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 (VO\textsubscript{max}) and the appearance of a plateau in oxygen consumption at VO\textsubscript{max} \textsuperscript{1-4} Therefore, the purpose of this study was to better clarify the VO\textsubscript{2} response to exercise to VO\textsubscript{max} using several sampling intervals. Methods: 10 subjects (8 men, 2 women) of varying fitness (mean age, height, weight, and VO\textsubscript{max} were 29.2 ± 6.6 yr, 172.7 ± 7.5 cm, 72.8 ± 13.2 kg, 3374.1 ± 537.3 ml-min\textsuperscript{-1}, respectively) completed three different VO\textsubscript{max} tests on a cycle ergometer (a 25 W-min\textsuperscript{-1} ramp protocol (R), a 75 W-3 min\textsuperscript{-1} step protocol (S), and a 25 W-min\textsuperscript{-1} ramp protocol (H) under hypoxic conditions [\text{F}O\textsubscript{2} = 0.15, P\textsubscript{a} = 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 VO\textsubscript{max} included 2 of the following: maximal RER > 1.10, a plateau in VO\textsubscript{2} ≤ 50 ml-min\textsuperscript{-1}, or a maximal HR within 10 b-min\textsuperscript{-1} 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 VO\textsubscript{2} at VO\textsubscript{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\textsuperscript{-1} and a SD = 500 ml-min\textsuperscript{-1}. Results: Average VO\textsubscript{max} was significantly different among the three VO\textsubscript{max} tests, F(2,18) = 61.58, p = .000. MS\text{between} = 22934.63. Mean VO\textsubscript{max} was significantly higher (HSD = 14.63, p < .05, and HSD = 12.23, p < .05) for the R (3374.08 ± 537.27 ml-min\textsuperscript{-1}) and S trials (3259.16 ± 604.33 ml-min\textsuperscript{-1}) compared to the H trial (2673.36 ± 420.28 ml-min\textsuperscript{-1}). No significant differences in average maximal RER values were exhibited between the R (1.33 ± .08), S (1.34 ± .07), and H (1.37 ± .07) trials. Average maximal HR was significantly different among the three trials, F (2,18) = 7.43, p = .004, MS\text{between} = 15.18. However, no significant differences were demonstrated between maximal HR during the H trial (172.60 ± 9.52 b-min\textsuperscript{-1}) compared to the R (178.00 ± 7.38 b-min\textsuperscript{-1}) or S trials (178.80 ± 7.86 b-min\textsuperscript{-1}). All subjects for all tests demonstrated a plateau in VO\textsubscript{2} when VO\textsubscript{2} was sampled either breath-by-breath or every 15 s. Subjects displayed a VO\textsubscript{2} plateau 57% of the time when data were sampled at 30 s intervals. No subjects displayed a VO\textsubscript{2} plateau when gas exchange was averaged every minute. Discussion: We hypothesized that the breath-by-breath technique of sampling VO\textsubscript{2} data would be most precise in clarifying the VO\textsubscript{2} response during progressive exercise to VO\textsubscript{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 VO\textsubscript{max} compared to the longer sampling intervals widely used. Also, it is apparent that the RER and O\textsubscript{2} plateau criteria are suitable for confirming attainment of VO\textsubscript{max}, yet the heart rate criterion is not a valid indicator of VO\textsubscript{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.