Modeling intermittent cycling performance in hypoxia using the critical power concept

Nathan Townsend\textsuperscript{1,2} Samantha Shearman\textsuperscript{2} Philip Skiba\textsuperscript{3} Dan Dwyer\textsuperscript{2}

Abstract

\textbf{Purpose:} Recently, a novel model derived from the critical power (CP) concept was developed to determine $W'$ balance ($W'_\text{BAL}$) during variable intensity exercise. The purpose of this study was to investigate the effect of hypoxia on the efficacy of the $W'_\text{BAL}$ model during high-intensity intermittent exercise.

\textbf{Methods:} Eleven trained, male cyclists (mean±SD; age 27±6.6 years, VO$_{\text{2peak}}$ 4.79±0.56) completed a maximal incremental ramp test and a 3 min "all out" test to determine end power (EP) and work performed above EP ($W'_\text{EP}$). On another day an intermittent test to task failure was performed. All procedures were performed in normoxia (NORM) and hypoxia (HYPO; FiO$_2$ ≈ 0.155). The experimental condition was single-blinded, randomized and counter-balanced, and the $W'_\text{BAL}$ model was used to calculate the minimum $W'$ ($W'_\text{BALmin}$) achieved during the intermittent test. $W'_\text{BALmin}$ in HYPO was also calculated using model parameters derived in NORM (N+H).

\textbf{Results:} In HYPO there was a significant decline in VO$_{\text{2peak}}$ (4.79±0.56 vs 3.93±0.47 L.min\textsuperscript{-1}; $P<0.001$) and EP (353±46 vs 319±49W; $P<0.001$), whereas no change occurred for $W'_\text{EP}$ (12.6±4.1 vs 13.3±5.3kJ; $P=0.34$; NORM vs HYPO). The change in VO$_{\text{2peak}}$ was significantly correlated with the change in EP ($r = 0.72; P<0.05$). There was no difference between NORM and HYPO for $W'_\text{BALmin}$ (1.7±0.9kJ vs 1.3±0.8kJ). The N+H analysis revealed a gross overestimation of $W'_\text{BALmin}$ (8.3±3.2kJ) and compared with HYPO ($P<0.001$). Figure 1 shows an example of modeled $W'_\text{BAL}$ for a typical subject.

\textbf{Conclusion:} The $W'_\text{BAL}$ model behaves similarly in hypoxic conditions equivalent to ≈2450m as previously reported for normoxia, but only when the model parameters (CP and $W'$) are determined under the same environmental conditions as the performance task is completed. The practical application of the $W'_\text{BAL}$ model for altitude training and performance monitoring, thus requires CP and $W'$ to be measured at altitude.

Figure 1. Modeled $W'_\text{BAL}$ for a typical subject during intermittent high intensity exercise. Light grey bars indicate work intervals. $P_4$ refers to the power output predicted to result in task failure in 4 min. NORM: FiO$_2$ = 0.2093, HYPO: FiO$_2$ = 0.155, N+H: exercise in HYPO modeled with CP + $W'$ measured in NORM.

Contact email: nathan.townsend@aspetar.com (N. Townsend)

\textsuperscript{1}Athlete Health & Performance Research Center, Aspetar Orthopaedic & Sports Medicine Hospital, Qatar
\textsuperscript{2}School of Exercise and Nutrition Sciences, Deakin University, Australia
\textsuperscript{3}Department of Sports Medicine, Advocate Lutheran General Hospital, USA