Change of H wave and MEP during pedalling by one leg

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Abstract

H wave and motor evoked potential (MEP) induced by trancranial magnetic stimulation in one leg was recorded during pedaling movement by contralateral leg in the healthy subjects and hemiplegic stroke patients. In the healthy subjects the amplitude of H wave was decreased and MEP was increased during pedaling. In the stroke patients H wave did not change but MEP appeared during pedaling though it was absent during rest. Pedaling by one leg can modulate the function of spinal motor neuron by activating motor control system in the brain.

1. INTRODUCTION

There are some excitatory or inhibitory neural circuits in the spinal cord connecting bilateral lower extremities. These neuronal systems play important roles to control reflexes concerning cooperative movement between right and left limbs. On the other hand, voluntary movement of a leg gives some influence to the upper motor neuron in the brain connecting with the contralateral side, and the neuronal activity of the lower motor neuron in the spinal cord ruling the contralateral leg is modified by the control command from cerebral motor cortex. We reported post-stroke patients with severe hemiplegia could drive a cycling chair and the muscles in the paretic lower limb showed significant activities during pedaling compared to isometric voluntary contraction. It suggests a possibility that driving a cycling chair facilitates the neuronal system controlling the paretic lower limb even in the severe hemiplegic patients. However it is unknown whether pedaling movement of the healthy leg brings some reflexes to the paretic muscles or effort of pedaling performed chiefly by the healthy leg activates the motor cortex of the contralateral side. The purpose of this study is to investigate the influence of the pedaling movement performed by one leg to the neuronal systems both of spinal and cerebral levels.

2. METHODS

Eight healthy adults (20.3±0.9 years) and two hemiplegic stroke patients (A:42 years with right hemiplegia, B:72 years with left hemiplegia) participated in this study. The level of paralysis in the affected lower extremity evaluated by Brunstrom's test was III in both patients. Informed consent was obtained from all subjects before the experiment started. Pedaling was performed with a recumbent type ergometer (Strength Ergo; Mitsubishi Electric Inc.). All the subjects sat on the chair with headrest and right foot (healthy foot) was fixed on the pedal. All the subjects were instructed to keep their left leg (paretic leg) resting with the knee flexed at 90 degrees and the ankle flexed at 0 degree. At first, during rest, H wave was recorded from left (paretic) Soleus muscle (SolH) and then motor evoked potential (MEP) induced by trancranial magnetic stimulation (TMS) was recorded from left (paretic) Soleus and Tibialis anterior muscles (SolMEP, TAMEP). After that, during pedaling with right leg (healthy leg), H waves and MEPs were recorded as same as resting state. Electrical stimulation to elicit H wave was given to the popliteal fossa with the intensity of 50% of H max. TMS was applied to Cz on the scalp with Magstim200 and the double-cone coil. The intensity of TMS was fixed at 120% of motor threshold. All the subjects were instructed to keep the rotation speed at 40 rpm during pedaling. H waves were recorded at 0 and 180 degrees of crank angle both during rest and pedaling and 8~10 waves in each were averaged with EPlizer (Kissei Comtec. Inc.). MEP was also treated as same as H wave. The amplitude of H wave and MEP was compared statistically between during rest and during pedaling by using Dunnet's method.

3. RESULTS

In the healthy subjects, the mean amplitude of SolH recorded during pedaling was significantly decreased in both 0 and 180 degrees of crank angle compared to during rest. Meanwhile, the mean amplitude of SolMEP and TAMEP in both 0 and 180 degrees were significantly increased during pedaling compared to rest. While the amplitude of SolH did not change in both patients, TAMEP in the patient B appeared during pedaling in all trials of stimulation although it did not appear during rest. SolMEP in both patients and TAMEP in the patient A could not be recorded even during pedaling.

4. DISCUSSION AND CONCLUSIONS

The results of the healthy subjects in this study suggest that during pedaling by one leg the activity of spinal motor neuron dominating the soleus muscle in the contralateral side is inhibited and the activity of the motor cortex ruling the contralateral leg is excited. According to our previous study the amplitude of SolH, SolMEP and TAMEP did not show significant change during passive pedaling without any voluntary effort to make pedaling movement in the healthy subjects. Afferent sensory information from the leg joints seems to reach the spinal cord and the brain even during passive pedaling. Therefore it is supposed that decrease of H wave in the resting leg during voluntary pedaling is brought about by the inhibiting action of inhibitory inter-neuron in the spinal cord activated with the Ia afferent input from the muscles of pedaling leg or by the inhibiting action of the descending central command from the motor cortex. However, in the hemiplegic stroke patients, the amplitude of SolH showed no change during voluntary pedaling. The spinal cord of the patients was intact. These suggest the decrease of the activity of spinal motor neuron dominating the contralateral soleus muscle is based on the inhibiting mechanism from the brain. The augmentation of the activity of the motor cortex during voluntary pedaling is clear at least in the healthy subjects because the amplitude of SolMEP and TAMEP were increased. This phenomenon implies the effort of pedaling movement by one leg induces increment of the cortical excitability in the bilateral hemisphere and the excitation will transfer to the spinal motor neuron via corticospinal tract. The appearance of TAMEP in the patient B during voluntary pedaling by healthy leg suggests that pedaling movement can facilitate motor function of the paretic lower extremity associated with cortical excitation even in the hemiplegic stroke patients. However, it seems contradictory that inhibition of the spinal motor neuron, decrease of SolH, caused by descending impulses from the brain and facilitation of the spinal motor neuron, increase of SolMEP and TAMEP, associated with cortical excitation are both via corticospinal tract. Therefore it is valid to postulate that the inhibitory impulses from the brain to the spinal motor neuron generated during voluntary pedaling descend via the pathway except corticospinal tract.

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