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# Cognitive and Cerebral Oxygenation Responses to Graded Normobaric Hypoxia in Middle-Aged Adults: A Single-Blind Randomized Crossover Study

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## Résumé

### Background

Approximately 81.6 million individuals reside permanently at altitudes above 2,500 meters, with many more intermittently exposed to high-altitude environments through travel, work, or recreation. Hypoxia, a reduction in available oxygen, can adversely affect human physiology and cognitive performance. While younger adults often exhibit resilience to moderate hypoxia(1), the extent to which middle-aged adults experience cognitive changes remains less established. Age-related declines in neurovascular coupling and cerebral autoregulation may increase susceptibility to hypoxia-induced impairments, underscoring the importance of focused research in this demographic.

### Methods

Sixteen healthy participants (aged 45–65 years) were recruited to investigate the impact of acute normobaric hypoxia on cognitive performance and cerebral oxygenation. Each participant attended four separate sessions in a hypoxia chamber, simulating altitudes of 0 m (normoxia), 1,500 m (low altitude), 3,000 m (moderate altitude), and 4,500 m (high altitude). At each session, participants completed a cognitive test battery comprising the Stroop test, N-back task, Corsi block-tapping test, and a divided attention task. Cerebral oxygenation was assessed continuously using near-infrared spectroscopy (NIRS), measuring tissue saturation index (TSI), total hemoglobin (tHb), deoxyhemoglobin (HHb), and oxyhemoglobin (O2Hb). Changes in these parameters ( $\Delta$ TSI%,  $\Delta$ tHb,  $\Delta$ HHb, and  $\Delta$ O2Hb) were determined by subtracting normoxic resting values from those obtained during each hypoxia level. Perceived exertion was evaluated after each cognitive task using the DP15 rating scale.

### Results

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\*Intervenant

Exposure to graded hypoxia significantly impaired cognitive performance in middle-aged adults, particularly at moderate to high altitudes (3,000–4,500 m). Compared with normoxia, participants exhibited both slower reaction times and decreased accuracy on the Stroop test ( $p < 0.05$ ), reduced accuracy on the N-back task ( $p < 0.05$ ), as well as declines in reaction time and accuracy on the Corsi block-tapping ( $p < 0.05$ ). These deficits were more pronounced under high-altitude conditions (4,500 m). Correlation analyses indicated a strong positive relationship between reduced oxygen availability (SpO<sub>2</sub>) and heightened perceived exertion ( $p < 0.05$ ), suggesting that lower oxygen levels may directly contribute to cognitive performance decrements.

## **Conclusion**

Acute normobaric hypoxia at simulated moderate to high altitudes significantly affects cognitive function in middle-aged adults, underlining a potential vulnerability in this demographic. These findings emphasize the importance of monitoring and mitigating hypoxia-related risks for individuals exposed to lower oxygen environments, and warrant further research into interventions that could preserve cognitive performance at altitude.

## **References**

1. Ramírez-delaCruz M, Ortiz-Sánchez D, Bravo-Sánchez A, Portillo J, Esteban-García P, Abián-Vicén J. Effects of different exposures to normobaric hypoxia on cognitive performance in healthy young adults.: Normobaric hypoxia and cognitive performance. *Physiology & Behavior*. 2025;288:114747.