Journal of Science and Medicine in Sport (2009) 12, 280–283

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Journal of Science and Medicine in Sport

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SHORT REPORT

Corticomotor excitability during precision motor tasks

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Received 30 May 2007; received in revised form 13 December 2007; accepted 19 December 2007

KEYWORDS
Transcranial magnetic stimulation;
Motor evoked potentials;
Motor skills;
Motor cortex

Summary The aim of this preliminary study was to investigate motor cortex (cortical) excitability between a similar fine visuomotor task of varying difficulty. Ten healthy adults (three female, seven male; 20–45 years of age) participated in the study. Participants were instructed to perform a fine visuomotor task by statically abducting their first index finger against a force transducer which displayed the level of force (represented as a marker) on a computer monitor. This marker was to be maintained between two stationary bars, also displayed on the computer monitor. The level of difficulty was increased by amplifying the position of the marker, making the task more difficult to control. Cortical measures of motor evoked potential (MEP) and silent period (SP) duration in first dorsal interosseous (FDI) muscle were obtained using transcranial magnetic stimulation (TMS) while the participant maintained the ''easy'' or ''difficult'' static task. An 11.8% increase in MEP amplitude was observed when subjects undertook the ''difficult'' task, but no differences in MEP latency or SP duration. The results from this preliminary study suggest that cortical excitability increases reflect the demand required to perform tasks requiring greater precision with suggestions for further research discussed.

Introduction

Transcranial magnetic stimulation (TMS) allows for the non-invasive study of neural changes associated with short-term[1] and long-term[2] motor skilled tasks. Short-term motor cortex (cortical) changes have been attributed to neural projections from multiple areas of the cerebral cortex increasing motor cortex excitability.[3] Long-term changes have been ascribed to long-term potentiation[4] of neural projections within the motor cortex or cortical projection to the muscle. One area to receive attention, albeit limited, is the assessment of cortical excitability associated with task complexity. Previous studies[5,6] have shown cortical changes associated with simple but repetitive tasks. Other studies have compared cortical excitability between simple, precision and power

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doi:10.1016/j.jsams.2007.12.005

grip tasks.[7] Taken together, these studies indicate that cortical activity changes through movement tasks requiring greater motor demand. However, although these studies have compared similar muscle groups and levels of EMG activity, the tasks performed differed. To date, no TMS study has investigated cortical excitability using the same movement but with differences in visuomotor difficulty underpinning the aim of this preliminary study.

Methods

Studies were performed on 10 healthy adult volunteers (three female, seven male), 20—45 years, all right hand dominant.[8] Participants gave written informed consent and the project had approval from the University Human Ethics Committee.

Participants were instructed to abduct the FDI muscle against a force transducer mounted on a custom-built board, acting as resistance as well as visual feedback. For each task, feedback was displayed to the participant on the computer monitor using custom-built software. The display showed the participant's response marker reflecting changes in static force between two stationery marker bars. The participant was instructed to maintain the response cursor between the two marker bars for each task. In order to mask any perception of difficulty, the markers remained at the same position on the computer screen for each task, but the level of difficulty in keeping the response marker within the two bars differed. This was achieved by changing the sensitivity of the force transducer. During the ''easy'' task, force variations would be presented accurately. However during the ''difficult'' task, adjustments made by the participant would cause a greater amplification in the position of the marker, making the task more difficult to control. The participant was not informed of the order of tasks which were randomized between participants.

Following a maximal voluntary contraction (MVC) of the first index finger, participants were instructed to abduct and hold a static 10 (±5%) of MVC force. For each task, 40 TMS stimuli (in eight sets of five stimuli) were delivered during the static abduction. Each stimulus was spaced 10 s apart and 30 s rest was provided between each set of stimuli to reduce the possibility of fatigue.

Electromyographic (EMG) activity was recorded from surface electrodes placed over the motor point and the insertion of the FDI muscle of the participant's dominant hand. EMG recordings were amplified (1000×) with bandpass filtering between 10 Hz and 1 kHz and digitised at 1.5 kHz for 500 ms.

A Magstim 200[2] magnetic stimulator (Whitland, Dyfed, UK) with a 50 mm figure-8 coil was used. The coil was positioned tangential to the skull with the handle in an antero-posterior orientation (handle posterior), and with the centre of the figure-8 coil placed over the site to be stimulated. A snugly fitting cap, with premarked sites at 1 cm spacing was placed over the subject's head and positioned with reference to the nasion—inion and interaural lines.

Sites near the estimated centre of the hand area (4—7 cm lateral to the vertex) were first explored to determine the site at which the largest motor-evoked potential (MEP) could be obtained. This site was defined as the ''optimal'' site. At this site, stimulus/threshold curves were measured by delivering groups of four stimuli at intensities (5% steps) from a level estimated below the participant's motor threshold. Motor threshold (MT) was defined as the stimulus intensity at which a MEP could be obtained with at least two of the four stimuli. For both visuomotor tasks, stimulus intensity was set at 10% of stimulator output above MT.

The MEP waveforms for both tasks were reviewed off-line using custom-built software. Fig. 1 illustrates typical measurement of cortical excitability (MEP latency, amplitude) and inhibition (silent period duration). MEP latency was cursored between stimulus artifact and MEP onset. MEP amplitude was measured by cursoring the peak to peak amplitude of the MEP. Silent period (SP) duration was cursored from the onset of the MEP until return of EMG activity. Corticomotor parameters between the two conditions were compared

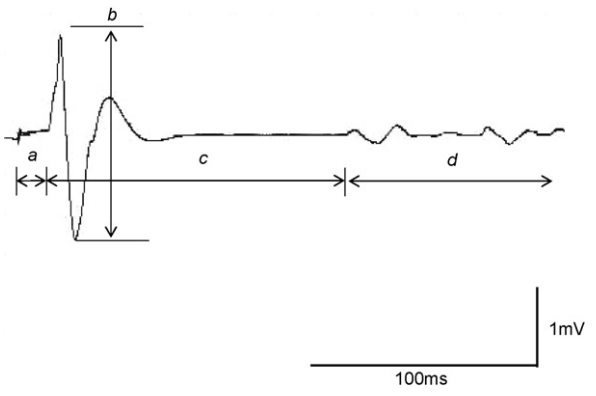

Figure 1 Example of a motor evoked potential (MEP). Measurement of MEP latency is from stimulus artifact to onset of MEP, shown at (a). Peak to peak MEP amplitude is shown at (b). Silent period duration is measured from onset of MEP to return of electromyography (EMG) at (c). Return EMG activity is shown at (d).

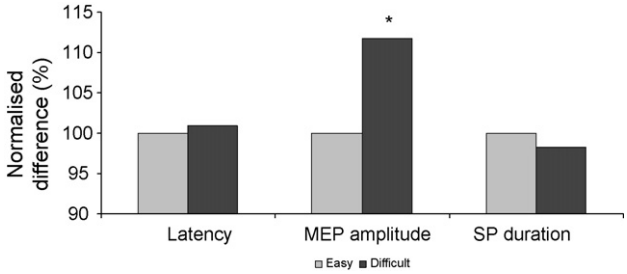

Figure 2 Normalised group comparison for MEP latency, amplitude and SP duration between the ''difficult'' and ''easy'' tasks (*$p < 0.05$).

using paired *t*-test at a significance level of $p < 0.05$ and Cohen's[9] effect size analysis was used to compare differences in individual mean data. Data is expressed as mean (±S.D.) and normalised for illustration in Fig. 2.

Results

Group mean MEP latency between the two tasks showed no significant differences. Individual mean MEP latencies ranged from 18.2 to 24.7 ms (Fig. 2).

Mean MEP amplitude was 11.8% larger for the ''difficult'' task (4.91 ± 2.69 mV) compared to the ''easy'' task (4.39 ± 2.66 mV; $p = 0.04$; Fig. 2). In all but one participant, MEP amplitudes were found to be significantly larger ($p < 0.05$) during the performance of the ''difficult'' task and effect size (ES) analyses in individual subjects showed moderate (ES = 0.30) to large (ES > 0.80) differences in means between the two tasks.

Comparison of mean SP duration (Fig. 2) did not show any significant difference, with group mean SP duration for the ''difficult'' task (105.70 ± 21.22 ms) being shorter compared to the ''easy'' task (107.60 ± 18.65 ms). When compared to the ''easy'' task, half of the participants showed a reduction in mean SP duration in the ''difficult'' task, ranging from 3.5 to 13.9 ms. In the remaining half of participants, the mean SP duration during the ''difficult'' task was lengthened, ranging from 1.4 to 7.8 ms. Effect size analyses in individual subjects showed small (ES = 0.07) to moderate (ES = 0.55) differences in mean SP durations.

Discussion

The aim of this preliminary study was to investigate the corticomotor effects of increasing the amount of precision of a visuomotor static task. The results showed that in a similar task, with similar muscle activation and TMS stimulation levels, cortical excitability increased during the visuomotor task that required greater precision compared to an easier task.

The increased MEP amplitude may arise from several sources; peripheral afferent feedback associated with the ''difficult'' task, and the effect of multiple cortical areas projecting to motor cortex. Changes in afferent feedback from fingers and intrinsic hand muscles have been shown to influence patterns of cortical activity associated with a movement task.[10] Further, given that multiple cortical areas contribute to the control of movement[3] the increased MEP amplitude may reflect greater inputs from other areas involved projecting to the motor cortex during performance of the ''difficult'' task.

Along with previous research findings,[5–7] results from this study indicate that increasing the precision of a movement task can increase cortical excitability reflecting greater motor demand during the more difficult precision task. We believe that this preliminary data is of clinical importance in the rehabilitation strategies used to re-acquire fine motor skills. For example, we have demonstrated that corticomotor amplitude is enhanced when the same exercises are performed with increasing difficulty. By prescribing movements patterns that are challenging to the neuromuscular system, this may lead to cortical-reorganisation, via either the processes involved in long-term facilitation, and/or long-term potentiation,[4] which is an important clinical process in the rehabilitation of fine motor control. Whilst the present data only represents changes at a cortical level during acute exposure to motor training, a logical extension of this work would be to repeat the procedures as a training intervention and to measure changes in plasticity and movement control at both cortical and spinal levels.

Conflict of interest

None.

Acknowledgements

The authors gratefully acknowledge the expertise of Mr. Ian Fairweather for the design of the custom-built software used in this study.

No financial assistance was provided for this project.

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