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Human Physiology in Space (2)

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SPACEFLIGHT-INDUCED NEUROPLASTICITY: FIRST INSIGHTS FROM PARABOLIC FLIGHTS AND LONG-DURATION SPACEFLIGHT

Abstract

Space travel poses an enormous challenge on the human body; microgravity, ionizing radiation, absence of circadian rhythm, confinement and isolation are just some of the features associated with it. Obviously, all of the latter can have an impact on human physiology and even induce detrimental changes. Some organ systems have been studied thoroughly under space conditions, however, not much is known on the functional and morphological effects of spaceflight on the human central nervous system (CNS). Previous studies have already shown that CNS changes occur during and after spaceflight in the form of neurovestibular problems, alterations in cognitive function and sensory perception, cephalic fluid shifts and psychological disturbances. However, little is known about the underlying neural substrates. In a first attempt to elucidate spaceflight-induced neuroplasticity, we examined functional brain connectivity before and after a parabolic flight in 28 participants. Interestingly, we found a decrease of intrinsic connectivity contrast strength in rest in the right temporo-parietal junction, a key region for the perception of upright and for the integration of multimodal input signals. Furthermore, this region is part of the cortical vestibular network, and is also important for bodily self-consciousness. These results suggest that even a short-term exposure to microgravity and alternating gravitational levels can induce alternations in the human brain. Secondly, we are currently investigating structural and functional brain alterations induced by long-duration spaceflights. Our pilot data show a decreased functional connectivity in the insular region, a crucial region for vestibular function. This suggests that the otolith deconditioning during spaceflight not only occurs at the level of the peripheral neurosensory end organ, but also at the cortical and infratentorial level. In addition, decreased connectivity strength between sensorimotor and cerebellar regions was found, suggesting a neural correlate of the problems often seen after long-duration spaceflight: problems of speed and accuracy of aimed movements, somatosensory problems and movement-timing problems. Elaborating on the understanding of how the brain reacts to and behaves during and after spaceflight is a crucial step in the development of more adequate countermeasures (e.g. mental imagery) against the detrimental changes often seen in space travellers. Furthermore, extending this knowledge is pivotal to guarantee the safety and efficiency of future space missions, such as interplanetary missions to Mars and the development of permanent space habitats.