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Human Physiology in Space (2)

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IMPACT OF LONG DURATION SPACEFLIGHT ON THE BRAIN OF 15 COSMONAUTS, INVESTIGATED WITH ADVANCED MRI METHODS.

Abstract

Long-duration spaceflight causes alterations in different physiological mechanisms, though brain structural changes after spaceflight remain to be further characterized. In this talk, we will present the results

of multimodal MRI techniques to investigate alterations in the brain. We prospectively acquired high angular resolution state-of-the-art diffusion MRI data of thirteen cosmonauts before (preflight) and after spaceflight (postflight), as well as seven months after return (follow-up) in nine cosmonauts. In each voxel of the brain, we estimated values for the fractions ("densities") and the total amount ("mass") of gray matter (GM), white matter (WM), and cerebrospinal fluid (CSF). Additionally, we investigated volume changes across time at the voxel-level. CSF density and mass was decreased in the upper part of the brain, mainly in voxels located near the longitudinal fissure and the (para)central sulci. The GM density, but not the mass, was increased in these areas. The lower part of the cerebrum shows increased CSF density and mass near inferior frontal, temporal, insular and inferior occipital regions, as well as at the ventricular borders. The GM density decreased in some of these areas, though the GM mass again remained unchanged. Furthermore, GM mass increased in the basal ganglia, and WM mass increased in the cerebellum, while CSF did not change in these areas. At long-term follow- up, most spaceflight-induced changes seem to reverse, with the exception of the ventricular borders and several local clusters at the lower part of the brain. The tissue mass increases in basal ganglia and cerebellum appeared to be rather persistent. Our results indicate the occurrence of two distinct mechanisms of microgravity. On one hand, CSF density and mass changes are best explained by fluid shift effects. This in turn could lead to the observed GM density changes as morphological alterations. On the other hand, tissue mass increases in basal ganglia and cerebellum point toward neuroplasticity as neural adaptation processes of the brain's motor areas in microgravity. Such structural alterations in response to spaceflight have not been identified previously. Next, the structural changes as observed with voxel and surface based morphometry as well as resting state analysis will be covered during the talk. This will give a broad overview of the impact of spaceflight on the brain as currently assessed with MRI methods.