EXAMINING THE INFLUENCE OF PHYSIOLOGICAL INTENSITY MARKERS ON THE RATE OF CHANGE OF HOMEOSTASIS CHALLENGE IN TRAINED CYCLISTS USING A STAMINA METRIC

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INTRODUCTION: The goal of most endurance sporting events is to complete a standardized distance as fast as possible. Therefore, an athlete must race at a work rate that maximizes intensity and optimizes the rate of fatigue to ensure a true maximal effort without premature exhaustion. This regulation of physical exertion is known as pacing and the planned regulation of physical exertion is an athlete's pacing strategy (Wu et al., 2014). The intensity/time to fatigue relationship is hyperbolic in nature (Abbiss & Laursen, 2009). Therefore, the pacing ability of an athlete is influenced quantitatively by individual fitness characteristics, but qualitatively by the event distance. "High" intensity exercise results in a fast rate of fatigue, while "low" intensity results in a slow rate of fatigue. The paces or work rates that constitute "high" or "low" intensity is highly individualistic and linked to physiological transitions (i.e. ventilatory or lactate thresholds) (Seiler, 2010). The use of technology in endurance sports is common to help coaches and athletes understand how the body responds to intensity (e.g. heart rate; input metrics) or to help understand what is being done (e.g. GPS velocity, power meters; output metrics) in an effort to optimize an athlete's pacing ability for a specific race. A recent addition to sport technology is a "stamina" metric as quantified by the GoMore (bOMDIC, Taipei, Taiwan) smartphone application.

Stamina may be defined as the ability to sustain prolonged physical effort. GoMore quantifies "stamina" as a relative metric (0-100%) from an algorithm that individualizes to the user based on outcome, input, and output metrics. Conceptually, stamina is central to the training and racing processes. Performance antecedents will influence the magnitude of stamina for an individual, while the product of intensity and duration (degree of homeostasis challenge) will influence the rate of fatigue and ultimately the magnitude and rate of stamina utilization. Based on the intensity/time to fatigue relationship, there should be a low, moderate, and high rate of stamina utilization during relative low, moderate, and high intensities, respectively.

The purpose of this research was to evaluate the rate of change in homeostasis challenge using stamina and oxygen consumption metrics during an incremental exercise test to volitional fatigue in trained cyclists. It was hypothesized that the rate of change would increase to coincide with physiological markers of homeostasis challenge, as measured by the individual ventilatory thresholds.

METHODS: Five trained cyclists completed an incremental cycling test until volitional fatigue. Testing was completed on a cycle ergometer (Velotron, Racermate, Seattle, WA) and consisted of a series of fixed work rate cycling stages. Testing began at 85 W and increase by 15 W every 5-minutes until volitional fatigue. Stamina was continuously recorded using the GoMore application and inspired and expired gases were continuously measured using a metabolic cart (Parvo Medics, Sandy, UT). Metabolic cart data were collected and analyzed by 15-second average intervals.

Stamina and oxygen consumption (VO_2; L/min) data were averaged over the final minute of each 5-minute stage. The individual VT_1 and VT_2 was assessed by participant using the criteria described by Meyer et al. (2004). In order to quantify the hyperbolic intensity/rate of fatigue relationship, the Δ homeostasis challenge was calculated. Specifically, the Δ homeostasis challenge was defined as:

$$\Delta \text{ homeostasis challenge} = \frac{| Stamina_{Stage\ X+1} - Stamina_{Stage\ X} |}{| VO2_{Stage\ X+1}\ VO2_{Stage\ X} |}$$

This variable will allow detection of a disproportionate decrease in stamina for each standardized, linear increase in VO_2 per cycling stage.

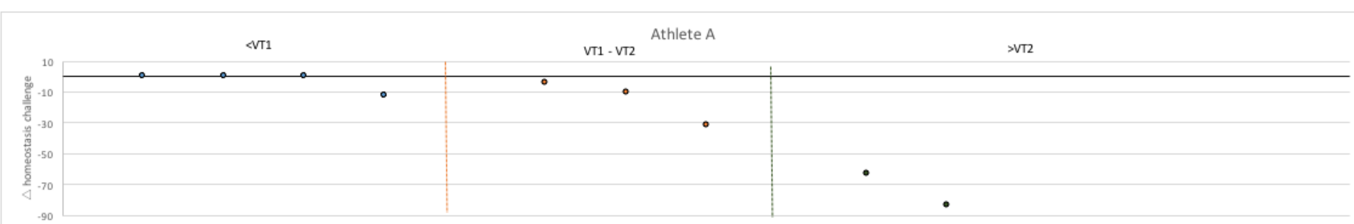
A multiple-baseline single subject design was employed for data analysis. The Δ homeostasis challenge was plotted per stage for each individual athlete on separate graph. The stage corresponding to the individual VT_1 and VT_2 was identified and a vertical line was placed before that stage on each graph. These physiological transitions indicated the breakpoints between low ($<VT_1$), moderate (VT_1-VT_2), and high ($>VT_2$) intensities (Seiler, 2010). A Tau-U effect size statistic (Parker et al., 2011) was calculated using baseline correction for each phase comparison per athlete ($<VT_1$ vs. VT_1-VT_2, $<VT_1$ vs. $>VT_2$, VT_1-VT_2 vs. $>VT_2$). Individual results were combined into a weighted average for a single omnibus effect size per phase comparison.

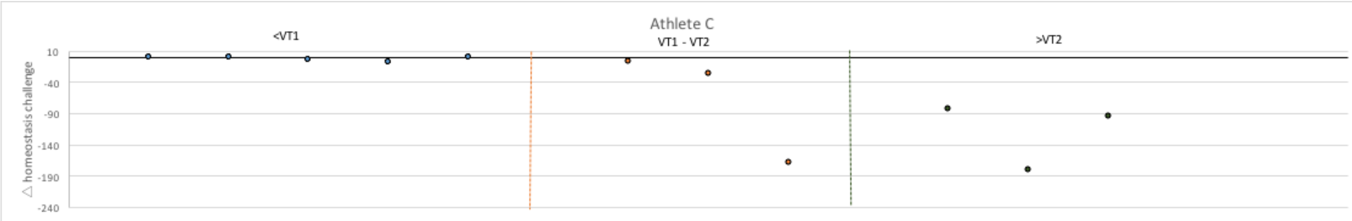
RESULTS:

Table 1. Omnibus Tau-U effect size per phase comparison

Phase Comparison	Tau-U	p	95% CI
<VT1 vs. VT1-VT2	-0.62	<0.01	-1.04; -0.21
<VT1 vs. >VT2	-0.73	<0.01	-1.14; -0.32
VT1-VT2 vs. >VT2	-0.47	0.04	-0.91; -0.03

Graph 1. Example comparison of relative exercise intensity and Δ homeostasis challenge between athletes





DISCUSSION: Based on the criteria of Vannest and Ninci (2015), results indicate a large effect size in Δ homeostasis challenge between low and moderate and low and high intensities and a moderate effect size between moderate and high intensities. These results provide evidence for the construct validity of the stamina metric for endurance athlete. When standardizing based on physiological markers of exercise intensity, there is an accelerated rate of stamina utilization with the linear increase in exercise intensity. The changes in acceleration coincide with the individualized markers of change in homeostasis challenge, as indicated by the individual VT_1 and VT_2. Therefore, the stamina metric was sensitive enough to increase rate of change with increasing exercise intensity, but specific enough to regulate that rate of change around the individualized markers of change in homeostasis challenge.

These results indicate that the stamina metric may prove to be a practical tool for coaches and athletes to better understand the individual intensity/fatigue relationship, allowing for more optimal training prescription and pacing strategies.

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