Cross-Coupled Stimulus During Artificial Gravity: Asymmetric Tumbling Sensation Response

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Artificial gravity (AG) through centrifugation is a promising countermeasure for long-duration spaceflight physiological deconditioning. Vestibular adaptation to AG is necessary in order to mitigate the negative side effects associated with the cross-coupled stimulus (CCS) that results from performing head turns out of the plane of centrifuge rotation. Previous research has investigated many of the factors that contribute to the CCS such as head turn velocity, centrifuge velocity, and magnitude of head turn rotation, among others. Most of these can be understood by an analysis of the physics of the CCS. However, we have consistently noted an asymmetry between clockwise (CW) and counter-clockwise (CCW) yaw-axis head turns. This asymmetric response is not readily explained by the physics of the CCS, and it has also not been adequately explained by any of the existing models of the vestibular system. We have characterized the asymmetry of the CCS through three experiments in which we provide yaw head turns during AG with: 1) CW supine, 2) CCW supine, and 3) CW prone centrifugation. The data indicate that head turns resulting in a subjective tumbling sensation of rotating away from the horizontal centrifuge bed always produce a more intense tumbling sensation than head turns that lead to a sensation of rotating into the bed. We propose that the perceived danger of the CCS-induced tumbling sensation movement modulates the subjective tumbling intensity responses.

This work was supported by the National Space Biomedical Research Institute NASA NCC 9-58.