Paper ID: 87604
oral
student

IAF/IAA SPACE LIFE SCIENCES SYMPOSIUM (A1)
Human Physiology in Space (2)

Author: Ms. Mimi Lan
Dartmouth College, United States

Dr. Jay Buckey
Dartmouth Medical School , United States

LOWER BODY NEGATIVE PRESSURE MAY NOT BE A SUITABLE COUNTERMEASURE FOR SANS

Abstract

Spaceflight associated neuro-ocular syndrome (SANS) is a collection of ophthalmic symptoms observed in many astronauts after long duration spaceflight. Mader et al. first reported the symptoms in 2011, which included optic disk edema, globe flattening, choroidal folds, and hyperopic shifts. The etiology is unknown but a common theory posits that a cephalad fluid shift produces chronically elevated intracranial pressure at the posterior of the eye leading to globe flattening and optic disc edema. Because of this theory, lower body negative pressure (LBNP) is considered a promising countermeasure to reverse the fluid shift and mitigate SANS.

To investigate fluid redistributions in microgravity and simulate LBNP, our group built a craniovascular numerical model, called the Numerical Model for Spaceflight (NuMoS). NuMoS includes extravascular compressive forces from tissue weight that affect vessel transmural pressure throughout the body. In the model, these pressures are proportional to the thickness of body tissue above the vessel. Gravity, lower body chamber pressure, and body position can be adjusted in the model to investigate changes to fluid distribution. The model parameters used to define hemodynamics of the eye and head space are based on published literature values.

Simulations with the model suggest LBNP could be detrimental and exacerbate SANS symptoms in some situations. Because the intracranial space has greater compliance than the intraocular space, LBNP reduced IOP more than it reduced ICP. The net effect was a translaminar pressure gradient that would aggravate globe flattening. Experimental results from head-down tilt experiments support the model findings. Marshall-Goebel et al. measured IOP and non-invasive ICP measurements simultaneously in 16 subjects during 12-degree head-down tilt, with and without 20mmHg of LBNP. IOP was reduced while ICP was unchanged, which would lead to a translaminar pressure gradient that favors further eye flattening. This result may be caused by underestimations of ICP by the non-invasive transcranial doppler method used. Studies directly measuring the ICP, however, using an Ommaya reservoir have also suggested that LBNP may have limited efficacy in reducing ICP in 0G. Head-down tilt and LBNP studies on subjects with Ommaya reservoirs show intracranial compliance depends on the ICP level. Higher ICP demonstrated lower compliance and greater LBNP efficacy (Petersen et al. 2019) while lower ICP levels showed limited pressure reductions when LBNP was applied. Parabolic flight studies show that ICP is not pathologically elevated in weightlessness, so in space LBNP may have limited ability to reduce ICP, while still reducing IOP.