Functional near-infrared spectroscopy as an evaluation and possible training tool for postural control and balance *

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Abstract—Postural control requires complex visuo-sensorimotor coordination, and previous studies have revealed that the cortical contribution is very important in the maintenance of bipedal posture in humans. Functional near-infrared spectroscopy (NIRS) could enable us to measure cortical activation during dynamic movements, including balance and postural tasks, and could provide novel insight into the underlying neural mechanisms for postural control in humans. In this minisymposium, we present the application of functional NIRS in studies investigating cortical mechanisms for balance and postural control in humans, and discuss the potential application of functional NIRS for enhancing functional recovery.

I. INTRODUCTION

Postural control requires complex visuo-sensorimotor coordination, and previous animal studies have revealed that multiple CNS structures, including the spinal cord, brainstem, cerebellum, basal ganglia, and cerebral cortex, regulate the autonomic and voluntary control of posture and gait in a hierarchical manner. However, human bipedal posture and gait are unstable in nature, and presumably, the cortical contribution is much more important in humans than in quadrupeds. Functional NIRS could enable us to measure cortical activation during dynamic movements, including gait and postural maintenance, and provide novel insight into the neural mechanism underlying gait and postural control in humans.

II. FUNCTIONAL NIRS AS AN EVALUATION TOOL FOR BALANCE AND POSTURE

To investigate the cortical activation associated with the maintenance of upright posture, we applied external postural perturbation by using combined brisk sliding of a platform for 4 cm. In healthy subjects, both prefrontal cortices were activated on postural perturbation. A foregoing warning cue provided 2 s before perturbation could enhance the postural perturbation-related cortical activation in the supplementary motor area and the posterior association cortex. These results indicated that the supplementary motor area and posterior association cortex might play important roles in intentional postural adjustment after postural perturbation. We also investigated the cortical mechanisms for balance recovery after hemiplegic stroke by using functional NIRS. We administered the postural perturbation task to patients with subacute hemiplegic stroke and investigated the correlation between individual balance ability and regional cortical activation (cross-sectional study) as well as longitudinal cortical activation changes and correlation between balance recovery and cortical activation changes (longitudinal study). Both studies revealed that the supplementary motor area was one of the crucial areas for balance recovery after stroke.

III. FUNCTIONAL NIRS AS A POSSIBLE TRAINING TOOL FOR BALANCE AND POSTURE

In addition to providing unique advantages as a neuroimaging tool for investigating neuronal mechanisms underlying balance and postural control, functional NIRS could be applied as a treatment tool for enhancing motor function or functional recovery. Recently, we have reported the potential usefulness of functional NIRS-mediated neurofeedback as a novel non-invasive neuromodulation technique. A combination of neurofeedback using a functional NIRS system and mental practice with motor imagery could enhance the motor imagery-related cortical activation and could augment the recovery of hand movement after hemiplegic stroke. Using similar neurofeedback techniques, we are trying to investigate the therapeutic effect of functional NIRS-mediated neurofeedback on the balance and postural ability in healthy subjects and patients with neurological diseases.

REFERENCES