Validation of Multisystem Countermeasures Protocol for Spaceflight during Antarctica Winter-over at Palmer Station (Palmer Countermeasures)

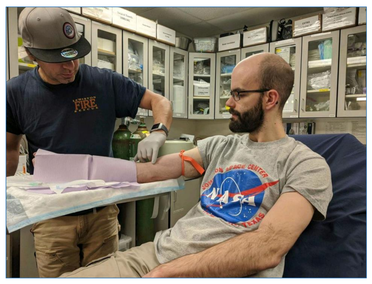
Cody L. Gutierrez[1], Mayra Nelman-Gonzalez[2], Satish Mehta[1], Douglass M. Diak[3], Audrie Colorado[2], Sara Bustos-Lopez[1], Scott Smith[4], Sara Zwart[5], Alexander Chouker[6], Sergey Ponomarev[7], Rickie Simpson[8], Raymond Stowe[9], Sara L. Castro-Wallace[4], Melissa VanderKaay Tomasulo[10], Dagan Loisel[10], and Brian Crucian[4]

JES Tech[1], KBR[2], Aegis[3], NASA[4], University of Texas Medical Branch[5], European Space Agency[6], Institute for Biomedical Problems of the Russian Academy of Sciences[7], University of Arizona[8], Microgen Laboratories[9], St. Michaels College[10]

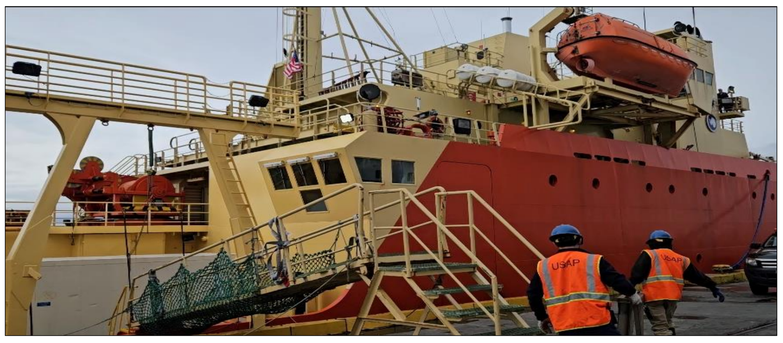
Introduction

Earth orbital spaceflight results in the persistent disruption of the human immune system, characterized by reductions in T and NK cell function, altered cytokine profiles, and the reactivation of latent herpesviruses. With future deep-space exploration missions being of unprecedented duration, it is reasonable to hypothesize that the immune perturbations observed aboard the International Space Station (ISS) will intensify during longer missions in deep space, thereby placing crewmembers at elevated clinical risk.

Therefore, Antarctica winter-over (AWO) at Palmer Station was chosen as the platform for testing and validating the effectiveness of a NASA multi-system countermeasures (CM) protocol designed for deep space missions to reduce immune dysregulation in crew members. Of all the Earth analogs studied to date, an AWO mission most closely reproduces the spaceflight experience: prolonged deployment, extreme environment, circadian misalignment, isolation, station lifestyle, and personal risk.







Images: Biocollection occurring at Palmer Station, Antarctica for an in-mission timepoint.

Objectives

To determine if the complete immune CM protocol developed for spaceflight ameliorates the detrimental effect of coastal Antarctica winter-over on a variety of physiological biomarkers.

Hypothesis

1. Winter-over at coastal Palmer Station will induce many of the immunologic and virologic consequences of missions aboard ISS
2. Implementation of a complete biomedical countermeasure protocol will ameliorate known negative effects of stress and environmental factors on effector lymphocyte distribution, proliferative capacity, and cytotoxic function.

Methodology

Blood, saliva, hair and health/data logs will be collected from a max of 20 volunteers, once pre-, and 4 times during each AWO (2 years total). CMs aimed at reducing immune-related dysregulation will be deployed either daily or centered around the biocollection, dependent on protocol and feasibility, throughout the mission. Biomarkers will be analyzed for CM effectiveness upon sample return to NASA Johnson Space Center. Data collected will be compared to an initial control year where no CMs were deployed.





Images: Biocollection occurring at Punta Arenas, Chile for 2025 baseline data collections.

Sample Collections

COUNTERMEASURE	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Detail:
Probiotic and Vit D Supplement				XXXXX	XXXXXXXXXX		XXXXXXXXXX		XXXXX		Daily throughout winterover
Log Diet			7d	7d	7d		7d		7d		7d continuous logging centered on blood day
Perform Exercise				XXXXX	XXXXXXXXXX		XXXXXXXXXX		XXXXX		daily throughout winterover except Sunday
Log Exercise				7d	7d		7d		7d		7d continuous logging centered on blood day
Perform VR Guided Meditation				XXXXX	XXXXXXXXXX		XXXXXXXXXX		XXXXX		4d per week, 20 min per session (at descretion of subject)
Log VR Meditation				7d(4d)	7d(4d)		7d(4d)		7d(4d)		log for 7d during each blood week (perform VR 4d/wk)
Wear Garmin Watch (2wk cap.)			2d	3d	3d		3d		3d		3d (2d pre-deploy week) continuous wear centered on blood day
Wear Oura Ring (6 wk Cap.)			7d	7d	7d		7d		7d		7d continuous wear centered on blood day
Virus Detection MinION				X	X		X		X		
Virus Detection ISOTHERMAL PCR				X	X		X		X		
BIOSAMPLING											
Saliva (1x/day; 4 days)			XXXX	XXXX	XXXX		XXXX		XXXX		DAYS VARY IN VOLUME/PROCESSING - SEE SALIVA COLLECTION DETAILS in GUIDE
Blood/Plasma			X	X	X		X		X		
Fingerstick Analysis			X	X	X		X		X		
Hair Sample			X	X	X		X		X		
Health Survey			X	X	X		X		X		
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	
	Deployment				Overwinter Isolation Period						
					Winterover Deployment						

Assays Performed Post-Mission

NASA Immunology/Virology Lab:
- Leukocyte and lymphocyte distribution
- Mitogen stimulated/Plasma cytokine profiles
- Saliva latent herpesvirus DNA

Russia Institute of Biomedical Problems:
- Proteomics

University of Arizona:
- NK cell function
- Virus specific T cell distribution
- Gamma delta T cell function

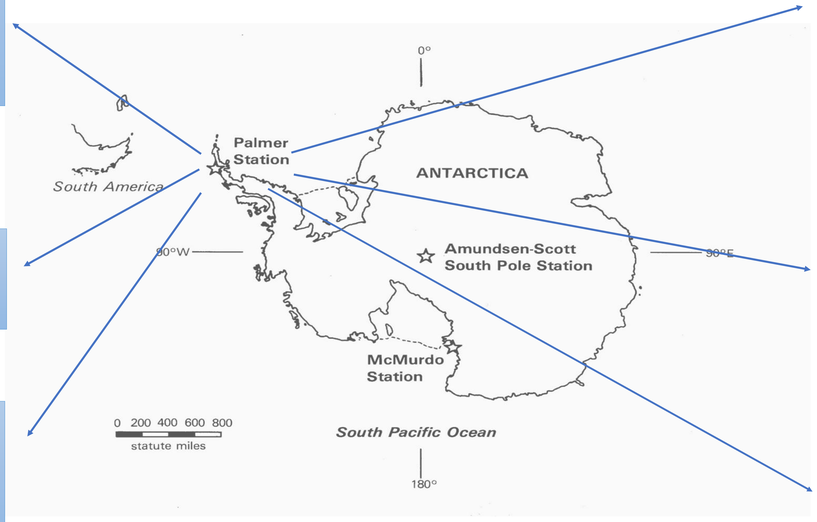


Image from: Multimedia Gallery - Map showing site of U.S. research stations on Antarctica | NSF - National Science Foundation (Multimedia Gallery | NSF - National Science Foundation)

NASA Nutritional Biochemistry Lab:
- Vitamin Status
- Serum Fatty Acid Profiles
- Plasma flavonoids
- Mineral Status
- General chemistry
- Inflammatory markers

NASA Microbiology/Microgen Lab:
- Latent herpesvirus DNA

University of Munich:
- Neuroendocrine stress hormones
- Transcriptomic
- Torque-teno virus quantification
- Functional responses to allergens

Current Study Status

AWO Year	AWO Sampling Session	Number of Subjects	Data Status
2022	Control Year	13	Currently being collected and compiled
2023	Countermeasure Year	16	Samples are being processed further by Co-I
2024	Countermeasure Year	13	Currently being distributed to Co-I for further processing