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Humans have been travelling in space for more than 40 years without clear evidence of visual impairment in astronauts. However very recently, it has been identified that some astronauts on the International Space Station (ISS) seem to be at risk for visual changes that may be due to elevated pressure inside the head (intracranial pressure (ICP)). It is well known that there is a relative shift in fluid towards the head in humans during space flight (microgravity) and therefore these changes may increase intracranial pressure to a greater degree than previously appreciated. Intracranial pressure may also be exacerbated or transiently elevated by small increases in the partial pressure of carbon dioxide in the International Space Station atmosphere and during strength training exercise that is employed to try and maintain astronaut's muscle mass. Therefore, the primary aim of this project will be to provide novel data about the impact of microgravity induced central fluid shifts on directly measured intracranial pressure, and the associated inflow and outflow of blood to the brain, accompanied by simultaneous assessment of structural changes in the eye. Furthermore, we will examine the above factors during small changes in atmospheric carbon dioxide and during strength training exercise in simulated microgravity. This information is entirely unknown and absolutely essential to establishing the pathophysiology of the recently identified visual impairments in some long duration astronauts, so as to develop appropriate countermeasures.

Rationale for HRP Directed Research:

The project has implications for public health by providing a better understanding of the regulation of intracranial pressure in normal healthy individuals and thus will offer an improved knowledge base to provide effective treatments for a wide range of intracranial disorders. We have clarified the key component of the physiology of the intracranial space in microgravity, which will go a long way to eliminating the Vision Impairment and Intracranial Pressure (VIIP) syndrome. We have developed a collaboration with Under Armour, Inc., to develop a wearable garment to deliver lower body negative pressure (LBNP) and reduce ICP not only in space, but also on Earth. For example, a major Earth-based benefit to society will be the application of LBNP in a clinical environment. Alongside pharmacological interventions, placing patients with intracranial hypertension in the semi-recumbent position is standard practice to lower ICP. This slight hydrostatic gradient reduces ICP, whilst maintaining arterial blood pressure and thus cerebral perfusion pressure. LBNP may provide a more controlled and robust intervention within a hospital and field-based environment. Indeed, pathological pressure waves are often observed during sleep when patients are in the supine position. Nocturnal LBNP may provide a novel method to lower ICP and improve intracranial stability during this critical period. Given our robust observation that simply placing the head on a pillow lowers ICP, the combination of low level LBNP and head elevation may prove optimal. If a practical and comfortable device is developed, LBNP could also be used to reduce the incidence of chronic headache in patients with pseudotumor cerebri (raised ICP), as well as patients with traumatic brain injury.

Task Description:

Research Impact/Earth Benefits:

The project has implications for public health by providing a better understanding of the regulation of intracranial pressure in normal healthy individuals and thus will offer an improved knowledge base to provide effective treatments for a wide range of intracranial disorders. We have clarified the key component of the physiology of the intracranial space in microgravity, which will go a long way to eliminating the Vision Impairment and Intracranial Pressure (VIIP) syndrome. We have developed a collaboration with Under Armour, Inc., to develop a wearable garment to deliver lower body negative pressure (LBNP) and reduce ICP not only in space, but also on Earth. For example, a major Earth-based benefit to society will be the application of LBNP in a clinical environment. Alongside pharmacological interventions, placing patients with intracranial hypertension in the semi-recumbent position is standard practice to lower ICP. This slight hydrostatic gradient reduces ICP, whilst maintaining arterial blood pressure and thus cerebral perfusion pressure. LBNP may provide a more controlled and robust intervention within a hospital and field-based environment. Indeed, pathological pressure waves are often observed during sleep when patients are in the supine position. Nocturnal LBNP may provide a novel method to lower ICP and improve intracranial stability during this critical period. Given our robust observation that simply placing the head on a pillow lowers ICP, the combination of low level LBNP and head elevation may prove optimal. If a practical and comfortable device is developed, LBNP could also be used to reduce the incidence of chronic headache in patients with pseudotumor cerebri (raised ICP), as well as patients with traumatic brain injury.

Task Progress:

Overall Task Progress: All objectives were met and all aims were accomplished for this study. This past year was notable for our second parabolic flight campaign during which we were able to recruit 3 women to create our final cohort of 8 subjects (5 men, 3 women).

Bibliography Type:

Description: (Last Updated: 02/28/2018)

Articles in Peer-reviewed Journals


Awards

Levine BD. (Benjamin D. Levine) "Fellow, American Heart Association, February 2015." Feb-2015

Awards

Levine BD. "NASA, Most Compelling Results from the 2013 International Space Station, May 2014." May-2014

Significant Media Coverage


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