The response to hypoxia: a comparison of the Human Patient Simulator (HPS) with human data

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Introduction

The Human Patient Simulator (HPS 337; METI; Sarasota, Florida) has a computer driven mechanical lung and gas exchange mechanism, designed to model the human respiratory system. We have previously demonstrated that the HPS is a useful tool for illustrating physiological principles but requires adjustments to the modelling software in order to improve the fidelity of the quantitative response to perturbations such as simulated hypovolaemia [1]. Data for a range of respiratory variables can be obtained from the HPS including breathing rate, tidal volume, simulated alveolar and arterial partial pressures of oxygen and carbon dioxide and arterial oxygen saturation.

HR 72		C.O. 5.9	Left Vol. 1059	Right Vol. 1206	Spont.VT 728	PaCO2 41.9	pH 7.43	PaO2 110.8
SpO2 98	Hct 42.30		PACO2 41.1	PAO2 118.5	Spont.RR 13	PvCO2 45.6		PvO2 45.4
ABP 118/52	PAP 29/15	CVP 6				TBody 36.5	Weight 70.0	TBlood 37.0

Baseline data for physiological variables from the HPS interface

Aims

The aim of this study was to compare the response of the HPS to hypoxia with available human data in order to determine the accuracy of the response and the utility of the HPS for teaching high altitude human physiology.

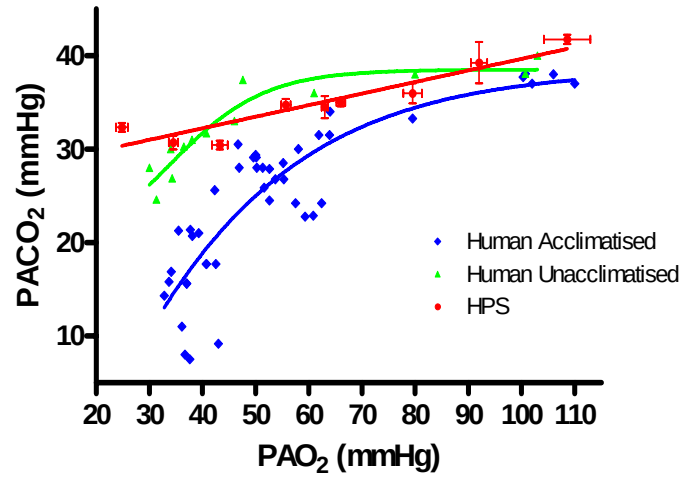
Experimental procedure

The simulator was intubated and baseline measurements were made of the respiratory variables including the partial pressures of oxygen and carbon dioxide in alveolar (PAO2 and PACO2) gas whilst "breathing" atmospheric air at ambient pressure. The responses were then determined to breathing hypoxic gas mixtures (range = 19–5% O2) applied using Douglas bags and a three-way valve system to separate inspired and expired gases.

The data were used to construct an Oxygen-Carbon Dioxide diagram for comparison with published human data [2, 3, 4]. For HPS, means ± SEM are shown.

Results

In response to hypoxia the HPS showed a linear relationship between PAO2 and PACO2 over the entire range investigated (PAO2 = 25-110mmHg; n = 6). Published human data for unacclimatised individuals shows a near linear relationship between PAO2 and PACO2 over a PAO2 range of 60-100 mmHg but below this range there is a non-linear relationship [2,3]. This is due to hyperventilation resulting in a respiratory alkalosis when PAO2 decreases below approximately 60mmHg [2].



The HPS failed to exhibit appropriate degrees of respiratory alkalosis in response to PAO2 below 60mmHg, equivalent to breathing atmospheric air at an altitude of around 2500m (8500ft) and a barometric pressure of 550mmHg [approximated values derived from 5]

Conclusion

The HPS is a useful tool for demonstrating trends in the response to changes in the environment, in this case hypoxia, but that the model requires some adjustment in order to more accurately represent human data and demonstrate high altitude physiology.

References

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Acknowledgements

We wish to acknowledge the assistance of Prof Judy Harris and the technical support of Mr Peter Dickens. HPS funding as part of the AIMS CETL was provided by the Higher Education Funding Council for England.