

HK*4550 Human Cardio-respiratory Physiology Midterm I Answer Key (Fall 2013)

1.

a) Dependent vs. independent variable

- Independent variable is modulated by the experimenter
- Dependent variable is measured by the experimenter

b) Hemoglobin isoform delta

- Component of the minor adult form of hemoglobin (HbA₂ - 2 α , 2 δ)
- Unknown function
- Minor form in blood (2-3%), may increase with disease

c) Break-point

- The point after which ventilation becomes dependent on P_ACO₂ levels/is driven by CO₂
- On ventilation (L/min) vs. P_ACO₂ (mmHg) graph ~ 40mmHg (difficult to measure)
- AKA ventilator recruitment threshold (VET)

d) Carbonic anhydrase

CA

- H₂O + CO₂ → H₂CO₃ → H⁺ + HCO₃⁻
- Enzyme that catalyzes the reaction between CO₂ and H₂O to form H₂CO₃; reaction is extremely slow otherwise
- High levels in cerebral spinal fluid (for H⁺/pH detection by central chemoreceptors)
- Second most abundant protein in red blood cells (for transporting CO₂ as HCO₃⁻)

e) Methyl Isocyanate (MIC)

- Causes pulmonary edema
- MIC leak in Bhopal, India in 1984 led to widespread exposure/death and discovery of Juxtacapillary (J) receptors
- J receptors detect pulmonary edema → ↓ muscle activity → ↓ ventilation

f) Duty cycle

- Duty cycle = Time inspired (T_I) / (Time inspired (T_I) + Time expired (T_E))
- Usually ~ 30-40%

g) Haldane effect

- Deoxygenation of the blood increases its ability to carry CO₂
- ↑ PCO₂ → ↑ O₂ offloading of Hb / ↓ PCO₂ → ↑ O₂ loading of Hb

2.

a) Reduced PvO₂ (normal – 40mmHg), elevated PvCO₂ (normal – 45mmHg).

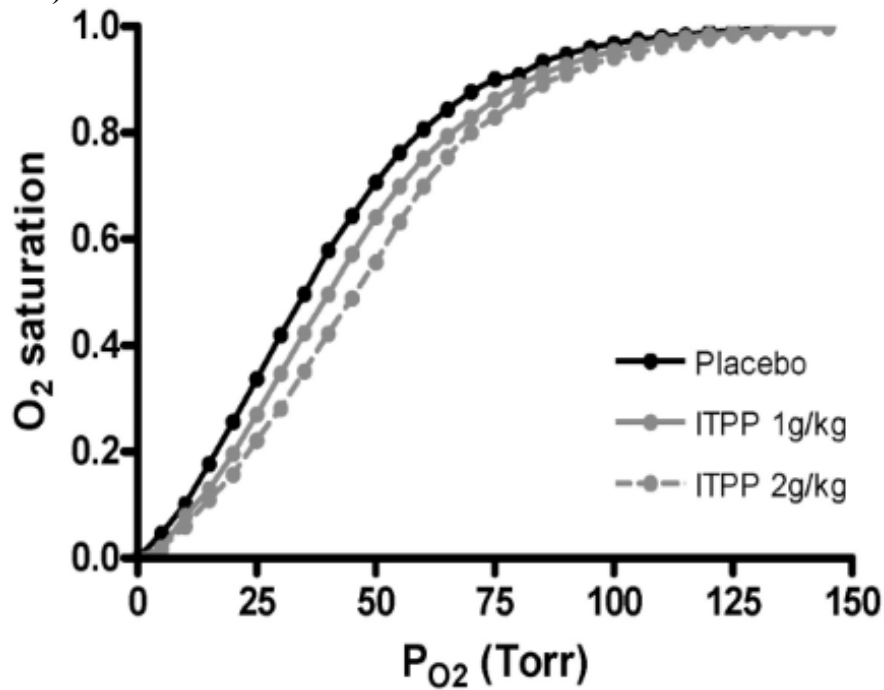
Samples could have been taken from exercising/metabolically active limb muscle → higher demand for O₂ by working muscle (↓ PvO₂) and increased metabolism (↑ PvCO₂).

b) Hypoventilation, decrease in atmospheric pressure (ie. higher altitude), decrease in % O₂ in inspired air (eg. hypoxia tent), impaired O₂ uptake in certain disease states (eg. COPD).

3. Diaphragm – Voluntary and involuntary movements, central tendon (does not cross a joint), innervation derived from C3-5, constitutively active (resistant to fatigue), limited proprioception (few muscle spindles)

Quadriceps – Voluntary movements only, tendon crosses joints, fatigable, high number of muscle spindles

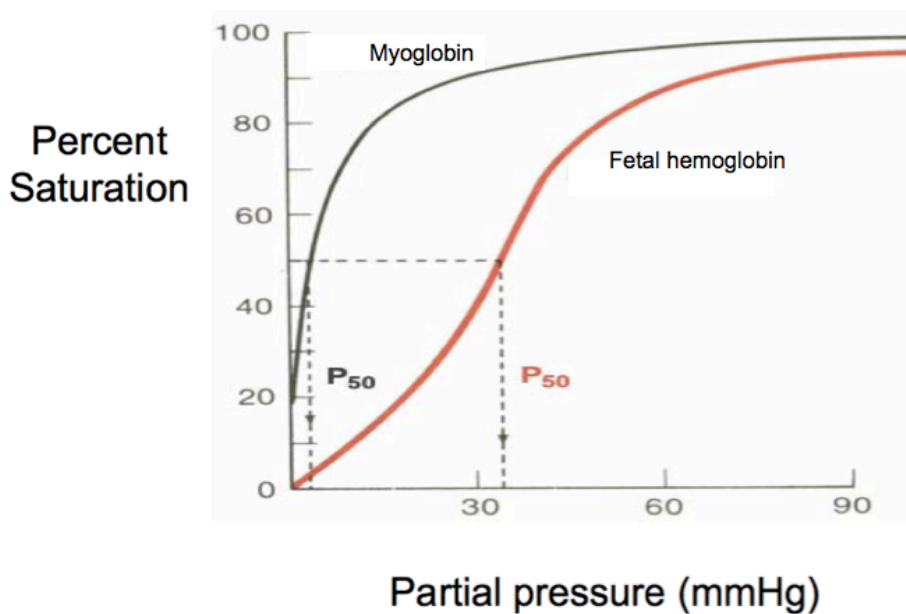
4. a)



Note: only needed to illustrate one ITPP curve

ITPP increases exhaustive treadmill running distance in mice by decreasing hemoglobin's affinity for oxygen. This results in a rightward shift of the oxygen disassociation curve and increased offloading of oxygen at the level of the working muscle. Improved delivery means more oxygen is available for metabolism and exercise performance is improved.

b)



c) Increased levels of 2,3-BPG/DPG α \downarrow Hb affinity for O₂ \rightarrow increased O₂ offloading

d) This would be good for an endurance athlete as you would be able to carry more oxygen per gram of Hb (normal = 1.39 mls O₂/g Hb). This would increase the amount of O₂ delivered to the working muscle allowing for increased athletic performance.

5)

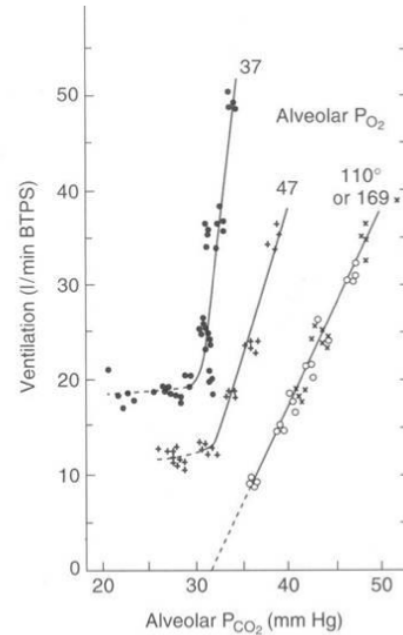
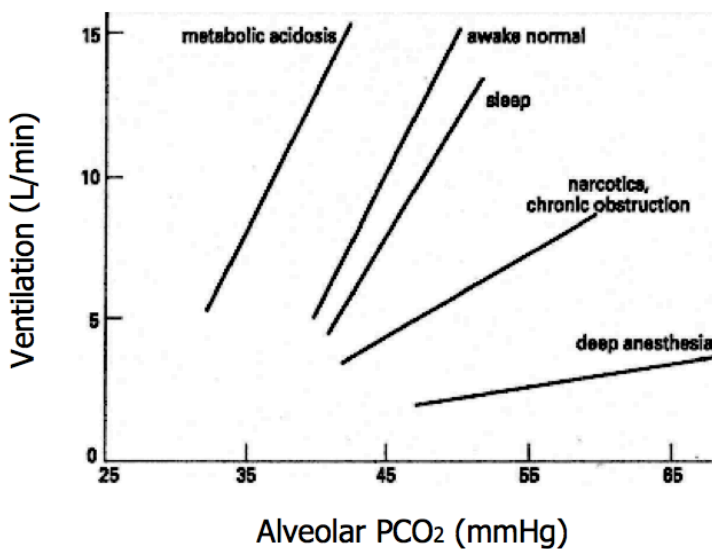
Sleep – Decreases the sensitivity of our ventilatory response to changes in PCO₂

Chronic obstruction/COPD – Neural output of the respiratory center not as effective at producing ventilation, decreases our sensitivity to CO₂

Hormones (eg. estrogen/progesterone) – Sensitises the respiratory center increasing the sensitivity of our ventilatory response to changes in PCO₂

PaO₂ – Extreme hypoxia can increase our ventilation at a given PCO₂ and increase our sensitivity to changes in PCO₂

Metabolic acidosis – \uparrow H⁺/ \downarrow pH increases the sensitivity of our ventilatory response to changes in PCO₂



6.

- Dissolved \rightarrow \sim 7%, \sim 20x more soluble than O₂ (k (CO₂) = 0.067ml CO₂ / 100ml blood / mmHg vs. k (O₂) = 0.003ml O₂ / 100ml blood / mmHg)
- Carbamino \rightarrow \sim 23%, CO₂ attaches to an amino group on hemoglobin in RBC, binding decreases Hb affinity for O₂
- Bicarbonate \rightarrow \sim 70%, carbonic anhydrase in RBC facilitates reaction (H₂O + CO₂ \rightarrow H₂CO₃ \rightarrow H⁺ + HCO₃⁻), H⁺ promotes O₂ offloading, HCO₃⁻ diffuses back into plasma

7. a) Transdiaphragmatic pressure can be used as an index of diaphragm force as it has been experimentally shown that P_{di} \propto diaphragm force (linear relationship).

b)

- Pneumotaxic area – located in the pons, inhibits inspiration
- Apneustic area – located in the pons, switches “on” inspiration and lengthens V_T
- Respiratory center – located in the medulla oblongata, controls the rate and depth of breathing (rhythmic breathing)