

**Incidence of the Oxygen Plateau During Exercise Testing to Volitional Fatigue**

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**Introduction:** Recently, lively debate in exercise physiology has occurred on the concept of maximal oxygen uptake ( $\text{VO}_{2\text{max}}$ ) and the appearance of a plateau in oxygen consumption at  $\text{VO}_{2\text{max}}$  (1-4). Therefore, the purpose of this study was to better clarify the  $\text{VO}_2$  response to exercise to  $\text{VO}_{2\text{max}}$  using several sampling intervals. **Methods:** 10 subjects (8 men, 2 women) of varying fitness (mean age, height, weight, and  $\text{VO}_{2\text{max}}$  were  $29.2 \pm 6.6$  yr,  $172.7 \pm 7.5$  cm,  $72.8 \pm 13.2$  kg,  $3374.1 \pm 537.3$  ml·min<sup>-1</sup>, respectively) completed three different  $\text{VO}_{2\text{max}}$  tests on a cycle ergometer (a 25 W·min<sup>-1</sup> ramp protocol (R), a 75 W·3 min<sup>-1</sup> step protocol (S), and a 25 W·min<sup>-1</sup> ramp protocol (H) under hypoxic conditions [ $\text{F}_i\text{O}_2 = 0.15$ ,  $P_b = 630$  Torr]) separated by at least 2 days. Subjects had no knowledge of the specific protocol to be completed on a particular test day. The order of the tests was randomized using a Latin Squares design. During each test, subjects breathed humidified air from a Tissot tank, and indirect expired gas analysis calorimetry was performed breath-by-breath (Medical Graphics). For data analysis, breath-by-breath data were smoothed using an 11-breath moving average. These data were then time-averaged using 15, 30, and 60 s sampling intervals. Heart rate (HR) was continuously measured by electrocardiography (Quinton Instruments) using a standard 5 lead configuration. Criteria for attainment of  $\text{VO}_{2\text{max}}$  included 2 of the following: maximal RER  $\geq 1.10$ , a plateau in  $\text{VO}_2 \leq 50$  ml·min<sup>-1</sup>, or a maximal HR within 10 b·min<sup>-1</sup> of the calculated value. **Statistics:** A one-way ANOVA with repeated measures was used to examine differences between each of the exercise protocols for RER, HR, and  $\text{VO}_2$  at  $\text{VO}_{2\text{max}}$ . Significant differences between means were identified using Tukey's post-hoc HSD test. Statistical significance was set at 0.05, with an estimated power of 0.8 for a mean difference of 500 ml·min<sup>-1</sup> and a SD = 500 ml·min<sup>-1</sup>. **Results:** Average  $\text{VO}_{2\text{max}}$  was significantly different among the three  $\text{VO}_{2\text{max}}$  tests,  $F(2,18) = 61.58$ ,  $p = .000$ ,  $\text{MS}_E = 22934.63$ . Mean  $\text{VO}_{2\text{max}}$  was significantly higher ( $\text{HSD} = 14.63$ ,  $p < .05$ , and  $\text{HSD} = 12.23$ ,  $p < .05$ ) for the R ( $3374.08 \pm 537.27$  ml·min<sup>-1</sup>) and S trials ( $3259.16 \pm 604.33$  ml·min<sup>-1</sup>) compared to the H trial ( $2673.36 \pm 420.28$  ml·min<sup>-1</sup>). No significant differences in average maximal RER values were exhibited between the R ( $1.33 \pm .08$ ), S ( $1.34 \pm .07$ ), and H ( $1.37 \pm .07$ ) trials. Average maximal HR was significantly different among the three trials,  $F(2,18) = 7.43$ ,  $p = .004$ ,  $\text{MS}_E = 15.18$ . However, no significant differences were demonstrated between maximal HR during the H trial ( $172.60 \pm 9.52$  b·min<sup>-1</sup>) compared to the R ( $178.00 \pm 7.38$  b·min<sup>-1</sup>) or S trials ( $178.80 \pm 7.86$  b·min<sup>-1</sup>). All subjects for all tests demonstrated a plateau in  $\text{VO}_2$  when  $\text{VO}_2$  was sampled either breath-by-breath or every 15 s. Subjects displayed a  $\text{VO}_2$  plateau 57% of the time when data were sampled at 30 s intervals. No subjects displayed a  $\text{VO}_2$  plateau when gas exchange was averaged every minute. **Discussion:** We hypothesized that the breath-by-breath technique of sampling  $\text{VO}_2$  data would be most precise in clarifying the  $\text{VO}_2$  response during progressive exercise to  $\text{VO}_{2\text{max}}$ . These data show that shorter sampling intervals (breath-by-breath and 15 s) are most appropriate for precisely identifying a plateau in oxygen uptake at  $\text{VO}_{2\text{max}}$  compared to the longer sampling intervals widely used. Also, it is apparent that the RER and  $\text{O}_2$  plateau criteria are suitable for confirming attainment of  $\text{VO}_{2\text{max}}$ , yet the heart rate criterion is not a valid indicator of  $\text{VO}_{2\text{max}}$ . **References:** 1. Bassett D. R. et al. *Med Sci Sports Exerc.* 29:591-603, 1997. 2. Howley E. T. et al. *Med Sci Sports Exerc.* 27:1292-1301, 1995. 3. Noakes T. D. *Med Sci Sports Exerc.* 29:571-590, 1997. 4. Noakes T. D. *Med Sci Sports Exerc.* 30:1381-1398, 1998.