Short-latency subliminal effects of transcranial magnetic stimulation on forearm motoneurones

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Abstract. The H-reflex technique has been used to evaluate the time-course of the effects evoked by transcranial clockwise magnetic stimuli in flexor or extensor carpi radialis motoneurones. In six subjects, magnetic stimulation was applied over the scalp in the focus for the motor response of those muscles. At intensities below motor threshold, a facilitation of the H-reflex started at a conditioning-test interval of −4 ms (i.e. when the magnetic stimulus lagged the test stimulus by 4 ms), reached a peak at about −2 ms and rapidly decayed. At about −1 ms, the decay attained a local minimum, which in three subjects had values indicating the presence of an inhibition. Thereafter, a second facilitatory phase peaked at about +1 ms. By matching the time course with the latency of the cortical muscle action potential (CMAP) evoked by suprathreshold magnetic stimulation, it is inferred that the motoneuronal discharge coincides with the second peak of facilitation and is preceded by 3–4 ms of subliminal excitation. This early effect could be brought to threshold by convergence of a subliminal Ia EPSP, leading to a reduction of the CMAP latency. The early excitatory effects reported above are as fast as those described as following transcranial electrical stimulation, and should likewise be considered as monosynaptic.

Key words: Transcranial magnetic stimulation – Corticospinal tract – Forearm motoneurones – H-reflex – Human

Introduction

Transcranial electric and magnetic stimulation evoke cortical motor action potentials (CMAPs) in several limb muscles by activation of the corticospinal tract (see Mills 1991). When compared in one and the same muscle at rest, the CMAPs have a longer latency after magnetic than after electric stimulation both in man (Day et al. 1986, 1987; Hess et al. 1987) and in the monkey (Amassian et al. 1990). For this reason, it has been suggested that the electric stimuli directly excite corticospinal neurones, giving rise to a direct (D) wave in the pyramidal tract, whereas magnetic stimuli activate them through a synaptic mechanism, thus producing indirect (I) corticospinal volleys (Day et al. 1989). However, Amassian et al. (1989) reported that during voluntary contraction the latency of the magnetic CMAP can be shortened to that of the electrical response, an event which might be ascribed either to a facilitation of motoneurones or to a depolarization of cortical neurones, favouring the appearance of a “D” wave.

It was therefore of interest to define the time-course of the corticospinal effects evoked by magnetic stimulation in forearm motoneurones. By using the H-reflex technique, it has been ascertained that, at rest, a period of subliminal excitation lasting 3–4 ms precedes the motoneuronal discharge which gives rise to the CMAP.

Materials and methods

Experiments were repeated three to six times on six normal volunteers, including the authors. All of them gave informed consent, and the project had the approval of the local ethical committee.

During the session, the subject was comfortably sitting on a dentist’s chair, the head restrained by a frame. Transcranial magnetic stimuli were delivered by an Esaote Biomedica device (monophasic pulse rise-time 2 μs, pulse duration 100 μs). The round stimulating coil (inner diameter 3 cm, outer diameter 12 cm) was mounted on a pantograph arm and kept tangential to the scalp over the vertex. In each experiment, the appropriate coil position was determined by slight displacements until the lowest threshold focus for the flexor carpi radialis muscle (FCR) or extensor carpi radialis muscle (ECR) was found. In several circumstances, this focus was reached by tilting the coil laterally on the left hemisphere (Amassian et al. 1990). Direction of the current in the coil was always clockwise. The intensity of the stimuli was graded as a percentage of the maximum output of the stimulator (2.5 T).

In five subjects, test H-reflexes were evoked in the right FCR by percutaneous electrical stimulation of the median nerve at the elbow. In one subject, the H-reflex was elicited in the right ECR by stimulation of the radial nerve in the spiral groove of the humerus.