Advanced Technologies in Neurorehabilitation to enhance Sensorimotor Integration in the Control of Posture and Balance

Joyce Fung, PhD, PT, Member, IEEE

The control of posture and upright balance requires complex multisensory integration and sensorimotor coordination. Sensory and motor systems compromised with aging or neurological diseases such as stroke likely impede this process. Sensory and motor functions, as well as their integration, however, can improve via experience-dependent neuroplasticity, which is achieved through motor learning and rehabilitation. Evidence-based technologies to evaluate and enhance functional recovery in posture and balance control after stroke will be presented in this minisymposium.

I. NEUROPLASTICITY AND REHABILITATION

Human and animal studies incorporating advanced neurophysiological and neuroimaging techniques provided evidence that the cerebral cortex is capable of widespread functional and structural plasticity [1]. In addition to functional substitution by the residual CNS structures and pathways, post-injury behavioral experience plays an important role in functional reorganization of the remaining intact CNS system. The inability to walk and regain balance control is one of the more devastating consequences of stroke and regaining mobility is the most common rehabilitation goal expressed by stroke patients [2].

Technologies to promote the recovery and relearning of balance and mobility skills must take advantage of the processes of neuroplasticity and comply with the elements required for the consolidation of motor skills. Extensive human and animal studies have shown that improvements in sensorimotor functions result from experience-dependent neuroplasticity which can be achieved through salient, repetitive, intensive and motivating practice, with demanding and varied environmental contexts, as well as increased patient empowerment [3].

II. VIRTUAL REALITY TECHNOLOGY

Virtual reality (VR) refers to a range of computing technologies that present artificially generated sensory information in a form that people perceive as similar to real-world objects and events [4]. The simulated objects and events are not only sensed, but the user can anticipate and react to them as though they were real [5]. The technology, with the capacity of simulating environments, offers a new and safe way to not only increase practice time but also to offer the varied environments and controlled constraints needed to maximize learning. An advanced balance and locomotor system that combines VR with a self-paced treadmill mounted on a motion platform has been developed to allow patients to be exposed to more complex physical environments (both indoors and outdoors) including environmental hazards without physical danger [6]. It also provides a gaming environment to motivate patients to adhere to training. Results showed that subjects could be trained to have full control of their balance both on the treadmill and within the VE, while experiencing a strong sense of presence.

III. SENSORIMOTOR INTEGRATION

VR systems can be combined with the manipulation of physical environments and sensory feedback to create a mixed reality system for multisensory integration and sensorimotor enhancement. Sensory manipulation with augmented cues from the visual, auditory and proprioceptive systems can be used to enhance motor functions for the control of balance. Haptic touch has emerged as a novel and efficient technique to improve postural control and dynamic stability. The enhancement of balance and mobility functions post stroke with a mixed reality system incorporating VR, surface perturbations and haptic manipulation is evidenced by kinematic and kinetic changes in postural adaptations and reactions.

REFERENCES