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Immunological Changes During Space Travel: A Ground-Based Evaluation of the Impact of Neutron Dose Rate on Plasma Cytokine Levels in Human Whole Blood Cultures

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Considering the upcoming long-duration spaceflight missions, a better understanding of the impact of spaceflight exposome on human health is urgently warranted. Consequently, particle accelerator facilities implement ground-based, Radiobiology experiments investigating the health effects of simulated-space environments with simulated-psychological or physical stressors. iThemba LABS is such a facility, with a proton vault enabling Spaceflight Radiobiology. Historically, the immune system is notably highly sensitive to spaceflight stressors although, there's limited information on the impact of the complex space radiation environment on the astronauts' immune functioning. This pilot study presents a first step in implementation of ground-based setups with neutron irradiation, which is an important intra-spacecraft radiation component.

Whole-blood samples (n=8) were exposed to 0.125 or 1Gy of neutron irradiation (fluence-weighted average energy 29.8MeV) at a lower 0.015Gy/min (LDR) or higher 0.400Gy/min dose rate (HDR). Post-irradiation, blood samples were stimulated with lipopolysaccharide (LPS), heat-killed Listeria monocytogenes (HKLM) or pokeweed mitogen (PWM), before 24hrs incubation. Cell-mediated immunity was examined using the Cytokine Release Assay to analyse interleukin-2 (IL-2), interferon-gamma (IFN-γ), tumour necrosis factor-alpha (TNF-α) and interleukin-10 (IL-10) plasma levels.

Stimulants significantly increased all cytokine levels except IL-2, where only PWM induced significant increases. Generally, no statistically-significant changes were observed in IL-2, IFN γ, and TNF α concentrations, irrespective of dose or dose rate, when compared to stimulated, sham-irradiated controls. After PWM-stimulation, IL-10 levels were significantly increased at 0.125Gy HDR and 1Gy LDR. Pooled analysis showed that HDR significantly increased IL-2 titres (under PWM-stimulation) and IFN-γ titres (with all stimulants), but significantly decreased TNF-α secretion, without stimulation.

Limited sample numbers restricted strong conclusions in this pilot study investigating the effect of neutron radiation as a single-stressor on cytokine secretion, induced by various stimulants. An interesting dose rate effects was observed, which encourages future investigations into the synergistic effects of multiple spaceflight stressors on immune functioning.

Attendance Type

Remote

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