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# Prescription of High-intensity Aerobic Interval Training Based on Oxygen Uptake Kinetics

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## Key words

endurance training, high-intensity aerobic exercise, oxygen uptake demanded, running, cycling

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## ABSTRACT

Endurance training results in diverse adaptations that lead to increased performance and health benefits. A commonly measured training response is the analysis of oxygen uptake kinetics, representing the demand of a determined load (speed/work) on the cardiovascular, respiratory, and metabolic systems, providing useful information for the prescription of constant load or interval-type aerobic exercise. There is evidence that during high-intensity aerobic exercise some interventions prescribe brief interval times (<1-min), which may lead to a dissociation between the load prescribed and the oxygen uptake demanded, potentially affecting training outcomes. Therefore, this review explored the time to achieve a close association between the speed/work prescribed and the oxygen uptake demanded after the onset of high-intensity aerobic exercise. The evidence assessed revealed that at least 80% of the oxygen uptake amplitude is reached when phase II of oxygen uptake kinetics is completed (1 to 2 minutes after the onset of exercise, depending on the training status). We propose that the minimum work-time during high-intensity aerobic interval training sessions should be at least 1 minute for athletes and 2 minutes for non-athletes. This suggestion could be used by coaches, physical trainers, clinicians and sports or health scientists for the prescription of high-intensity aerobic interval training.

## Introduction

Endurance exercise training results in diverse metabolic and physiological adaptations that lead to increased performance and the ability to perform prolonged exercise bouts [1–3]. These adaptations depend on the “FITT principle,” including frequency, intensity, time (volume), and type, all of which determine the load of the exercise [4, 5]. External load measures the work a subject performs; meanwhile, the internal load measures the imposed biological stress of the exercise [6, 7]. Therefore, to yield an optimal adaptive response, training prescription (external load) must represent the exercise's physiological demand (internal load).

Cycling and running are the traditional and most practiced endurance exercise modalities. In cycling, the external load is commonly monitored by the power generated [in watts (W)] [8], while in running, the variable used to determine the external load is

speed/velocity [9, 10]. For both cycling and running, the internal load can be monitored through a variety of methods, including oxygen uptake ( $\dot{V}O_2$ ), blood lactate (BLa), heart rate (HR), HR variability, perception of effort (RPE), biochemical evaluations (hormonal and immunological), sleep quality, cognitive load, training impulse, among others [6, 11, 12]. A commonly used internal load to measure training response in both disciplines is the analysis of the  $\dot{V}O_2$  kinetics, as this measurement represents the demand of a determined external load (power or speed) on the cardiovascular, respiratory, and metabolic systems (internal load) [13, 14].

The  $\dot{V}O_2$  kinetics or dynamics is defined as the speed or time at which the exchange of  $O_2$  responds to satisfy the energy demands of the exercise (i. e. steady-state) [14]. During *light to moderate-intensity* (from now on low-intensity) exercise (below gas exchange threshold (GET) or lactate threshold (LT)) [15–20], the time to reach