

# **The combined effect of hypoxia and mental fatigue on physical and cognitive performance**

Kate O'Keeffe<sup>a</sup>, Giuseppe Racuglia<sup>a</sup>, Simon Hodder<sup>a</sup>, Alex Lloyd<sup>a</sup>

<sup>a</sup> Environmental Ergonomics Research Centre, Loughborough University, UK.

Humans are rarely exposed to a single environmental stressor. Working at altitude is characteristic of a combination of conditions including hypobaric hypoxia, cold, solar radiation and prolonged cognitive effort. This study aimed to explore the individual and combined effects of mental fatigue and hypoxia on physical and cognitive performance. Following ethical approval from Loughborough University, 15 healthy males (mean  $\pm$  SD;  $24.2 \pm 3.27$  years) completed one familiarisation session and six experimental trials, including: 1) normoxia (0.209 FiO<sub>2</sub>) and no mental fatigue; 2) normoxia (0.209 FiO<sub>2</sub>) with mental fatigue; 3) low normobaric hypoxia (0.13 FiO<sub>2</sub>) and no mental fatigue; 4) low normobaric hypoxia (0.13 FiO<sub>2</sub>) with mental fatigue; 5) high normobaric hypoxia (0.10 FiO<sub>2</sub>) and no mental fatigue; 6) high normobaric hypoxia (0.10 FiO<sub>2</sub>) with mental fatigue. All conditions were completed at 21°C with 50% relative humidity. Mental fatigue was induced using a 16-min individualised cognitive test. Each condition included a 15-min self-paced time trial on an arm bike, followed by a 60-s isometric maximal voluntary contraction of the biceps brachii (MVC). Supramaximal nerve stimulation was used to quantify central and peripheral fatigue. Stimulations were superimposed on each MVC every 10-s, with voluntary activation (VA%) calculated using the twitch interpolation method. Oxygen consumption and Near Infra-Red Spectroscopy (NIRS) quantifying muscle oxygenation were also measured. Following each time trial, participants performed the Tower of Hanoi (TOH) cognitive test. Subjective measures of mental fatigue included a visual analogue scale of fatigue (VASF) and the Brunel Mood Scale (BRUMS). Results indicated that mental fatigue was induced as evidenced by a decrease in cognitive test performance ( $-20.2 \pm 1.1\%$ ), increases in VASF scores ( $+ 67.59 \pm 2.44\%$ ,  $P \leq 0.001$ ) and confusion post-test ( $+ 68.44 \pm 8.37\%$ ,  $P \leq 0.031$ ). A main effect of hypoxia was observed on average power output, oxygen consumption and muscle oxygenation ( $P \leq 0.004$ ), with no effect of mental fatigue, ( $P \geq 0.599$ ). Voluntary activation of the biceps brachii was reduced in hypoxia, ( $68.42 \pm 5.64\%$ ,  $P = 0.039$ ). Time to completion in the TOH was significantly increased in all conditions ( $+ 14.74 \pm 6.99$ -s,  $P \leq 0.041$ ). No effect of mental fatigue or hypoxia was observed on cognitive performance ( $P \geq 0.138$ ). In conclusion, hypoxia impacted physical performance whilst mental fatigue had no effect on physical or cognitive performance.