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PHYSIOLOGICAL ADAPTATION DURING LONG-DURATION ANALOGUE HABITAT MISSIONS IN HIGH-ALTITUDE ENVIRONMENTS

Abstract

Future lunar and Martian expeditions will expose crews to prolonged isolation, operational stress, and extreme environments requiring sustained physiological resilience. This study investigates cardiovascular, cognitive, and sleep-related adaptations during long-duration missions conducted at the Astra-LM high-altitude Mars analog habitat in Ladakh, India. Participants perform mission-representative activities, including habitat confinement, simulated extravehicular operations, and resource management tasks. Physiological parameters such as heart rate variability, blood oxygen saturation, sleep quality, and cognitive performance are continuously monitored using wearable and digital assessment systems. Machine-learning techniques are applied to identify adaptation trends and early indicators of performance degradation. By combining high-altitude environmental stressors with operational analog conditions, Astra-LM provides a unique platform for evaluating human performance beyond low Earth orbit. The findings will support predictive health monitoring and operational countermeasures for future lunar and Martian exploration missions.