APPROXIMATE SIMULATION OF ACUTE HYPOBARIC HYPOXIA WITH NORMOBARIC HYPOXIA

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INTRODUCTION. Some manufacturers of reduced oxygen \( (O_2) \) breathing devices claim a comparable hypobaric hypoxia (HH) training experience by providing \( F_{O_2} < 0.209 \) at or near sea level pressure to match the ambient \( O_2 \) partial pressure (iso-p\( O_2 \)) of the target altitude. METHODS. Literature from investigators and manufacturers indicate that these devices may not properly account for the 47 mmHg of water vapor partial pressure that reduces the inspired partial pressure of \( O_2 \) (\( P_{iO_2} \)). Nor do they account for the complex reality of alveolar gas composition as defined by the Alveolar Gas Equation. In essence, by providing iso-p\( O_2 \) conditions for normobaric hypoxia (NH) as for HH exposures the devices ignore \( P_{A O_2} \) and \( P_{ACO_2} \) as more direct agents to induce signs and symptoms of hypoxia during acute training exposures. RESULTS. There is not a sufficient integrated physiological understanding of the determinants of \( P_{A O_2} \) and \( P_{ACO_2} \) under acute NH and HH given the same hypoxic \( pO_2 \) to claim a device that provides isohypoxia. Isohypoxia is defined as the same distribution of hypoxia signs and symptoms under any circumstances of equivalent hypoxic dose, and hypoxic \( pO_2 \) is an incomplete hypoxic dose. Some devices that claim an equivalent HH experience under NH conditions significantly overestimate the HH condition, especially when simulating altitudes above 10,000 feet (3,048 m). CONCLUSIONS. At best, the claim should be that the devices provide an approximate HH experience since they only duplicate the ambient \( pO_2 \) at sea level as at altitude (iso-p\( O_2 \) machines). An approach to reduce the overestimation is to at least provide machines that create the same \( P_{iO_2} \) (iso-\( P_{iO_2} \) machines) conditions at sea level as at the target altitude, a simple software upgrade.

Learning Objectives:

1. Applying basic principles of respiratory physiology to the design of reduced oxygen breathing devices.
2. Working toward a better understanding of hypoxia.
INTRODUCTION. Some manufacturers of reduced oxygen (O2) breathing devices claim a comparable hypoxic hypoxia (HH) training experience by providing FIO2 < 0.209, breathed either through a mask or within a "hypoxia tent." Some manufacturers claim an equivalent acute hypoxic (HH) experience but under NH conditions. This eliminates the need for an expensive hypobaric chamber and the risk of decompression sickness associated with hypoxic exposure, creating a cost-effective hypoxic training method.

METHODS

The method to convert face mask to ambient pressure was never specified, a necessary detail to determine the operation of these devices. But through analysis, it appears that Eq. 1 is used. Eq. 1 defines a "Standard Atmosphere - 1976" where distance in kilometers is converted to the equivalent ambient pressure as mmHg.

**Equation 1**

\[ P_{\text{bb}}(\text{mmHg}) = 286.15 - 6.5 (\text{altitude} \times 10^{-3}) \]

where Eq. 1 is an alternative to Eq. (10). Eq. 2 is written as:

**Equation 2**

\[ P_{\text{bb}}(\text{mmHg}) = 808.8728 - 0.1112 (\text{altitude} - 540) \]

The devices seem to duplicate the ambient partial pressure of O2 (Pₒ2 NORMO) at sea level as it is at the target altitude with the consequence of an incorrect PIO2.

**Equation 3**

\[ F_{\text{IO2hypo}} / (P_{\text{Bnormo}} - 47) \]

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**Equation 5**

\[ V_{\text{CO2}} = (F_{\text{IO2}} + ((1 - F_{\text{IO2}}) / R_{\text{Q}})) \times P_{\text{A}} \]

The device in using the upper curve in Fig. 3. It is shown that when a FIO2 at sea level to match the Pₒ2 at the altitude you create a PIO2 that is greater than the that at the altitude, a consequence of a greater PIO2.

**Equation 6**

\[ F_{\text{IO2hypo}} = \frac{P_{\text{B}} - 47}{P_{\text{Bnormo}} - 47} \]

The device in using the upper curve in Fig. 3. It is shown that when a FIO2 at sea level to match the Pₒ2 at the altitude you create a PIO2 that is greater than the that at the altitude, a consequence of a greater PIO2.

**Equation 7**

\[ V_{\text{CO2}} = (F_{\text{IO2}} + ((1 - F_{\text{IO2}}) / R_{\text{Q}})) \times P_{\text{A}} \]

The device in using the upper curve in Fig. 3. It is shown that when a FIO2 at sea level to match the Pₒ2 at the altitude you create a PIO2 that is greater than the that at the altitude, a consequence of a greater PIO2.

**Equation 8**

\[ F_{\text{IO2hypo}} = \frac{P_{\text{B}} - 47}{P_{\text{Bnormo}} - 47} \]

The device in using the upper curve in Fig. 3. It is shown that when a FIO2 at sea level to match the Pₒ2 at the altitude you create a PIO2 that is greater than the that at the altitude, a consequence of a greater PIO2.

**Equation 9**

\[ V_{\text{CO2}} = (F_{\text{IO2}} + ((1 - F_{\text{IO2}}) / R_{\text{Q}})) \times P_{\text{A}} \]

The device in using the upper curve in Fig. 3. It is shown that when a FIO2 at sea level to match the Pₒ2 at the altitude you create a PIO2 that is greater than the that at the altitude, a consequence of a greater PIO2.

**Equation 10**

\[ F_{\text{IO2hypo}} = \frac{P_{\text{B}} - 47}{P_{\text{Bnormo}} - 47} \]

The device in using the upper curve in Fig. 3. It is shown that when a FIO2 at sea level to match the Pₒ2 at the altitude you create a PIO2 that is greater than the that at the altitude, a consequence of a greater PIO2.