Changes in Psychomotor Performance and Arterial Oxygenation during acute exposure to Moderate Hypobaric Hypoxia and concurrent Exercise at 17,500 feet

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Background Information

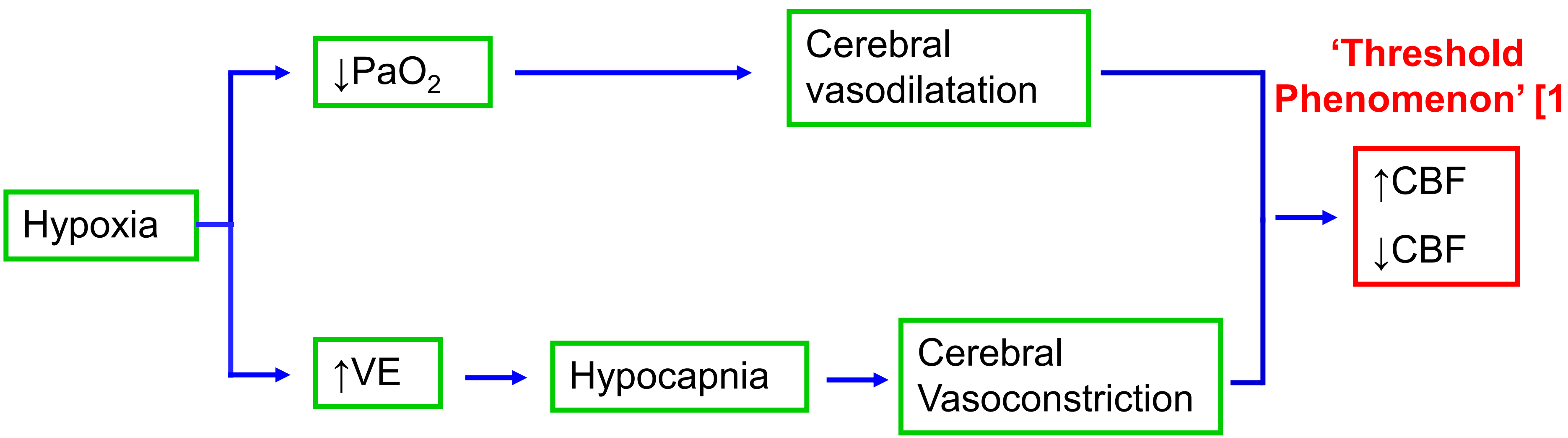
- Current military operations can involve flying of unpressurised aircraft without integral O_2 systems at altitudes of moderate hypoxia

- Hypobaric Hypoxia: ↓performance ↔/↑ perceived performance [4]

- Uncertainty regarding:
  - Threshold
  - Magnitude
  - Specificity

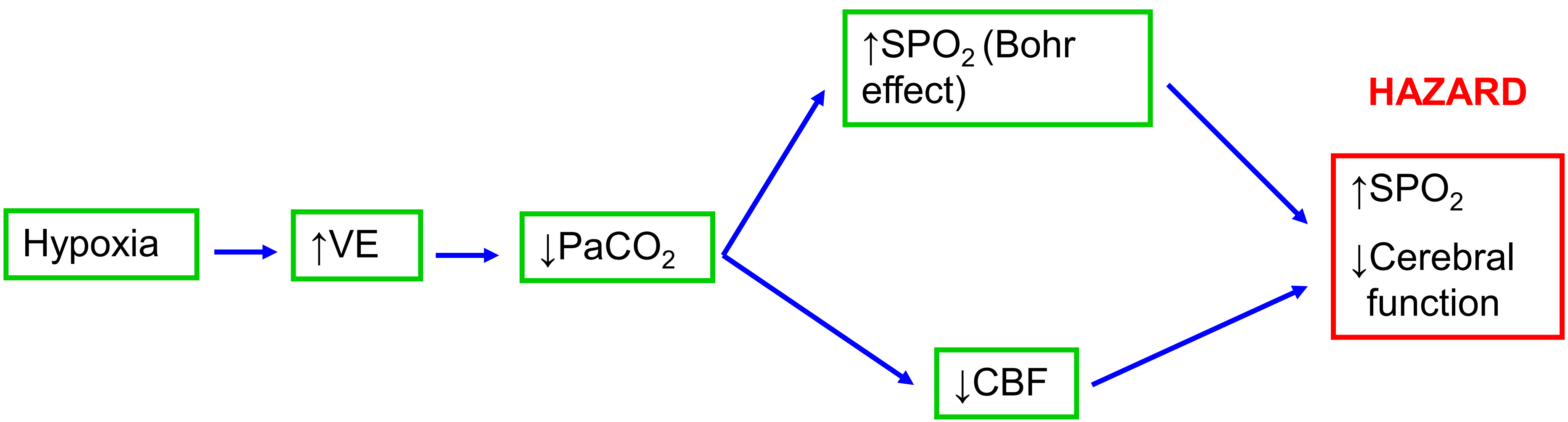
Background Information

- Cerebral blood flow α PP important:
  - ↕CBF → ↕Cerebral tissue PO_2 → neurological effects



Background Information

- Finger pulse oximeters widely used by pilots to monitor arterial O_2 sats & give indication of cerebral PO_2 ∴ aiding prevention of hypoxia
- However, SpO_2 is a poor indicator of cerebral O_2 tension [3]



Background Information

- Military aircrew often perform moderate levels of physical activity in hypoxic conditions

- Most studies investigating: Hypobaric hypoxia α PP conducted at rest & do not consider effects of concurrent physical activity

- Moderate activity (~30W) <10,000ft → neurological imp [6,8]

Aim

To investigate whether PP as determined by the CogScreen Hypoxia Edition (HE) test is modified by breathing air equivalent to an altitude of 17,500ft with and without moderate exercise (30 W)

Method

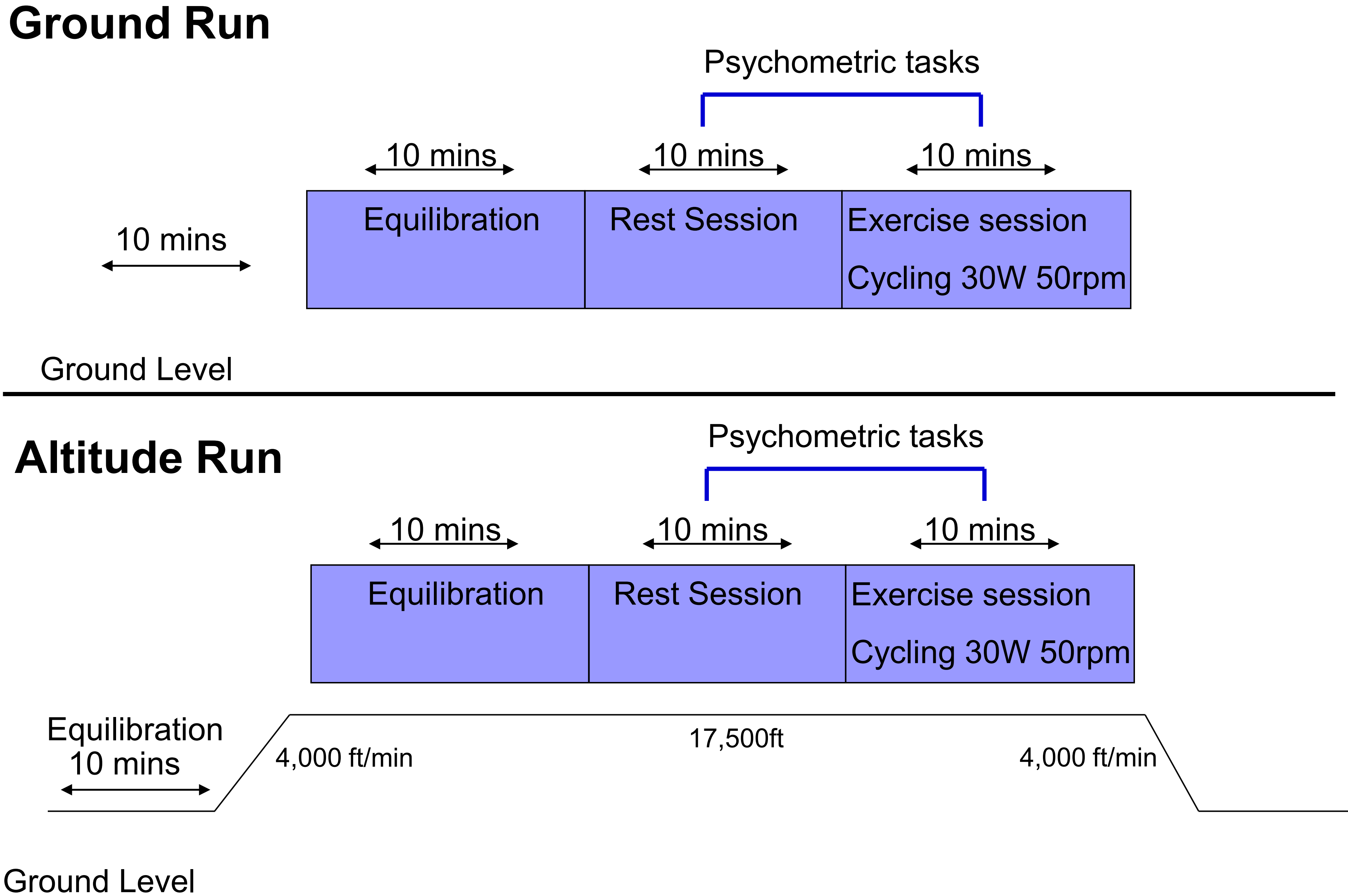
16 healthy subjects (9 and 7 ; 21.9 1.2 years)

Written informed consent & MODRec approval obtained

Variables monitored at RAF CAM within a hypobaric chamber:

Altitude chamber differential pressure	Chamber temperature and humidity
Inspiratory gas flow	Inspired volume
End tidal oxygen tension	End tidal carbon dioxide tension
Mean arterial pressure	Heart rate
Peripheral arterial oxygen saturation	Psychomotor performance
Subjective hypoxia symptoms	

Method


Ground Run
Psychometric tasks
10 mins
10 mins
10 mins
10 mins
Equilibration
Rest Session
Exercise session
Cycling 30W 50rpm
Ground Level
Altitude Run
Psychometric tasks
10 mins
10 mins
10 mins
Equilibration
Rest Session
Exercise session
Cycling 30W 50rpm
Equilibration
10 mins
4,000 ft/min
17,500ft
4,000 ft/min
Ground Level

Method

Psychomotor performance:

- Assessed using the CogScreen Hypoxia edition:
  - Tests cognitive capacity & ability to execute aircraft procedures
  - Subtests: Visual Sequence Comparison, Divided Attention, Symbol Digit Coding, Numeric trail making & Matching to Samples
  - Results: Task speed (response time in secs), accuracy (%) & throughput (nº of correct responses/min) across ALL Subtests

Clinical Manifestations:

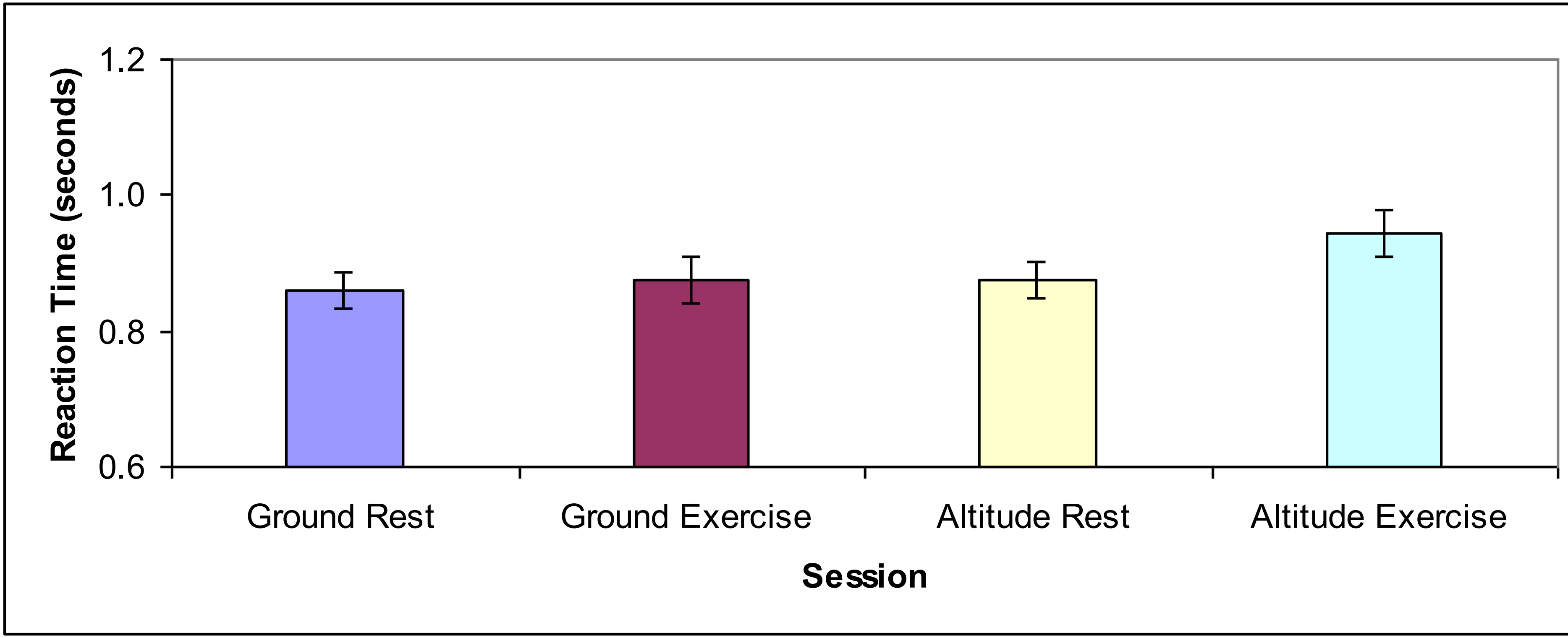
- Assessed by subjective symptoms questionnaire
  - Subjects graded symptom severity from 0 (none) to 7 (severe)

Results

	Ground	Ground	Altitude	Altitude
Variables	Rest	Exercise	Rest	Exercise
$PETO_2$ (mmHg)	110.41 (4.6)	105.27 (5)	39.10 (4.2)	39.94 (3.6)
$PETCO_2$ (mmHg)	35.32 (4.2)	39.59 (4.5)	30.70 (2.3)	30.46 (2.7)
Ventilation, [BTPS]/min)	11.54 (1.7)	19.23 (2.5)	12.85 (3.3)	24.79 (3.1)
SpO_2 (%)	98.00 (0.9)	98.00 (0.9)	65.70 (6.8)	59.10 (8.8)
Heart Rate (bpm)	85.30 (2.3)	102.30 (9.8)	103.70 (16.4)	126.40 (17.0)
MAP (mmHg)	105.00 (15.4)	112.80 (15.7)	103.10 (15.7)	106.40 (14.7)

Table 1: Mean values (standard deviation) of physiological variables during Ground rest and Ground exercise and Altitude rest and Altitude exercise sessions

Results



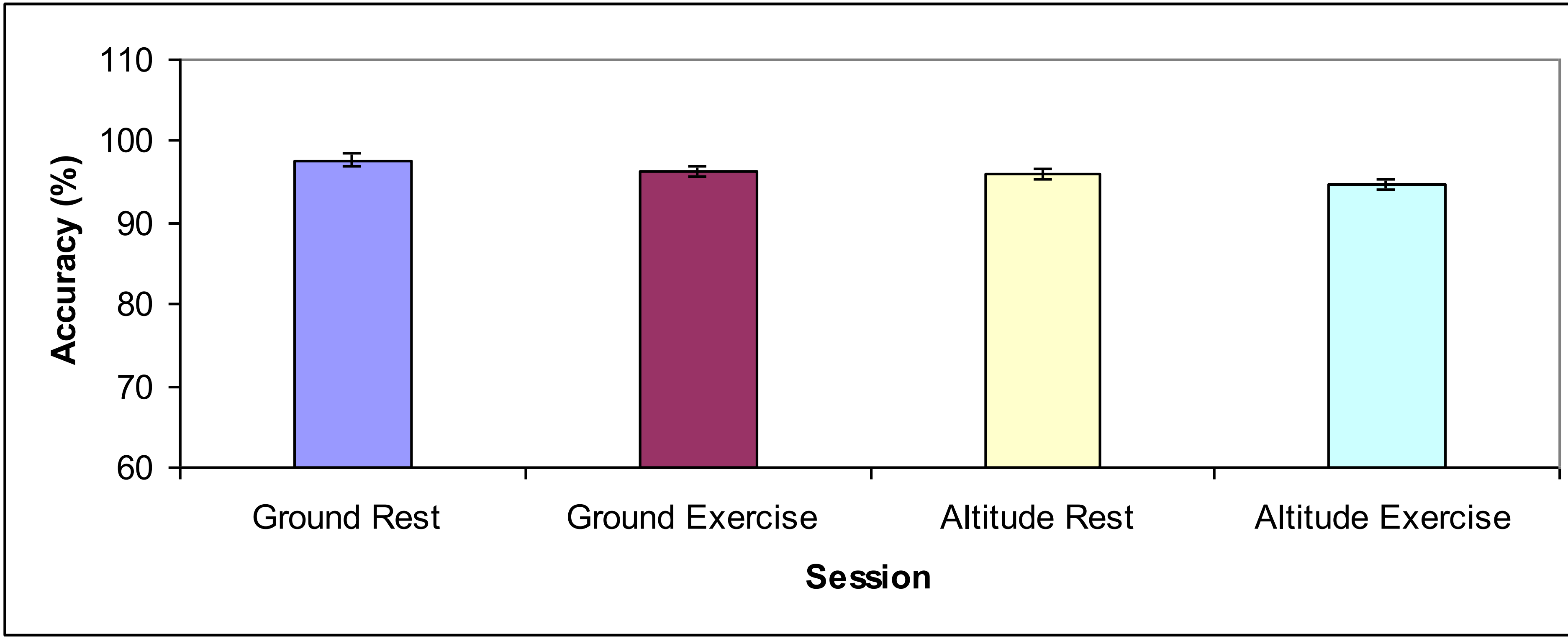
Altitude caused significant reduction in task speed (p=0.042)

Between ground rest and alt rest (1.7%)

Between ground exercise and alt exercise (7.8%)

Task speed not significantly affected by exercise at altitude (p=0.175)

Results

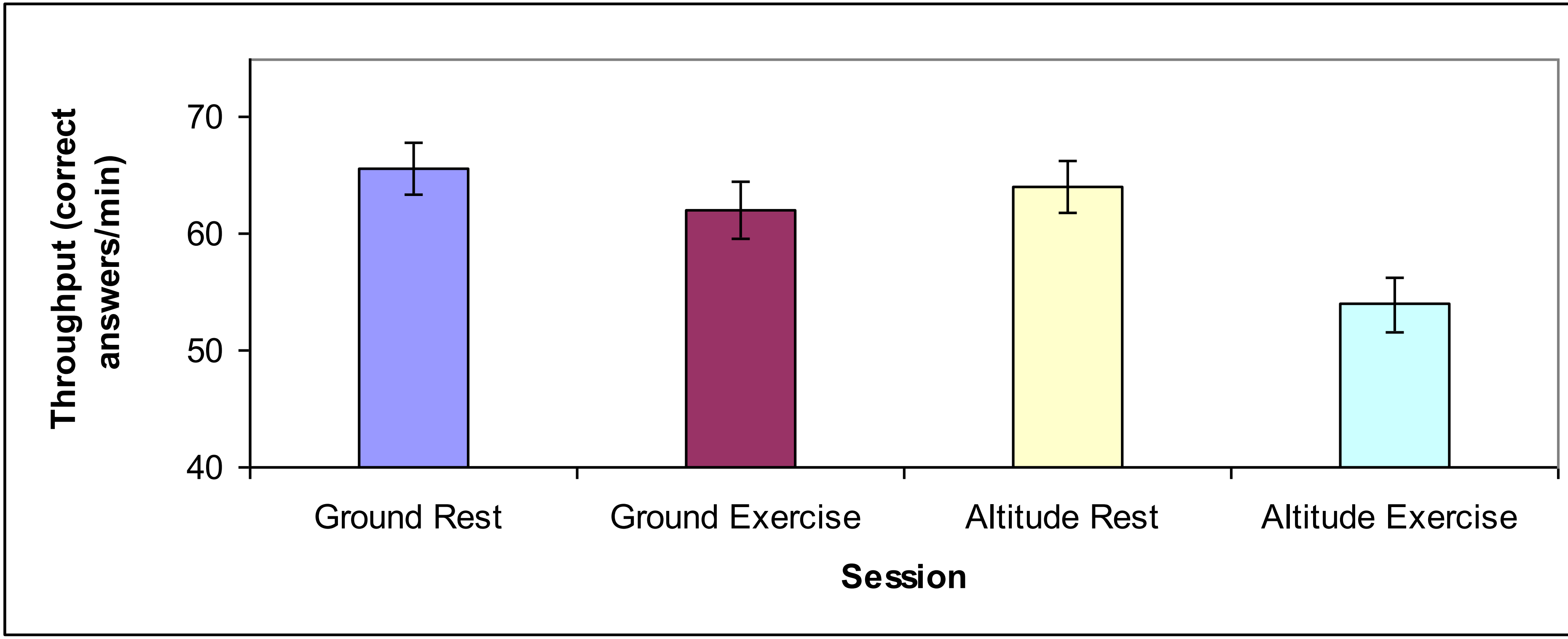


Altitude caused significant reduction in accuracy ($p=0.004$)

Accuracy not significantly affected by exercise at altitude ($p=0.931$)

Little variation between subjects: Mean accuracy never fell <94%

Results



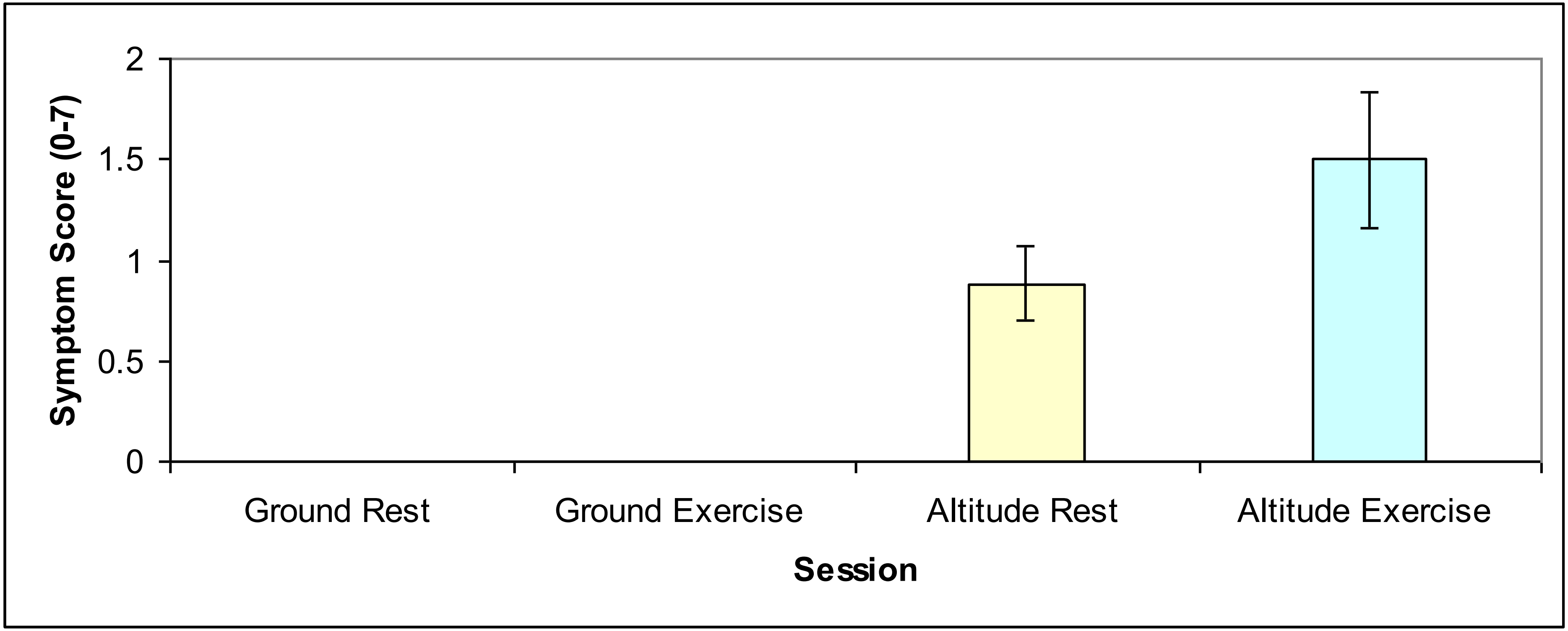
Altitude caused significant reduction in throughput ($p=0.001$)

Between ground rest and alt rest (6.8%)

Between ground exercise and alt exercise (12.95%)

Throughput not significantly affected by exercise at altitude ($p=0.252$)

Results

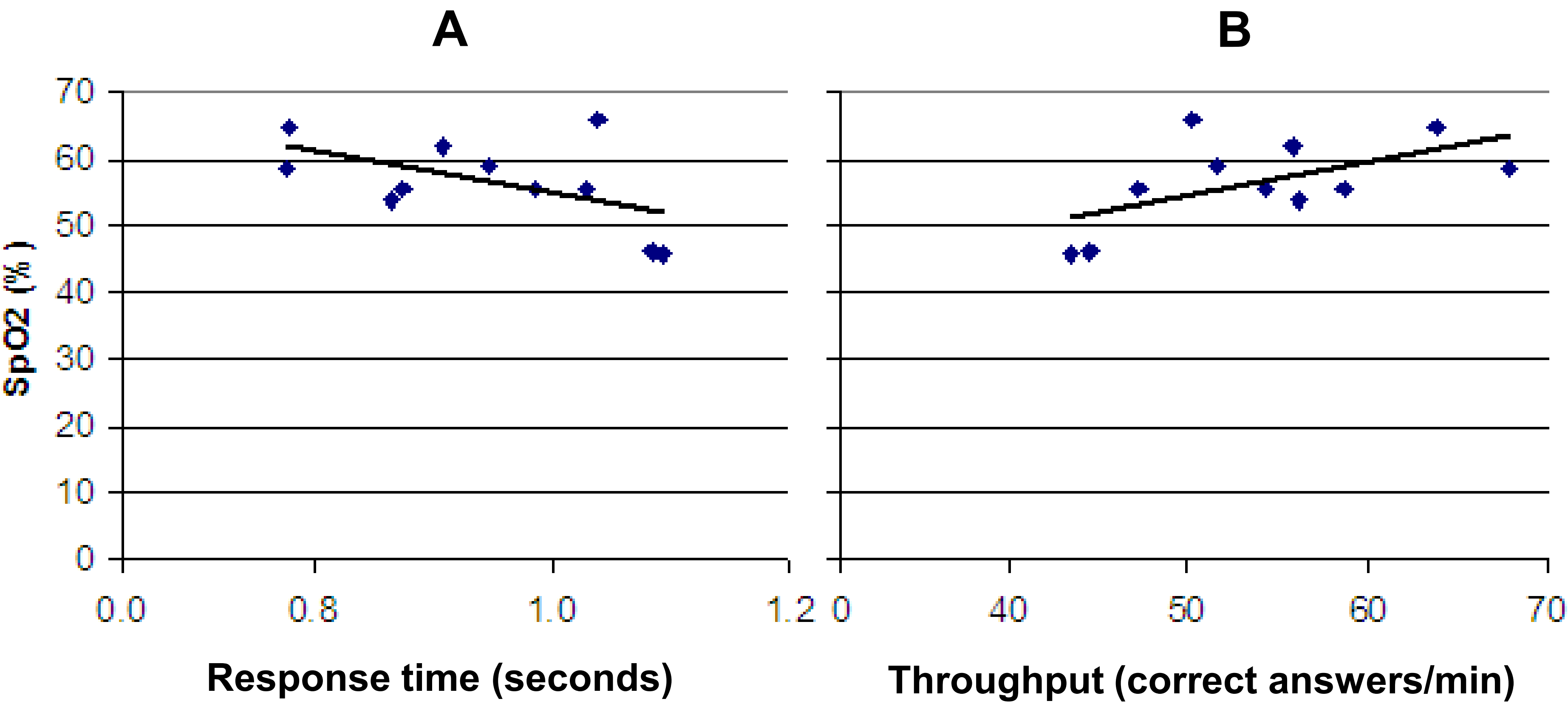


Much inter-individual variation of mean symptom scores

Altitude caused significant increase in mean symptom score (p=<0.001)

Symptom score not significantly affected by exercise at altitude (p=0.124)

Results



Graph A: mean SpO_2 (%) of each subject against mean Response time (seconds) at altitude exercise (r=-0.530)

Graph B: mean SpO_2 (%) of each subject against mean Throughput (correct answers/min) at altitude exercise (r=0.571)

Discussion

Major Findings:

- Breathing air at 17,500ft significantly ↓PP
- Moderate exercise (30W) at 17,500ft did not have any significant supplementary effect upon PP or symptom scores
- Strong correlations: SpO_2 α Response Time & Throughput

Discussion

- Accuracy & response time ↓ due to alt:
  - Perhaps subjects realized worse performance & slowed response time to compensate → judgment relatively well maintained?
- Weak correlations between symptom score & PP
  - Expected → subjective nature of symptom scoring
- Strong correlations:
  - As SpO_2↓, speed & throughput ↓
- No correlations showing ↓PP as $PETCO_2$↓
  - Hypoxia induced cerebral vasodilatation?
  - Sig ↑HR produced by altitude → ↑CO → ↑cerebral O_2 supply, compensating for ↓CBF

Improvements & Further Study

- Harder CogScreen test
  - Mean accuracy v.high > 94% → little disparity between subjects → unable to attain correlations
  - Throughput little more than another indicator of speed
- Use of experienced subjects to minimize anxiety
  - Reduced reflex CV responses
  - Anxiety shown to have a positive affect on psychomotor performance [2]
- Aircrew often perform higher workloads thus further studies, workloads > 30W at altitude required

Conclusion

- Psychomotor performance significantly declined upon exposure to 17,500ft
- However, moderate exercise at 17,500ft did not have any supplementary effect upon psychomotor performance
- Blood oxygen saturation → best recorded determinant of psychomotor performance
  - Use of pulse oximeters by pilots may be useful to monitor such performance
- Aircrew often perform higher workloads, and thus further studies utilising workloads in excess of 30W at altitude are required

References

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