Plasticity of Neurovestibular Systems Following Micro- and Hyper-Gravity Exposure and Re-adaptation to Earth's 1G.

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The gravity-sensing organs sense the sum of inertial force due to head translation and head orientation relative to gravity. Normally gravity is constant, and yet the neural sensors show remarkable plasticity. When the force of gravity changes, such as in spaceflight or during centrifugation, the neurovestibular system responds by regulating its neural output, and this response is similar for the vertebrate utricular nerve afferents and for the statocyst hair cell in invertebrates. First, we examine the response of utricular afferents in toadfish following exposure to μG on two orbital missions (STS-90 and –95). Within the first day after landing, magnitude of neural response to an applied acceleration was significantly elevated, and re-adaptation back to control values occurred within ~30 hours. Time course of return to normal approximately parallels the decrease in vestibular disorientation in astronauts following return. Next, we use well-controlled hyper-G experiments in the vertebrate model to address: If μG leads to adaptation and subsequent re-adaptation neural processes, does the transfer from 1G to hyper-G impart the opposite effects and do the effects accompanying transfer from the hyper-G back to the 1G conditions resemble as an analog the transfer from 1G to the μG? Results show a biphasic pattern in reaction to 3G exposures: an initial sensitivity up-regulation (3- and 4-day) followed by a significant decrease after longer exposure. Return to control values is on the order of 4-8 days. Utricular sensitivity is strongly regulated up or down by gravity load and the duration of exposure. Interestingly, we found no correlation of response and hair cell synaptic body counts despite the large gain difference between 4- and 16-Day subjects. Lastly, we examine responses of statocyst receptors in land snail following exposure to μG on two unmanned Russian Orbital missions (Foton M-2 and -3). Here, we have the ability to measure the output directly from the hair cells. Similar to afferents in vertebrates the hair cells increased their response sensitivity to vestibular stimulation. Two major pieces of information are needed: the precise vertebrate hair cell response to altered gravity and the impact of longer duration exposures on sensory plasticity.