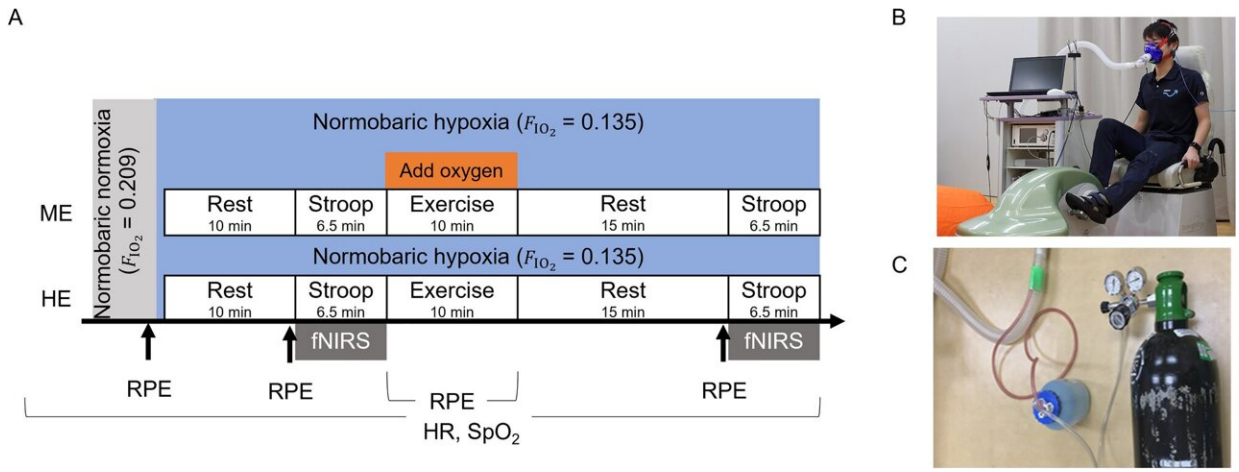
Investigating exercise-induced loss of executive function at high altitude

June 29 2022



(**A**) The two conditions, breathing a moderately hypoxic gas (hypoxic exercise [HE]) and breathing a milder hypoxic gas, during which oxygen was added to the moderately hypoxic gas to maintain the oxygen saturation (SpO_2) level during milder hypoxic exercise (ME). Cortical hemodynamic changes were monitored with functional near-infrared spectroscopy (fNIRS) while participants performed the Stroop task. HR, heart rate. (**B**) In both conditions, the exercise and color-word Stroop task (CWST) were performed on a recumbent cycle ergometer. Hypoxic gas (F_{IO2} = 0.135) stored in a Douglas bag was inhaled through a mask. (**C**) In the ME condition, SpO_2 was adjusted during exercise by adding oxygen gas with humidity to prevent the participant's throat from drying out to the hose connecting the Douglas bag to the mask. Credit: *Scientific Reports* (2022). DOI: 10.1038/s41598-022-14146-5

When physically demanding activities are performed at high altitude or in other low-oxygen environments, excellent coordination, judgment, and decision-making are important. In some cases, such as when mountaineering, these capabilities may be the difference between life and death.

What is executive function and why is it important? Executive functions control and coordinate other brain functions, like memory, emotions, and movement control, to enable more complex behaviors—for example, learning, planning, judgment, and decision-making.

In a study published this month in *Scientific Reports*, researchers at the University of Tsukuba showed that reductions in neural activity in brain regions responsible for executive control-related cognitive functions and cognitive performance during exercise in low-oxygen conditions could be prevented by maintaining oxygen saturation.

Demonstrating causality—that the decreases in neural activity and performance are caused by low oxygen availability to brain tissue—is not straightforward because of the complexity exhibited by the brain and all its functions. Yet the University of Tsukuba research team have done just that. "We compared the effects of hypoxic conditions in which blood oxygen levels is reduced with those in which blood oxygen levels remains stable during exercise," says senior author Professor Hideaki Soya. "By doing this, we isolated low oxygen saturation as a factor for decreased neural activity and decreased performance."

Neural activity in the prefrontal cortex was measured with functional near-infrared spectroscopy to show change in oxygenated hemoglobin (i.e., oxygen usage from regional blood supply). Cognitive performance was assessed using Stroop interference, which is the difference in completion time (or number of errors) between neutral and incongruent trials. In incongruent trials, the color of the text must be identified when,

for example, the word red is written in green. In neutral trials, only the color of a swatch must be identified.

"When blood oxygen levels remained stable during exercise, the Stroop effect was not as pronounced," says senior author Dr. Genta Ochi. "In the brain region of interest—the left dorsolateral prefrontal cortex—there was less of a decrease in activation from the neutral to the incongruent trial."

The study suggests that oxygen supply is important for maintaining cognitive function during exercise in low-oxygen environments. Furthermore, regions of the brain with newer (from an evolutionary point of view), less critical functions may be lower priority than those responsible for functions that keep us alive. Thus, the effects of cognitive fatigue must be taken into account when physical activities that require judgment and critical thinking are performed in low-oxygen environments.

More information: Genta Ochi et al, Cognitive fatigue due to exercise under normobaric hypoxia is related to hypoxemia during exercise, *Scientific Reports* (2022). DOI: 10.1038/s41598-022-14146-5

Provided by University of Tsukuba