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Task-specific impairment of motor cortical excitation and inhibition in patients with writer's cramp

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Abstract

Abnormalities in motor cortical excitation and inhibition have been reported in patients with writer's cramp, at rest and during muscle activation. We were interested in whether such abnormalities might be task-specific and depended on the type of movement task used to activate the dystonic hand. We therefore assessed motor-evoked potentials (facilitation/rest MEP amplitude ratio) and duration of the cortical silent period (CSP) from the right first dorsal interosseus (FDI) muscle to transcranial magnetic stimulation (TMS) in 10 patients with writer's cramp and in 10 healthy volunteers performing pincer and power gripping tasks. The mean facilitation/rest MEP amplitude ratio measured during the pincer grip task was significantly larger in dystonic subjects than in controls, but in the power grip condition was similar in the two groups. The CSP measured in the power grip condition was of similar length in normal controls and dystonic subjects, but in the pincer grip condition was significantly shorter in patients than in controls. These results indicate a task-specific impairment of motor cortical excitation and inhibition in writer's cramp.

Keywords: Magnetic stimulation; Motor cortex; Motor control; Task-dependence; Sensorimotor integration; Dystonia

Writer's cramp is the most common form of focal hand dystonia and has been attributed to basal ganglia dysfunction [1,3,5,12]. An important clinical feature of this condition is that it manifests most frequently during the execution of complex motor tasks, such as writing, but not during simple movements [1,3,5,12]. Studies using transcranial magnetic stimulation (TMS) in patients with writer's cramp have demonstrated an increased cortical excitability and decreased inhibition of the primary motor cortex in the forearm or in the hand muscles both at rest and during muscular activation [2,6,11,13,16,17]. These abnormalities suggest that writer's cramp leads to changes in cortical motor activities. Patients with writer's cramp also have difficulty in controlling the force motor output during manipulative activities using precision grip, suggesting an abnormal sensorimotor processing during the control of precision grip [14,19].

In healthy persons, the output from the motor cortex is organized in a task-related manner. This type of organization is important for selecting the correct muscles needed to execute hand movements. Task-related changes in motor-evoked potential (MEP) amplitudes and CSP duration, have been described in FDI muscle during performance of complex finger tasks (precision and power gripping) and during a simple abduction index task [8,9,18,20]. In this paper we were interested to see whether a complex manual task such as pincer gripping in patients with writer's cramp is associated with task-specific changes in motor cortical excitability. We therefore compared the size of MEPs and the duration of the CSP, recorded from the first dorsal interosseus (FDI)

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Table 1
Demographic and clinical information on writer's cramp patients

Subject	Age (year)/sex	Diagnosis	Severity score[a]	Duration of symptoms (year)
1	25/F	WC	6	4
2	33/F	WC	6	7
3	31/M	WC	3	6
4	36/M	WC	4	8
5	42/M	DC	5	9
6	27/F	DC	10	12
7	24/F	WC	3	7
8	30/M	WC	4	3
9	46/M	WC	7	10
10	31/M	DC	3	11

WC: writer's cramp; DC: dystonic cramp.
[a] According to the Burke–Fahn–Marsden Scale.

muscle after TMS delivered to the left motor cortex, during two complex motor tasks based on manipulation activities in daily life: pincer gripping—an elementary motor task that entails a specific precision grip in controlling a pen during writing, and power gripping—a more general activation task.

We studied 10 right-handed patients with idiopathic focal hand dystonia (age range 24–46; mean 32 years). Ten healthy right-handed subjects matched for sex, and age (range 23–37; mean 29 years) served as a control group. Demographic and clinical information is provided in Table 1. In all patients, the right upper limb manifested a mixed pattern of forearm flexor and extensor dystonia during writing. Seven patients were untreated; the remaining three patients had received treatment with botulinum toxin until 6 months before the study. All subjects gave their written informed consent before participating in the study. The procedures used were approved by the institutional ethics committee.

The methods are detailed elsewhere [20]. In brief, subjects were seated comfortably at a table, with their right hand placed on a board while the left hand remained on the table and was kept relaxed. Subjects were asked to perform two motor tasks with their right hand: "pincer gripping", pressure applied with the thumb and index finger on the contact surfaces of a strain gauge; and "power gripping", power grip of a 4-cm diameter brass cylinder involving all digits. All subjects were then trained to perform the pincer and power gripping tasks with a force level producing the same steady amount of voluntary background EMG activity, 20% of a maximal voluntary contraction index finger abduction. Subjects were aided to maintain the same force level by an EMG acoustic–visual feedback system. Brain stimuli were delivered only when the rectified and smoothed EMG level was comparable between the two tasks. Tasks were presented in randomized order across subjects. The surface recording electrodes were fixed to the belly of the right FDI and the reference electrode was positioned dorsally over the second metacarpophalangeal joints. For TMS a Magstim 200 (Novametrix) and a circular coil (13 cm in external diameter) were used. The coil was held over the left motor cortex in the optimal scalp position to elicit motor responses in the contralateral right FDI with the induced current flowing in a counter-clockwise direction for preferential activation of the left hemisphere. The position of the coil was marked on the scalp so that the coil could be kept at exactly the same site during subsequent sessions. Because even small displacements of the coil relative to the brain can produce differences in MEPs and CSP, we stabilized the head by asking the subject to bite on a restraint made of a dental impression compound. The stimulating coil was clamped to a frame placed in the predetermined position over the left motor cortex. Magnetic shocks were delivered at an intensity 20% of the maximum stimulator output above the resting motor threshold (RMT), defined as the minimum stimulus intensity producing an EMG response of at least 50-μV peak-to-peak amplitude in 5 out of 10 trials in the relaxed muscle. During the tasks, magnetic stimuli were given pseudo-randomly at intervals ranging between 4 and 8 s after the task began, but were never delivered before the performance had reached a steady-state level. To avoid fatigue, subjects were allowed to rest after each stimulus. In this way the intervals between the stimuli usually ranged between 20 and 30 s. Blocks of 10 magnetic stimuli were delivered at rest and during each task.

The EMG background activity was measured as the mean amplitude of the smoothed rectified EMG activity for 5 s before stimulation, and during the 25 ms immediately preceding the brain stimulus. The amplitude of the MEPs obtained at rest and during the two tasks was measured peak-to-peak. The amplitude ratio of MEPs measured during each task and at rest (facilitation/rest MEP amplitude ratio) was also determined [13]. The duration of the CSP was measured from stimulus onset to the reappearance of continuous EMG background activity.

For statistical analysis MEP amplitudes and CSP duration were measured in two separate analyses of variance (ANOVAs). Each ANOVA had one between-subjects factor Group (two levels: writer's cramps versus controls), and one within-subjects factor Task (two levels: pincer gripping and power gripping). Planned comparisons between the two tasks were performed by using *t*-tests (unpaired Student's *t*-tests for comparing data in patients versus controls, and paired Student's *t*-tests for comparing data obtained in both controls and patients). The Spearman correlation coefficient was used to assess the possible relationships between the motor impairment severity score and MEP amplitudes and CSP duration during the two tasks. The alpha level for significance was set at $p < 0.05$.

No significant differences were found in mean resting motor threshold (RMT) and mean MEP amplitudes at rest in relaxed muscle in patients and controls ($p > 0.05$). No significant difference was found in EMG background activity between pincer and power gripping in normal controls or between the two groups ($p > 0.05$). ANOVA on the amplitude ratio of MEPs (facilitation/rest MEP amplitude ratio) showed that the factor Group was significant MEPs being larger in patients than in controls [$F(1,18) = 4.59$; $p = 0.046$]. The factor Task was also significant [$F(1,18) = 42.56$; $p < 0.00001$]