Last Word on Point: Counterpoint: The kinetics of oxygen uptake during muscular exercise do/do not manifest time-delayed phases

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TO THE EDITOR: Not one of the proposed physiological mechanisms supports the existence of time-delayed instantaneous stepwise increments in oxygen demand that mark the beginning of each time-delayed phase and are the very foundation of the time-delayed three-phase exponential model. The chance of finding physiological mechanisms to support such behavior is nonexistent, due mainly to the instantaneous nature of the increment.

Not one of the proposed physiological mechanisms contradicts the model (2, 3), as even without time-delayed phases it produces features that only become apparent after a period of time. As shown in (5), this model can incorporate a far more realistic oxygen demand (i.e., one that changes smoothly with intensity and time to account for inertia and changing underlying physiological processes) than the obviously erroneous instantaneous increments of the three-phase model.

The sigmoid shaped $V\dot{O}_2(t,v)$ curve in Refs. 2 and 3 initially increases approximately exponentially from its initial value and during a small period of time this increase becomes rapid. Hence, even without an initial time-delayed phase, this model clearly does not contradict known anatomy and physiology.

The model of Refs. 2 and 3 is based on the indisputable physiological facts that $V\dot{O}_{2\text{min}} \leq V\dot{O}_2(t,v) \leq V\dot{O}_{2\text{max}}$ and that $V\dot{O}_2(t,v)$ does not take values greater (less) than the oxygen demand for the on (off) transient.

In response to Whip’s Point (4):

Obviously the three-phase intensity-dependent response parameters cannot remain constant for all exercise intensities, as they are functions of exercise intensity. In the model of Refs. 2, 3 the parameters are constant for an individual at a particular fitness level for all exercise intensities and what causes the changes in $V\dot{O}_2(t,v)$ for different exercise intensities, $v(t)$, is not changes in the parameters but changes in $v(t)$.

It is mathematical fact that

Deleting both too little and too much of the early response will effect the value $\varphi_2-\tau$.

Parameter estimation from an individual response, including breath-by-breath variability, can yield “a different curve” from that after ensemble averaging.

We believe that until the mathematical methods of data handling, analysis, and modeling are corrected and modernized to include more powerful and sophisticated techniques currently used elsewhere in biology, physiology, and medicine, then progress in understanding the basic physiological mechanisms will be severely limited. We finish with a quote from Glass and Mackey (1) as it directly relates to the study of oxygen uptake kinetics: “Somehow, a myth has arisen (which we believe is accepted by the great majority of practicing biologists) that detailed mathematical and theoretical analyses are not appropriate in biology. Certainly the mathematical training of most biologists and physicians is minimal. Yet if the complex dynamic phenomena that occur in the human body were to arise in some inanimate physical system—they would be subject to the most sophisticated experimental and theoretical study.

We have two aims [...] The first is to make physical scientists aware of the enormous complexity and beauty of dynamical phenomena in physiology and medicine. The second is to show physiologists and physicians that the techniques of nonlinear mathematics are applicable, and in some cases essential, to the analysis of dynamical phenomena in physiology.”

REFERENCES