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SPACEFLIGHT-ASSOCIATED CHANGES IN THE PERIVASCULAR SPACES OF ASTRONAUTS AND COSMONAUTS

Abstract

Very recently, it was observed that long duration spaceflight is associated with an upward shift of the brain towards the cranium, redistribution of CSF with narrowing of the subarachnoid space at the vertex, crowding of brain tissue along the superior sagittal sinus, and enlargement of the cerebral ventricles. Continued enlargement of the ventricles has been documented after spaceflight even up to one year after return to Earth in both NASA astronauts and Russian cosmonauts. The current study focuses on perivascular spaces (PVS), a brain-wide network of perivascular channels along which a large proportion of CSF (or CSF-like fluid) circulate through the brain parenchyma, which have not yet been evaluated after spaceflight. Hereto, a comparative, joint quantitative analysis of alterations in cerebral CSF spaces across astronauts and cosmonauts, using the same analysis pipeline thereby eliminating investigators bias, has been performed for the first time in space research history. We performed a joint analysis of MRI brain scans in 23 NASA astronauts, 13 Roscosmos cosmonauts, and 4 ESA astronauts before and after long-duration spaceflight (mean: 179.0 48.3 days) on the ISS. An additional follow-up scan was performed in 4 ESA astronauts and 10 cosmonauts 7 months after return to Earth. Brain MRI data from 13 age- and education-matched male volunteers acquired with a time interval similar to the preflight-postflight and preflight-follow-up (n=8) intervals and from 7 NASA astronauts acquired before and after missions of short duration in the Space Shuttle Program were used as controls. The NASA ISS group (n = 23, M = 25.27%, SD = 17.24) had a significantly greater percent change in PVS than the Roscosmos group (n = 13, M = 12.44%, SD = 6.27, p = .03), the NASA Shuttle group (n = 7, M = 1.31%, SD = 4.57, p ¡ .001), and the control group (n = 13, M = 5.27%, SD = 9.12, p ¡ .001). We hypothesize this difference may be related to on-board differences in countermeasure or exercise usage between the American and Russian programs. Additionally, PVS differences between the Russian and American crewmembers could point towards a physiological mechanism underlying spaceflight associated neuro-ocular syndrome (SANS), a condition associated with visual acuity changes and ophthalmological exam findings which is considered a serious medical risk for long-duration spaceflight. Our study is the first ever reporting on combined results of brain data from 3 different space agencies.