

Ionizing radiation, Parkinson's disease and space: perspectives and recommendations

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Parkinson's disease (PD) is a progressive, neurodegenerative disease that primarily affects movement, balance and behavior. Evidence from epidemiological studies of terrestrial cohorts exposed to ionizing radiation (IR), such as nuclear workers, suggests a significant risk for IR-induced PD. Planned long-duration missions to the Moon and Mars will increase chronic, low-dose exposures to ionizing space radiation. Therefore, understanding the biological mechanisms by which IR may induce PD is vital for creating accurate, personalized risk models and developing effective countermeasures to protect astronaut health. The purpose of this perspective is to describe potential drivers of IR-induced PD and discuss recommendations for future research. Shared pathophysiology between IR and PD includes mitochondrial dysfunction, iron-mediated oxidative stress, disrupted dopaminergic signaling, impaired protein clearance, neuroinflammation, and α -synuclein aggregation. Furthermore, complex gene-environment interactions involving susceptibility genes such as LRRK2 and GBA may modulate the interaction between IR and PD risk. Future experiments will require a multi-pronged research approach, leveraging chronic, low-dose radiation exposures, advanced animal and organ-on-chip models, omics technologies, and analysis of archived tissues. Additional research is needed to address critical knowledge gaps in IR-induced PD and is essential to understand PD risk for crewmembers on future missions to the moon, mars, and beyond.

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