ABSTRACT

Effects of Jump Motor Learning on the Synaptic Efficacy of Cerebellar Purkinje cells and Hippocampal Pyramidal cells and on Morphology of Medial Gastrocnemius Muscle Spindles in Rat

Im, Jae-Hyeng
Department of Physical Education
Graduate School
Seoul National University

The neurophysiological correlates of motor learning have not been clearly elucidated. Experimental evidence, however, suggests that the cerebellum is critical in the learning process. The cerebellum is known to operate as an error detector in voluntary movement, particularly in smooth and slow movement. In support of this idea, studies with primates have demonstrated that the frequency of simple spikes evoked by parallel fiber input in Purkinje cells, the output neurons of the cerebellum, decreases chronically after learning the skill for voluntary movement, whereas the frequency of complex spikes evoked by climbing fiber input increases temporarily during the motor learning process. In line with these studies, electrophysiological studies have shown that the efficacy in the parallel fiber-Purkinje cell synapse is chronically depressed following low-frequency (4 Hz, 25 sec), conjunctual stimulation of parallel and climbing fiber inputs to Purkinje cell, suggesting that long-term depression of parallel fiber-Purkinje cell synapse might be the part of the engram of motor learning.
The possible role of the cerebellum in learning the skills for involuntary, automated movement has not been tested. In the present study, I addressed this issue by comparing trained and untrained rats for automated movement (i.e., jump induced by classical conditioning) in the efficacy of the parallel fiber-Purkinje cell synapse. In addition, I compared trained and untrained rats in the efficacy of the Shaffer's collateral-pyramidal cell synapse in the hippocampus, since this brain site is known to be important in various aspects of learning and memory. Finally, I examined if the morphology of the medial gastrocnemius muscle spindle changed after the training, since the spindle is an integral part of the movement per se.

The data of the present study have shown that: 1) the population spike of cerebellar Purkinje cells from parallel fiber stimulation is potentiated in a long-term fashion in trained rats after tetanic stimulation (100 Hz, 1 sec) of granular cell layer, whereas it is depressed in untrained ones, 2) the population spike in hippocampal pyramidal cells evoked by Shaffer's collateral stimulation is potentiated after tetanus (100 Hz, 1 sec) in both trained and untrained rats and 3) the size of the medial gastrocnemius muscle spindle decreases after training.

On the basis of the present results, I have drawn the following conclusions: 1) the cerebellum, not the hippocampus, is involved in learning the skills for involuntary, automated movement, 2) long-term potentiation, not depression, is probably the electrophysiological signature for automated motor learning and 3) in the peripheral side, changes in muscle spindle morphology accompany the motor learning.

Key Words: Involuntary movement, Mossy fiber, Purkinje cells, LTP, Hippocampus, Medial gastrocnemius muscle spindle.