



Bio-Medical

Improving Balance Function Using Low Levels of Electrical Stimulation of the Balance Organs

A device based on this technology may be used as a miniature patch worn by people with disabilities to improve posture and locomotion, and to enhance adaptability or skill acquisition.

Lyndon B. Johnson Space Center, Houston, TX

Crewmembers returning from long-duration space flight face significant challenges due to the microgravity-induced inappropriate adaptations in balance/sensorimotor function. The Neuroscience Laboratory at JSC is developing a method based on stochastic resonance to enhance the brain's ability to detect signals from the balance organs of the inner ear and use them for rapid improvement in balance skill, especially when combined with balance training exercises. This method involves a stimulus delivery system that is wearable/portable and provides imperceptible electrical stimulation to the balance organs of the human body.

Stochastic resonance (SR) is a phenomenon whereby the response of a nonlinear system to a weak periodic input signal is optimized by the presence of a particular non-zero level of noise. This phenomenon of SR is based on the concept of maximizing the flow of information through a system by a non-zero level of noise. Application of imperceptible SR noise coupled with sensory input in humans has been

shown to improve motor, cardiovascular, visual, hearing, and balance functions. SR increases contrast sensitivity and luminance detection; lowers the absolute threshold for tone detection in normal hearing individuals; improves homeostatic function in the human blood pressure regulatory system; improves noise-enhanced muscle spindle function; and improves detection of weak tactile stimuli using mechanical or electrical stimulation. SR noise has been shown to improve postural control when applied as mechanical noise to the soles of the feet, or when applied as electrical noise at the knee and to the back muscles.

SR using imperceptible stochastic electrical stimulation of the vestibular system (stochastic vestibular stimulation, SVS) applied to normal subjects has shown to improve the degree of association between the weak input periodic signals introduced via venous blood pressure receptors and the heart-rate responses. Also, application of SVS over 24 hours improves the long-term heart-rate dynamics and motor responsiveness as

indicated by daytime trunk activity measurements in patients with multi-system atrophy, Parkinson's disease, or both, including patients who were unresponsive to standard therapy for Parkinson's disease. Recent studies conducted at the NASA JSC Neurosciences Laboratories showed that imperceptible SVS, when applied to normal young healthy subjects, leads to significantly improved balance performance during postural disturbances on unstable compliant surfaces. These studies have shown the benefit of SR noise characteristic optimization with imperceptible SVS in the frequency range of 0–30 Hz, and amplitudes of stimulation have ranged from 100 to 400 microamperes.

This work was done by Jacob Bloomberg and Millard Reschke of Johnson Space Center; Ajitkumar Mulavara and Scott Wood of USRA; Jorge Serrador of Dept. of Veterans Affairs NJ Healthcare System; Matthew Fiedler, Igor Kofman, and Brian T. Peters of Wyle; and Helen Cohen of Baylor College. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809. MSC-25013-1