MOTOR CONTROL STRATEGY TO MANAGE CENTRAL FATIGUE

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INTRODUCTION

Muscle fatigue is a common phenomenon that causes loss of force generation ability. Mechanisms underlying peripheral fatigue are well understood [1]. However, how the brain manipulates the fatiguing muscle is little tackled due to technical limitations and the difficult nature of the issue itself. More specifically, whether the brain suffers a central fatigue or it has other "smart" strategies to manage the situation is mostly unclear. Here we present our recent studies on this important issue of motor control using advanced functional neuroimaging methods.

METHODS

Fatigue Tasks: Intermittent handgrips of the right (dominant) hand were performed by a group of normal subjects at maximal voluntary contraction (MVC) level.

Force and EMG Recording and Analysis: Handgrip force and electromyogram (EMG) from involved muscles were recorded using a custom-built data recording system compatible with fMRI and EEG lab environments [2].

fMRI Data Recording and Analysis: Functional magnetic resonance imaging (fMRI) data were collected using EPI sequence on a 1.5 T Siemens scanner during rest and task-performance periods. Data of the two periods were statistically compared using *t*-test combined with other noise reduction procedures to determine which voxels of the brain were activated [3]. The number of activated voxels was calculated in each motor-related cortical region of interest (ROI) including both the primary sensorimotor cortices (SMI) and the higher order ones.

EEG Data Recording and Analysis: EEG data were recorded using a NeuroScan 64-channel system. Movement-related cortical potentials (MRCPs) were measured at motor-related locations. Sources that generated the signals were determined in the frame of current dipole model and effects of fatigue on their strengths and locations were analyzed.

RESULTS

1. Force and EMG decreased substantially to about 40% of initial MVC levels.
2. fMRI and MRCP-represented cortical activation levels stayed relatively unchanged while showing slight decreases (Figs. 1,2).
3. The strength of the current dipole source was little changed by fatigue, however, the source location showed substantial rotation in comparison to the result of the non-fatigue control condition (Fig. 3).

Figure 2: cortical activation level along fatigue (time). (a) fMRI results; (b) EEG (MRCP) results.

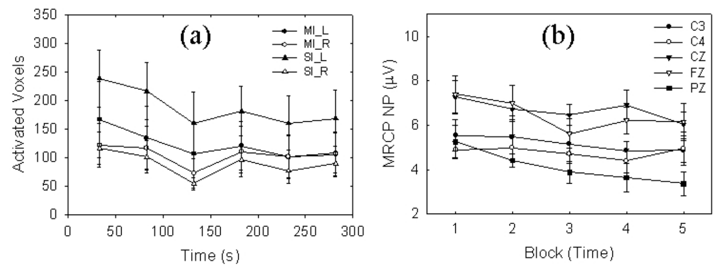
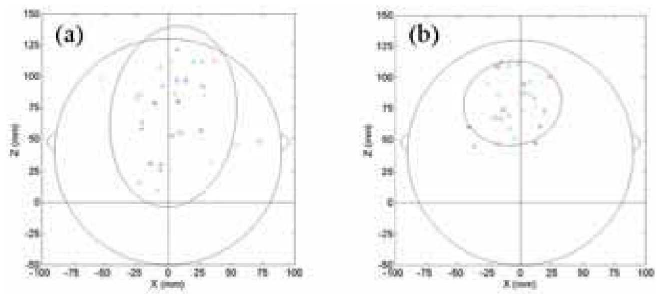


Figure 3: Distribution of source location. (a) fatigue condition; (b) non-fatigue control condition.



CONCLUSIONS AND DISCUSSION

The results suggest that there is a ceiling level for the cortical activation. The slight decreases indicate that central fatigue had factored in; however, the brain had successfully managed to maintain the task by recruiting additional cortical parts as indicated by the rotation of source location. These data support the concept that the neurons are activated in an alternate way so that the brain's power of motor control can be optimized/maximized, especially during severe situations such as fatigue.

REFERENCES

1. Enoka RM, Stuart DG. *J Appl Physiol* **72**, 1631-48, 1992.
2. Liu JZ, et al. *J Neurosci Methods* **101**, 49-57, 2000.
3. Liu JZ, et al. *Brain Res*, in press.

ACKNOWLEDGEMENTS

Supported by NIH and DoD grants (NS 37400-01, HD 36725, DAMD17-01-1-0665-02).

Figure 1: fMRI-determined cortical activation along the progress of fatigue (time), represented by the color points.