

## Fatigue in U.S. Astronauts Onboard the International Space Station: Environmental Factors, Operational Impacts, and Implementation of Countermeasures

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Introduction: Since 2000, US astronauts have been supporting missions up to a six month duration on the International Space Station (ISS). Crewmembers have experienced fatigue for reasons similar to military deployments. Astronauts experience psychological stressors such as heavy workloads, extended duty periods, circadian misalignment, inadequate/ineffective sleep, and loss of the environmental cues of a gravity environment. Complicating the psychological stressors are environmental factors; distracting background noise, unexpected and variable mission schedules, unfavorable thermal control, elevated CO<sub>2</sub> levels, and an unusual sleep environment with schedules that impinge on pre-sleep periods. Physiological contributors to poor sleep and fatigue include a cephalad fluid shift and back pain. Restful sleep is further challenged due to a lack of gravity-related proprioceptive cues and need for restraints. The term “space fog” has been used by astronauts to describe a phenomenon of forgetfulness, slowed reaction time and transient confusion while trying to complete tasks. There is a distinct temporal correlation with arrival on the Space Station and the onset of slowed cognitive skills and a spontaneous resolution that may take up to 6 weeks. The Genesis of this phenomenon may be chronic fatigue secondary to transitioning from a planar environment to a 360° microgravity perspective. Recently, countermeasures to improve sleep duration and quality in astronauts on the ISS have been instituted with moderate degrees of success as measured by self-reaction time (psychomotor vigilance task testing), actigraphy, and subjective reports. Judicious use of stimulants and hypnotics, light therapy, controlled sleep periods and sleep shifting and reducing ambient CO<sub>2</sub> levels are a few of the most promising countermeasures being used in space to improve sleep and reduce fatigue.