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Human Physiology in Space (2)

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IMPACT OF LONG DURATION SPACE FLIGHT ON THE BRAIN STRUCTURE OF SPACE CREW MEASURED WITH VOXEL AND SURFACE BASED MORPHOMETRIC METHODS USING MRI


### Abstract

The impact of long-duration spaceflight on the human brain is only recently being studied. We performed automated, observer-independent analyses of the brain of space crew using magnetic resonance imaging (MRI). We prospectively acquired T1 weighted scans of 11 cosmonauts before and shortly after 6 months long-duration spaceflight. Seven cosmonauts received an additional follow-up scan approximately 7 months after return from the ISS. We performed whole-brain volumetric analyses of gray matter (GM), white matter (WM) and cerebrospinal fluid (CSF) tissue compartments through a voxel-based approach. Furthermore, surface-based analyses were performed to obtain measures for cortical thickness, sulcal depth, fractal dimension (complexity) and gyrification (curvature). Statistical analyses included a whole-brain uncorrected threshold of $p<0.001$ and FDR-corrected $p<0.05$ using threshold-free cluster enhancement and non-parametric permutation testing (5000 permutations). Result: Shortly after spaceflight, the dorsal side (top) of the brain showed decreased CSF volume, increased cortical thickness and decreased sulcal depth, the latter particularly on the right side. The ventral side of the brain (base) showed increased CSF volume, decreased GM volume, decreased cortical thickness and both increased and decreased sulcal depth. Seven months after return from the ISS, GM volume, cortical thickness and sulcal depth (partially) normalised, while the CSF in the whole subdural space, between the brain and the skull was enlarged. The temporal poles showed increased sulcal depth, fractal dimension and gyrification compared to postflight and inferior frontal and occipital areas showed increased gyrification. Discussion: Our findings can be explained by both a redistribution of bodily fluids within the skull, as well as by changes in mechanical pressure causing subtle deformations of brain morphology. The observed changes are seen in regions which might be most susceptible to cortical deformations and water accumulation or drainage, such as the temporal poles, orbitofrontal gyri, insula and dorsal fronto-parietal areas. Between the postflight and follow-up scans, normalisation processes seem to be ongoing, again inducing morphological changes and fluid redistribution. However, 7 months after return to Earth, normalisation does not seem completed and also shows some asymmetry. Overall, our results reveal for the first time changes in different brain tissue volume compartments and morphological characteristics shortly after spaceflight as well as at long-term follow-up. The course of normalisation and the relation of our findings to other clinical parameters require further investigation.