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Case Study

Muscle tone changes in the lower limbs of stroke patients induced by trunk stabilization exercises

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Abstract. [Purpose] The purpose of this study was to identify the effects of trunk stabilization exercises on the spasticity of the lower limbs in stroke patients. [Subject] The subject of this study was a 38-year-old male patient who experienced a spontaneous intracranial hemorrhage, and had motor paralysis symptoms and spasticity on the left side. [Methods] The Hmax/Mmax ratio was measured before and after the trunk stabilization exercises, by using proprioceptive neuromuscular facilitation techniques. [Results] The Hmax/Mmax ratio changed from 37% to 20%. [Conclusion] Trunk stabilization exercises help control the muscle tone in stroke patients.
Key words: Trunk stability, Stroke, Spasticity

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INTRODUCTION

Spasticity is defined as a motor disorder characterized by “a velocity-dependent increase in the tonic stretch reflex (muscle tone) with exaggerated tendon reflexes, resulting from the hyperexcitability of the stretch reflex, as one component of the upper motor neuron syndrome”[1)]. It often appears in patients with central nervous system diseases such as multiple sclerosis, spinal cord injury, and traumatic brain injury[2)]. This spasticity leads to involuntary muscle contractions that interfere with the normal movements of the arms and legs, restrict the range of motion of joints, cause joint contractures, and lower the functions of daily living, thereby restricting the functional recovery of patients[3)]. To control spasticity, drug treatment, injection therapies, and operative treatments are being used; however, they have the risk of causing adverse reactions and their effects differ depending on the technical abilities of the operators[4)]. Physical therapies that pose less risks of adverse reactions include massage therapy[5)], electrical stimulation treatment[6)], stretching stimulation therapy[7)], and vibration stimulation therapy[8)]. Recent clinical studies found that trunk stabilization exercises influence the muscle tone of the distal part; however, there is still insufficient clinical evidence. Therefore, this study was conducted to investigate the effects of trunk stabilization exercises on the spasticity of the lower limbs of stroke patients.

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SUBJECT AND METHODS

The subject of this study was a 38-year-old male patient. In January 2003, he experienced a spontaneous intracranial hemorrhage in the basal ganglia and pons of the right side, which led to motor paralysis symptoms on the left side. He scored 30 on the Mini-mental State Examination and could perform the intervention according to the instructions of the therapist. His sensory functions were normal. His abnormal reflexes, Babinski’s reflex, and Hoffmann reflex (H-reflex) were evaluated. His motor functions were Fair+ in the proximal part of the left upper limb, Poor in the distal part, Fair+ in the proximal part of the left lower limb, and Zero in the distal part. His motions of the upper and lower limbs of the right side were normal. The modified Ashworth scale (MAS) score was 3 for the upper limb and 3 for the lower limb. The subject consented to participate after receiving an explanation about the purpose and procedure of the study. This study was approved by the institutional review board of Pusan National University Hospital (E-2015012).

The Hmax/Mmax ratio was used to measure the excitability of the α-motor neuron, which indicates spasticity[9)]. For the electrical stimulation to obtain the H-reflex, the posterior tibial nerve at the midpopliteal crease was stimulated with bipolar electrodes. The stimulation was applied with 1-Hz frequency in the forward direction, and the stimulation frequency was one per 2 s. The low-pass filtering was set to 10 kHz, high-pass filtering to 5 Hz, sensitivity to 5,000 mV, and sweep speed to 5 ms. For the attachment of the electrodes for H-reflex, the patient was laid in prone position and the active electrode was attached to the medial triceps surae of the tibial crest, at the center of a line connecting the middle point of the bisected medial surface of the tibia at the knee, with the tip of the medial malleolus. The reference electrode was attached to a site above the Achilles tendon, and the ground

electrode was attached between the exciting electrode and the active electrode. The intensity of the electrical stimulation was gradually increased to obtain the H-reflexes, and the intensity was increased again to obtain the maximum M-wave. The Hmax/Mmax ratio is the ratio of each maximum value to the two action potentials, and the amplitude was measured from the positive peak to the negative peak.

For the trunk stabilization exercises, among the proprioceptive neuromuscular facilitation techniques, rhythmic stabilization (RS)—which produces isometric contractions for manual resistance—and combination of isotonic (CI)—which repeats concentric and eccentric contractions for one muscle—were applied. Both techniques increase stability[10, 11]. First, three sets each of RS and CI were applied to the trunk of the subject in the sitting position. One set consisted of 10 repetitions, and the exercises were performed with optimal resistance. A 30-s break was given between sets. A 60-s break was given after the application of RS was completed, before applying CI. The focused treatment was applied for 30 min.

RESULTS

To evaluate the muscle tone, the Hmax/Mmax ratio of the subject's left lower limb was measured before and after treatment. As a result, the Hmax/Mmax ratio changed from 37% before treatment to 20% after treatment.

DISCUSSION

The rhythmic motions of the trunk decrease the abnormal muscle tone and cause muscle relaxation[12]. Lechner, Feldhaus, Gudmundsen, Hegemann, Michel, Zäch, Knecht[13] reported that the rhythmic motions of the trunk in hippotherapy in patients with spinal cord injury decreased the muscle tone of the lower limbs. However, their findings could not be objectively and quantitatively evaluated because they used MAS. The H-reflex method used in this study is a useful test for observing the excitation and inhibition of spinal cord motor neurons. The amplitude of the H-reflex indicates the degree of excitation and inhibition of the spinal cord motor neurons[14]. In other words, an increase of the amplitude of the H-reflex implies the excitation of the motor neuron pool and a decrease of the amplitude implies the inhibition of the motor neuron pool[15]. The Hmax/Mmax ratio indicates the ratio of the motor neurons contributing to the H-reflex and represents the degree of excitation of the motor neurons. Therefore, the excitation of motor neurons can be measured with the Hmax/Mmax ratio, which can serve as an indicator of spasticity. In this study, the Hmax/Mmax ratio decreased after the trunk stabilization exercises, which can be explained as a decrease of spasticity because the excitation of the spinal cord motor neurons decreased after the trunk stabilization exercise. In the early stage of motor learning, the unnecessary degree of freedom is decreased to simplify movements. This gives stability and facilitates the learning of motions by fixing the angles of various joints involved in the motions[16]. This type of movement strategy also appears in the early stage of balance development during which the degrees of freedom of the legs and trunk are restricted to enable the selective movements of the muscles surrounding the ankle joint. With the progress of learning, the degrees of freedom of the legs and trunk increase, which in turn improves the balance performance capability[17]. Also, in this study, a more selective movement control of the lower limb was possible because the trunk stabilization exercise that induced cocontraction of the trunk restricted the degree of freedom of the body. This study has the limitation of having a single subject; however, the result shows that a combination of the trunk stabilization exercise with other exercises could help better control the muscle tone in the clinical treatment of hemiplegic patients.

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