Functional and structural changes in otolith structures from micro- to hyper-gravity in vertebrates. *R. Boyle, Y. Popova, J. Varelas; BioVIS Technol Ctr, NASA Ames Research Center, Moffett Field, CA 94035 USA.

Vertebrates sense gravitoinertial acceleration by mechanoreceptors in the utricle and saccule of the inner ear. These organs consist of ciliated sensory hair cells surmounted by biomineral grains of calcium carbonate ($CaCO_3$) called otoconia (mice) or a solid structure called an otolith (fish), and a provide mechanical loading of hair cell cilia. In a gravity environment when the head moves or is tilted, the mass load lags behind because of inertia and the hair bundles are bent. A widely considered mechanism by which the animal responds to a chronic change in amplitude of gravity is a change in weight-lending otoconia. In μG, it is argued, the organism counters the loss of gravity by increasing $CaCO_3$ production, thereby increasing otolith mass, as a means to increase "system gain". In hypergravity, the converse is argued. Here, we present the results obtained in 2 species exposed to μG, normal 1G, and to 2-3G. Adult toadfish, *Opsanus tau*, were exposed to μG in 2 short-duration shuttle missions and to 3G centrifugation from 1-32 days; re-adaptation to 1G was studied following 1-8 days post-centrifugation. Results show a biphasic pattern of utricular afferent response to linear acceleration following 3G exposure: an initial hypersensitivity up to the fourth day, perhaps related to the observed vestibular disorientation experienced by astronauts in the earlier periods of space flight, followed by transition to a significant decrease in afferent sensitivity at 16-32 days. Recovery from hypergravity exposure is ~ 4-8 days.  Combined serial reconstructions of hair cells in two regions of the sensory macula in physiologically tested animals do not indicate a direct relationship between synaptic organization and afferent sensitivity.  The results are interpreted as an initial response of the nervous system to compensate to the novel environment. Two major pieces of information are still needed: direct vertebrate hair cell response to altered gravity and impact of longer duration exposures on sensory plasticity. To address the latter we applied electron microscopic techniques to image otoconia mass obtained from 1) mice subjected to 91-days of weightlessness in the Mouse Drawer System (MDS) flown on International Space Station, 2) mice subjected to 91-days of 2G centrifugation on ground, and 3) mice flown on 2 short-duration orbital missions.  Images indicate a clear restructuring of individual otoconia, suggesting deposition to the outer shell of flight mice. Images from their 2G counterparts indicate the converse - an ablation of the otoconia mass.  For shorter duration exposures to weightlessness on 13-day shuttle missions mice otoconia appear normal. Despite the permanence of 1G in evolution the animal senses exposure to a novel, non-1G, environment and adaptive mechanisms are initiated - in the short term compensation is likely confined to the peripheral sensory receptors, the brain or both. For longer exposures structural modifications of the endorgan may also result. More sophisticated techniques remain to be applied to the different samples to clarify the constructive or destructive processes involved in altering otoconia structure. How these structural changes of the otolith mass effect mechanotransduction of the hair cells are yet to be determined.

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