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ScienceDirect
Journal of Science and Medicine in Sport 13 (2010) 167–171
Journal of Science and Medicine in Sport
www.elsevier.com/locate/jsams

Original paper

Comparison of corticomotor excitability during visuomotor dynamic and static tasks

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Received 4 June 2008; received in revised form 3 December 2008; accepted 24 December 2008

Abstract

The human central nervous system (CNS) has the ability to modulate its activity during the performance of different movements. Recent evidence, however, suggests that the CNS can also modulate its activity in the same movement but with increased precision during a visuomotor static task. This study aimed to extend on these findings by using transcranial magnetic stimulation (TMS) to measure the CNS during the performance of two visuomotor dynamic tasks. Twelve volunteers participated in this study, performing two separate motor tasks. Study I ("Position Tracking") involved participants to perform a visuomotor tracking task using a dial potentiometer and matching their response icon to the computer generated tracking icon whilst holding a pincer grip. Study II ("Force Tracking") involved participants to perform a similar visuomotor tracking task by applying or releasing pressure against a fixed force transducer. Tasks were conducted at two speeds ("slow" being one tracking cycle in 10 s; and "fast" being two tracking cycles in 10 s) and compared to a visuomotor static task at a similar muscle contraction level. Results showed corticospinal changes with significant increases ($p = 0.002$) in excitability demonstrated during Study I ($42.3 \pm 16.8\%$) and Study II ($56.3 \pm 34.2\%$) slow speed tasks. Moreover, significant reduction in corticospinal inhibition was also observed during both tracking tasks at slow ($59.3 \pm 13.7\%$; $p = 0.001$) and fast speeds ($31.9 \pm 12.3\%$; $p = 0.001$). The findings may provide information on the underlying physiology during the early stages of motor skill acquisition.

Keywords: Transcranial magnetic stimulation; Motor-evoked potentials; Motor skills; Motor cortex

1. Introduction

It is now accepted that the human nervous system is capable of neural change, termed plasticity, with a number of techniques to investigate plasticity following motor skill training.[1] Transcranial magnetic stimulation (TMS) is a noninvasive and painless method to assess the central nervous system (CNS).[1] Previously, TMS had been used to show changes in motor cortex (M1) and spinal (corticospinal) excitability following movement tasks in forearm flexor muscles (biceps brachii and brachioradialis) suggesting that modulation in corticospinal excitability was due to the type of task performed.[2] Later TMS studies investigating intrinsic hand muscles did not show corticospinal excitability changes but rather changes in inhibition, further demonstrating task-related plasticity in the CNS.[3,4]

Recently we demonstrated, using TMS, that the CNS can modulate its activity, showing increased excitability during the performance of a simple motor task when varying the level of precision.[5] Although generally supporting task-related plasticity, our findings differed to the previous research showing changes in inhibition during the performance of different tasks.[3,4] Our findings suggested that corticospinal neurons not only modulate its activity to reflect the type of task, but also modulate to accommodate the demands of the task.[5] However, our previous study investigated a *static* task. The purpose of this investigation was to further investigate the CNS using TMS during the performance of two different types of *dynamic* motor tasks.

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doi:10.1016/j.jsams.2008.12.632

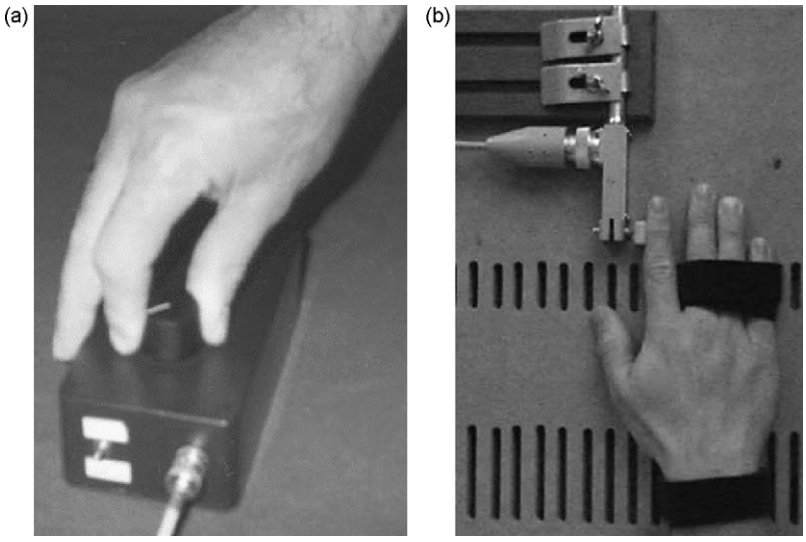

Fig. 1. The rotary potentiometer (a) used in Study I, and the force tranducer (b) used in Study II.

2. Methods

Studies were performed on 12 healthy volunteers (5 females; 7 males), 20–38 years, all right handed as assessed by questionnaire.[6] Participants gave written informed consent prior to testing, which had approval from the University Human Ethics Committee.

Participants were requested, using their dominant hand, to perform two separate tracking tasks (Fig. 1a and b) and given adequate time for familiarisation. The visuomotor tracking tasks were adapted from previously described methods.[7] The computer monitor displayed two icons: a target and a response icon. Participants were instructed to keep their response icon as closely aligned to the target icon to the best of their ability. The amplitude and frequency of the target icon were pre-determined with the "slow" tracking task being one cycle (down and up) in 10 s or two cycles in 10 s for the "fast" tracking task. The target and indicator icons were digitised at 10 ms intervals.

Prior to testing, the participant's maximum rmsEMG was determined by a 3 s maximal voluntary contraction (MVC) of the first dorsal interosseaous (FDI) muscle which required the participant to position their index finger and thumb in a pincer position over a rotary dial, pinching the dial, and activating, as best possible, the FDI muscle. Study I ("Position Tracking") required the participant to rotate the dial, whilst holding a pincer group on a dial attached to a custom-built electric potentiometer (Fig. 1a), in an anticlockwise direction (moving their response icon on the monitor downwards) then returning by moving in a clockwise direction. Participants were instructed to use the index finger as the prime mover (facilitating FDI) with support from the thumb in holding the dial. Participants were further instructed that the dial range of movement was between "2 o′clock" (start) and "10 o′clock" (finish) and that the movement, whilst matching their icon to the computer icon to the best of their ability, should be 'slow and smooth'. Transcanial magnetic stimulation was timed to occur halfway during the anticlockwise phase of the tracking task. The control condition in Study I was a visuomotor static task that required the participants to statically hold the similar pincer grip on the dial. Although no movement occurred, the background muscle activity of the FDI muscle was controlled at 10% of maximum rmsEMG.

After a 1 h rest, participants then completed a second visuomotor task (Study II—Force Tracking) by matching their response icon to the computer target icon. Participants applied pressure against a fixed force transducer (Fig. 1b) by abducting their index finger thereby moving the icon on the monitor downwards, and releasing pressure, moving the icon on the monitor upwards back to the starting point. Similar to Study I, participants provided a maximal abduction contraction to obtain MVC rmsEMG and were instructed to keep their response icon as closely aligned to the computer icon. Similar to Study I, the amplitude and frequency of the target icon were fixed with the "slow" tracking task being one cycle (down and up) in 10 s or for the "fast" tracking task being two cycles in 10 s. Study II control condition, using the transducer, was completed with participants holding a static contraction similar at 10% of MVC rmsEMG level to the tracking task. TMS was timed to occur halfway during the "down" phase of the tracking task.

TMS was delivered using a Magstim 200[2] stimulator (Whitland, UK) with a 5 cm diameter, figure-of-eight coil which was held tangential to the skull in an antero-posterior orientation. A snugly fitting cap, with premarked sites at 1 cm spacing was placed over the participant'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. Active motor threshold, for Study I and II, was defined as the intensity at which an MEP could be obtained, at background