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Effects of low-frequency repetitive electric and magnetic brain stimulation on somatosensory evoked potentials in rats

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Abstract. Since the mechanism that repetitive electric (rES) or transcranial magnetic stimulation (rTMS) transiently modulates cortical neuron excitabilities is not clear, we studied the effects of rES and rTMS on somatosensory evoked potentials (SEPs) in rats. After anesthetizing rats, a pair of burr holes was drilled in the skull over the right somatosensory area for the hind limb. rES was performed with a frequency of 1 or 0.2 Hz for 3 h and 20 min using two stainless screws inserted into the burr holes. The right somatosensory areas were magnetically stimulated with a frequency of 0.2 Hz for 2 h and 20 min using a small eight-figure coil. SEPs elicited by stimulating the left hind limb was recorded before and after rES or rTMS. Amplitudes and latencies of SEP components were measured and compared between the rES or rTMS and control groups. As a result, amplitudes of cortical components of SEPs were significantly reduced after rES or rTMS compared with those in the control. Amplitudes of other components were not significantly changed by rES or rTMS. The present results support rES and rTMS having similar effects on cortical neuron excitabilities.

Keywords: Electric stimulation; Transcranial magnetic stimulation; Somatosensory evoked potentials; SEPs

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1. Introduction

Recent studies showed that low frequency repetitive brain stimulation using a magnetic stimulator transiently inhibited excitability changes of cortical neurons, which was shown by recordings of motor evoked potentials (MEPs) or by measuring regional cerebral blood flow using single photon emission tomography (SPECT) or positron emission tomography (PET) [1–3]. However, the mechanism of modulating effects of cortical neuron excitabilities was still unknown. To evaluate the effects of repetitive electrical (rES) and transcranial magnetic brain stimulation (rTMS) on cortical neuron excitabilities and elucidate its mechanism in rats, we recorded somatosensory evoked potentials (SEPs) before and after rES or rTMS with low frequency.

2. Subjects and methods

This study was approved by the ethics committee of our institution. Sprague–Dawley rats were employed to evaluate the effects of rES or rTMS on cortical neuron activities. Rats were anesthetized by urethane (1.3 g/kg) solved by saline (1.3 g/2 ml), and were mounted on a stereotactic apparatus. After injecting 2% xylokine hydrate, the skin and muscles on the scalp were removed. Two burr holes of 1 mm diameter were punctuated using an electric drill; a burr hole located at a point 2 mm right and 1 mm caudal to the bregma, which distributed at the primary sensorimotor area and another burr hole located at 3 mm right and 2 mm caudal to the bregma. A pair of stainless steel screws of 1 mm diameter were inserted into the burr holes. A pair of stainless steel needles was attached at the left hind leg to stimulate the sciatic nerve with a frequency of 0.5 Hz using a square pulse of 200 μs duration. The stimulus intensity was fixed to induce the minimum twitches of the left foot. To record SEPs, electric signals were induced with a bandpass between 10 Hz and 3 kHz and a sensitivity of 10 μV/division via the stainless steel screws described above, and were averaged 20 times.

rES was performed using stainless steel screws inserted into the scalp described above. The one positioned at the primary sensorimotor area was set as negative for cathodal stimulation. Stimulus intensity was just below ones which produce minimum twitch of scalp muscles (1–2 mA). Stimulation with a frequency of 1 or 0.2 Hz was continued for 3 h and 20 min with breaks. SEPs were recorded before stimulation and every 1 h after the onset of stimulation except for the first 20 min.

rTMS was performed using a single magnetic stimulator with a small double-cone coil. The double-cone coil of 44 mm diameter with an angle of 150° was set as the center of coil was positioned at the primary sensorimotor area. rTMS was delivered with a stimulus frequency of 0.2 Hz for 2 h and 20 min, with breaks of 5 min after each 20 min to cool down the coil. Median nerve SEPs were recorded at the same time points as those for rES.

3. Results

3.1. Effects of 1 or 0.2 Hz rES on SEPs

The amplitudes of a cortical component of SEPs were linearly increased according to time after the onset of rES. Compared with control, the amplitudes