**SENSORIMOTOR ASSESSMENT AND REHABILITATION APPARATUS (SARA)**

**Introduction:**

Exposure to novel gravitational environments during spaceflight elicits modulations in otolith signaling, disrupting multiple sensorimotor subsystems simultaneously. Functional consequences include an impaired ability to read, disorientation, dizziness, postural and locomotor instabilities, and motion sickness. Therefore, the goal of our *Sensorimotor Assessment and Rehabilitation Apparatus (SARA)* is to develop a portable device to rapidly and unobtrusively measure the changes in sensorimotor function that occur during and following spaceflight. The results of the SARA assessment tests enable prescription of individually-based rehabilitation exercises to restore sensorimotor function and mitigate symptoms.

**Methods:**

SARA incorporates a tablet computer, small (watch-size) three-axis wireless motion and surface EMG sensors, and a pair of red-blue eyeglasses (one lens is red and the other is blue). Combining this simple hardware with clever analytical algorithms, we can assess changes in multiple sensorimotor subsystems quickly, on the order of several seconds to minutes. Specifically, SARA evaluates the vestibulo-ocular reflex (VOR), ocular skew and torsional disconjugacy, spatial orientation, posture, and locomotion.

Novel approaches have been developed to address the vestibular control of eye movements to eliminate the need for measuring the eye movements directly, which often involves delicate equipment that can be invasive, time consuming, and computationally expensive. There are two techniques we use to evaluate the VOR: vestibulo-ocular nulling (VON) and dynamic visual acuity (DVA). In VON, head movement data is used to control the position of a visual target displayed on the tablet through a variable motion-gain in real-time. The subject adjusts this motion-gain until the target appears fixed-in-space with head movements (i.e., the subject “nulls” the target movement). By measuring the amount of illusory movement experienced for a given head movement, we can therefore obtain a surrogate measure of VOR gain. In DVA, subjects read letters of decreasing optotype size on the tablet screen while moving their head. The inability to read progressively smaller letters during head movements is indicative of vestobule-ocular impairment.

To evaluate otolith asymmetries, marked by asymmetries in the vertical and torsional positioning of the eyes, subjects wear the red-blue eyeglasses and we display red and blue lines on the tablet screen; this effectively provides different visual information to each eye. By asking subject to align a red and blue line, which are vertically offset from one another in the vertical skew test or rotated relative to one another in the torsional disconjugacy test, we can quantify the functional consequences of otolith asymmetries.

In the spatial orientation test, subjects hold one of the wireless motion sensors and point to various locations in the surrounding environment with their eyes closed. The difference between the perceived direction and the actual direction is a measure of the accuracy in their spatial orientation perception.

To evaluate postural balance and locomotion, subjects wear the wireless motion and surface EMG sensors. Strategic placement of the motion sensors on various body parts can track changes in the coordination of head-on-trunk movements and left-right asymmetries during standing balance and gait tests. Changes in the underlying muscle activity, indicative of modified neural patterns, are assessed with the surface EMG sensors.

**Conclusions:**

Here we describe the development of a hand-held Sensorimotor Assessment and Rehabilitation Apparatus (SARA) and describe its ability to measure changes in sensorimotor function in both laboratory environments and during parabolic flight. SARA’s portability and rapid assessment makes it an ideal tool for scientists, clinicians, and researchers who need to quickly quantify sensorimotor function with minimal resources (time, equipment, personnel). Future work will include the development of individualized rehabilitation protocols, based on the assessment results output by SARA.