Inhalation Flow Rates During Strenuous Exercise

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ABSTRACT

It would be helpful if peak inhalation flow rates were characterized for respiratory design, testing, and use. However, peak flow rates depend strongly on the wearer and the type of work being performed. Instantaneous inhalation rates for subjects exercising on a treadmill have been measured for the following conditions: 1) at 80-85% $\dot{V}O_2$ max without a respirator, 2) at 80-85% $\dot{V}O_2$ max while wearing a breath-responsive PAPR (blower flow rate) and 3) at 100% $\dot{V}O_2$ max without a respirator. Instantaneous inhalation flow rates were found to vary greatly among subjects and at different times for each subject. Depending upon the time that any given flow rate can be sustained, peak flow rates can vary considerably. Instantaneous flow rates were recorded and classified according to 20 L/min ranges so that the flow rate distribution could be obtained. If flow rates in the top one percentile are defined as peak flow rates, then a peak inhalation flow rate of up to 359 L/min (BTPS) was measured for condition 1. Peak instantaneous (less than 1% of flow rates) recorded flows were even higher, up to 442 L/min (BTPS). A peak blower flow rate of up to 679 L/min (BTPS) was measured for condition 2.Flow rates recorded at 100% $\dot{V}O_2$max were generally higher than flow rates 80-85% $\dot{V}O_2$ max, although this varied somewhat among subjects. A linear relationship has been found between peak flow rate and average minute volume, which can then be used in a procedure to calculate peak flow rates expected at any given work rate.

Keywords: peak inhalation flow rates, oxygen consumption, and respirators

INTRODUCTION

Wave shapes for flow rates of working humans are different from the sinusoids seen during inhalation at rest. If inhalation flow rate was sinusoidally-shaped, then there would be an easily definable relationship between average and peak flow. The pattern of flow rate is, instead, nearly trapezoidal, with a peak often occurring near the beginning or the end of the wave (Johnson, 1991; Johnson, 1993). The peak flow rate relationship varies among people and among breaths from the same person. Thus, the peak flow is not easily calculated from average flow rate.

Peak inhalation flow rates should be known for a number of reasons. First, flow rates supplied by powered-air purifying respirators (PAPRs) must be adequate to protect wearers (although flow rates alone do not guarantee protection). Especially for loose-fitting PAPRs, it is necessary to provide sufficient air to prevent breathing contaminated air. Face seal leakage for tight-fitting PAPRs is of concern when breathing flow rate exceeds blower flow rate and pressure inside the facepiece becomes negative. Leakage is especially of concern when beard stubble appears on the face of the wearer (deRoza et. al.,