

## **NASA 14 Day Undersea Missions: A Short-Duration Spaceflight Analog for Immune System Dysregulation**

B. E. Crucian,<sup>1</sup> R. P. Stowe<sup>2</sup>, S. K. Mehta<sup>3</sup>, H. Quiariarte<sup>4</sup>, D. L. Pierson<sup>5</sup> and C. F. Sams<sup>5</sup>

<sup>1</sup>Wyle, Houston, Texas, <sup>2</sup>Microgen Laboratories, Houston, Texas, and <sup>3</sup>EASI, Houston, Texas, <sup>4</sup>JES Tech, Houston, Texas, and <sup>5</sup>NASA-Johnson Space Center, Houston, Texas

### **BACKGROUND**

Spaceflight-associated immune dysregulation (SAID) occurs during spaceflight and may represent specific clinical risks for exploration-class missions. An appropriate ground analog for spaceflight-associated immune dysregulation would offer a platform for ground-evaluation of various potential countermeasures. This study evaluated the NASA Undersea Mission Operations ('NEEMO'), consisting of 14 day undersea deployment at the 'Aquarius' station, as an analog for SAID. Sixteen 'Aquanauts' from missions NEEMO-12, 13 and 14 participated in the study.

### **RESULTS**

Mid-mission alterations leukocyte distribution occurred, including granulocytosis and elevations in central-memory CD8+ T-cells. General T cell function was reduced during NEEMO missions in roughly 50% of subjects. Secreted cytokines profiles were evaluated following whole blood stimulation with CD3/CD28 (T cells) or LPS (monocytes). T cell production of IFN $\gamma$ , IL-5, IL-10, IL-2, TNF $\alpha$  and IL-6 were all reduced before and during the mission. Conversely, monocyte production of TNF $\alpha$ , IL-10, IL-6, IL-1b and IL-8 were elevated during mission, moreso at the MD-14 timepoint. Antibodies to Epstein-Barr virus (EBV) viral capsid antigen and early antigen were increased in approximately 40% of the subjects. Changes in EBV tetramer-positive CD8+ T-cells exhibited a variable pattern. Antibodies against Cytomegalovirus (CMV) were marginally increased during the mission. Herpesvirus reactivation was determined by PCR. EBV viral load was generally elevated at L-6. Higher levels of salivary EBV were found during the NEEMO mission than before and after as well as than the healthy controls. No VZV or CMV was found in any pre, during and after NEEMO mission or control samples. Plasma cortisol was elevated at L-6.

### **CONCLUSION**

Unfortunately, L-6 may be too near to mission start to be an appropriate baseline measurement. The general immune changes in leukocyte distribution, T cell function, cytokine production, virus specific immunity and viral reactivation are similar to those observed during or following spaceflight. The NEEMO platform may thus have utility for short-duration, ground-based spaceflight-immune research, such as investigations of mechanism or countermeasures validation.