A NEW MATHEMATICAL MODEL OF OXYGEN CONSUMPTION AND CARBON DIOXIDE PRODUCTION IN HORSES EXERCISING AT 110% OF MAXIMUM OXYGEN CONSUMPTION

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A number of mono-exponential functions have been published to describe the rapid increases in oxygen consumption (V_{o2}) during moderate and maximum workload in human athletes. However, in people working above their anaerobic threshold, the V_{o2} does not clearly terminate in a steady state. Additional kinetic components were necessary to characterise a second slower phase of V_{o2} response. It has been our experience that in horses undergoing rapid increases in speed mono or bi-exponential equations do not adequately describe all of the features present in the rapidly changing V_{o2} and V_{co2} curves. To address this shortcoming, we present a novel equation that describes all of the features present in curves obtained from continuous measurement of V_{o2} and V_{o2} in exercising horses. The standard logistic Hill equation, that describes a sigmoid curve with a plateau, was modified by the inclusion of additional structure ($P4 \bullet t$) to describe curves with either increasing or decreasing terminal slopes. The equation is as follows:

$$\dot{V}_{o2co2} = \frac{P_1 + (P_4 \bullet t)}{\{1+\exp(-P_2 \bullet (t-P_3))\}} + P_5$$

where: P1 is the intercept of the asymptote of the V_{o2} and V_{co2} curves (at the knee portion of the curve), P_2 is maximum rate of increase of the curves where rapid increases are occurring in V_{o2} and V_{o2}, P_3 is the time (sec) of the maximum slope, and P_4 is the slope of the asymptote, and P_5 is baseline of V_{o2} and V_{co2}. Other indices that can be derived from the simultaneous modelling of V_{o2} and V_{co2} curves include: total area under the concentration curves, the calculation of V_{o2MAX}, the point in time in s when V_{co2} exceeds V_{co2} and anaerobic metabolism may become apparent. The difference in the areas between V_{o2} and V_{co2} beyond the V_{o2}–V_{co2} cross-over point is an indication of the accumulated oxygen deficit. These parameter estimates and calculated values will be useful in studies that employ full mixed effects analysis to determine treatment effects (pharmacological or physiological modifications) and within and between horse effects. The usefulness of the equation was tested by an analysis of data obtained from 9 fully trained fit horses. Each horse was exercised for 2 min at 110% of maximum oxygen consumption, 3 times, with a minimum of 10 days rest between runs. All were control runs prior to planned studies. All horses had consistent within horse V_{o2}–V_{co2} patterns and model parameters. For individual horses, the coefficients of variation of specific parameters were generally less than 5%, but between horses, the coefficients of variation of specific parameters were greater than 15%. This study suggests that models can be useful in defining changes in exercising horses.