine (ARG) administration (Placebo: 0.76 ± 0.29 L·min^{-1} *vs.* ARG: 0.58 ± 0.23; Placebo: 562 ± 145 s *vs.* ARG: 707 ± 232 s, respectively) and dietary nitrate supplementation administered as nitrate-rich beetroot juice (BR) (Placebo: 0.74 ± 0.24 *vs.* BR: 0.57 ± 0.20 L·min^{-1}; Placebo: 583 ± 145 s vs. BR: 675 ± 203, respectively). However, compared to a control condition without prior exercise, the completion of a prior exercise bout at 70% Δ (70% of the difference between the work rate at the gas exchange threshold [GET] and the work rate at the $\dot{V}_{O_2max}$ + the work rate at the GET) with 3 minutes recovery (70-3-80) speeded overall $\dot{V}_{O_2}$ kinetics by 41% (Control: 88 ± 22 s, 70-3-80: 52 ±

13 s), but impaired exercise tolerance by 16% (Control: 437 ± 79 s, 70-3-80: 368 ± 48 s) during a subsequent exercise bout. When the recovery duration was extended to 20 minutes (70-20-80) to allow a more complete replenishment of the W′, overall kinetics was speeded to a lesser extent (by 23%; 70-20-80: 68 ± 19 s) whereas exercise performance was enhanced by 15% (70-20-80: 567 ± 125 s) compared to the control condition. In addition, the faster $\dot{V}_{O_2}$ kinetics observed when exercise was initiated with a fast start (FS; 35 ± 6 s), compared to an even start (ES; 41 ± 10 s) and slow start (SS; 55 ± 14 s) pacing strategy, allowed the achievement of $\dot{V}_{O_2max}$ in a 3 minute trial and exercise performance was enhanced. Exercise performance was unaffected in a 6 minute trial with a FS, despite faster $\dot{V}_{O_2}$ kinetics, as the $\dot{V}_{O_2max}$ was attained in all the variously paced trials. Therefore, the results of this thesis demonstrate that changes in exercise performance cannot be accounted for, purely, by changes in $\dot{V}_{O_2}$ kinetics. Instead, enhanced exercise performance appears to be contingent on the interaction between the factors underpinning $\dot{V}_{O_2}$ kinetics, the $\dot{V}_{O_2max}$ and the W′, in support of the proposed 'triad model' of exercise performance.

Table of contents

Chapter 1   Introduction

Chapter 2   Review of literature

Chapter 3   General methods

EXPERIMENTAL CHAPTERS