



INFLUENCE OF ELEVATED OXYGEN (O₂) PARTIAL PRESSURE ON CARBON DIOXIDE (CO₂) NARCOSIS

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BACKGROUND

- ❖ Divers risk CO₂ retention from inadequate ventilation or inspired CO₂.
- ❖ CO₂ is narcotic and affects both cognitive performance and consciousness.
- ❖ Previous studies suggested the hypothesis that hyperoxia reduced hypercapnic symptoms putting divers at risk of unconsciousness (see Figure 1; Donald. *AEDU Report XVI*, 1945).
- ❖ We investigated O₂ and CO₂ effects on cognitive performance and discomfort.

Figure 1. "Human Chariot" Divers



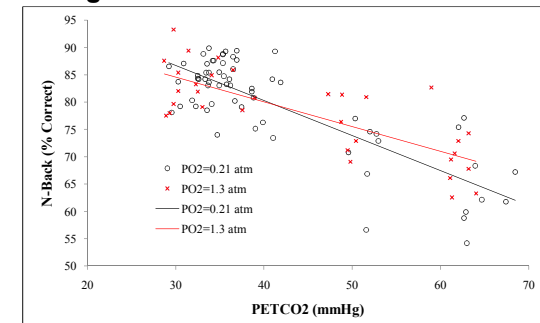
Table 1. Rest Gas	A-Normoxia/ Normocapnia	B-Hyperoxia/ Normocapnia	C-Normoxia/ Hypercapnia	D-Hyperoxia/ Hypercapnia
n-back (%correct)	84.6±7.0	84.4±6.5	70.2±10.7*	73.5±9.9@
RPD	0.4±0.8	0.6±1.0	4.4±1.6*	3.9±1.3@
P _{ET} CO ₂ (mmHg)	36.3±3.4	31.8±3.6#	60.4±5.1*	57.4±5.2@
V _E (L/min BTPS)	11.9±5.4	14.3±6.1#	60.5±17.1*	59.5±18.9

p<0.05 for #-A vs. B, @-C vs. D, *-A vs. C

RESULTS (see Table 1 for resting values)

- ❖ Tolerable CO₂ ranged from 0.065 to 0.085 atm at rest.
- ❖ Exercise often lowered CO₂ tolerance by 0.01 atm.
- ❖ Results were comparable for rest and exercise.
- ❖ Four subjects who breathed gas C had tunnel vision, dizziness, panic, exhaustion, or near-syncope (2 rest, P_{ET}CO₂=57.4, 61.3 mmHg; 2 exercise, P_{ET}CO₂=51.3, 74.8 mmHg).

Figure 2. N-Back Score vs. PETCO₂



METHODS

- ❖ Twelve males (37±11 [28-59] years [mean±SD, range]) breathed four gases for 4 min at 1.45 ata:
 - ❖ Gas A (Normoxia/Normocapnia) – 0.21 atm O₂/0.0 atm CO₂
 - ❖ Gas B (Hyperoxia/Normocapnia) – 0.21 atm O₂/"high CO₂"
 - ❖ Gas C (Normoxia/Hypercapnia) – 1.3 atm O₂/0.0 atm CO₂
 - ❖ Gas D (Hyperoxia/Hypercapnia) – 1.3 atm O₂/"high CO₂"
- ❖ "High CO₂" was defined for each subject as the maximum inspired CO₂ tolerable for 4 min among gases presented in order: 0.055, 0.065, 0.075, or 0.085 atm CO₂.
- ❖ Gas A was paired with gases B, C, and D in a Latin Square design of nine experimental pairs.
- ❖ Experiments were conducted at rest and with 75 watts of dry, cycling exercise.
- ❖ Cognitive performance was assessed with an n-back auditory test.
- ❖ Subjects reported a rating of perceived discomfort (RPD; 0-10 scale).
- ❖ Minute ventilation (V_E) and end-tidal CO₂ (P_{ET}CO₂) were recorded.
- ❖ Measurements were assessed by multiple linear regression with repeated measures.

CONCLUSIONS

- ❖ Hyperoxia reduced perceived discomfort slightly in subjects breathing hypercapnic gas for 4 min.
- ❖ Hyperoxia improved n-back performance scores (Figure 2).
 - ❖ Whether this was due to reduced discomfort or improved cognitive function is unknown.
- ❖ P_{ET}CO₂ decreased with hyperoxia but hyperventilation was unaffected.
- ❖ The most severe symptoms were associated with normoxic/hypercapnic gas C.
- ❖ Reduced discomfort with hyperoxia was consistent with Donald's hypothesis, and severe symptoms occurred with normoxic rather than hyperoxic gas.

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