Gait Rehabilitation in Patients with Calf Muscle Spasticity

Choong Hyun Kim
Center for Bionics, Korea Institute of Science and Technology, Seoul, Korea

*Corresponding author: Choong Hyun Kim, Center for Bionics, Korea Institute of Science and Technology, Seoul, Korea, Tel: +82-2-958-5668; E-mail: chkim@kist.re.kr

Received date: June 20, 2016; Accepted date: June 29, 2016; Published date: July 05, 2016

Introduction

Spasticity is one of the major complaints of patients with spinal cord injuries. It has negative effects such as limitations in activities of daily living (ADLs), pain, fatigue, sleep disorders, instability, joint contractures, pressure ulcers, and infection, and decreases gait ability through changes in timing of gait-related muscle contraction and co-contraction [1,2]. Spasticity, also, is a major factor inhibiting functional recovery, as it reduces joint range of motion (ROM), joint contracture, and severe functional impairment of ADLs [3]. Erik et al. emphasized that aggressive treatment of spasticity is required as patients with spasticity have a 1-year treatment cost more than 4 times higher than that of patients without spasticity, indicating that spasticity increases not only functional limitations but also increases the financial burden [4,5]. Therefore, a multidisciplinary approach is being attempted to control spasticity in clinical settings.

The treatments generally used for the relief of spasticity in patients with spinal cord injury include medical treatments, physical therapy, and surgical therapy [6]; among them, medical treatment is the most common [7]. However, prescribed anti-spastic medications have adverse effects such as sedation, drowsiness, insomnia, fatigue, muscle weakness, ataxia, dizziness, hypotension, depression, reduction of memory and attention, hallucination, and toxicity-induced hepatic damage, which may negatively affect the quality of life of patients with spinal cord injury [8].

In physical therapy, electrical stimulation therapy, heat therapy, stretching stimulation therapy, and vibratory stimulation therapy are currently used [9]. Vibratory stimulation, as a method of somatosensory stimulation for the functional recovery of patients with brain lesions, has merits, in that, it has no significant adverse effects and no effort to learn an exercise method is necessary [10]. Interest in vibratory stimulation therapy has been increasing, as studies about rehabilitation therapy are being increasingly published since the 1990s [11]. Particularly, it has been reported that vibratory stimulation has significant inhibitory effects in patients with abnormal muscle contraction [12,13], and is effective in reducing spasticity in paralyzed patients [14]. This study showed that the reduction of spasticity in patients with spinal cord injury occurred by promoting reciprocal inhibition through vibration and interrupting the reflex causing spasticity [14]. That is, vibratory stimulation can have both stimulant and inhibitory effects in spinal reflex activity simultaneously. The stimulatory effect of vibration increases muscle contraction by constantly stimulating the vibration reflex, activating the muscle spindles receiving the vibration [15]. At the same time, vibration can have an inhibitory effect on spinal reflex activity. In spinal injuries, motor function abnormality and pain are caused by loss of presynaptic inhibition, and vibration can increase presynaptic inhibition [16]. Vibration also causes Achilles stimulation as well as the inhibition of the soleus Hoffmann reflex occurring at the la afferent terminal of soleus [17]. Although the vibratory stimulus releases acetylcholine, a major neurotransmitter of muscle contraction, by stimulating primary afferent muscle fibers, constant stimulation of this may cause reduction of muscle contraction by neurotransmitter depletion and reducing the excitation of motor neurons. It has previously been shown that there are few adverse effects of vibration therapy in studies that used vibration therapy for therapeutic purpose in normal adults, the elderly, and children [18].

In our previous study [19], we developed a downsized local vibrator and demonstrated that local vibration with stimulation parameters of 70 Hz and a 65 µm amplitude using the local vibrator on the gastrocnemius belly reduced the H-reflex, which was a quantitative indicator of alteration in the segmental reflex pathway, more than that on the Achilles tendon. A number of studies proved the physiologic effects of local vibration in young healthy subjects [20-25], and these effects were eventually applied to patients with neurologic disorders. Therefore, the purpose of the study was to determine effective local muscle stimulation parameters to inhibit the H-reflex of the gastrocnemius in young healthy subjects.

We also suggest that local muscle vibration may be an adjuvant therapy for gait rehabilitation in patients with calf muscle spasticity [26]. In this study, muscle stimulation with parameters of 80 Hz and 0.3 mm amplitude for local vibration on the gastrocnemius effectively inhibit the segmental reflex pathway.

It is supposed that the application of vibration therapy would be an effective intervention to reduce spasticity of gastrocnemius in patients with calf muscle spasticity. This may help the posture as well as the mobility of patients with calf muscle spasticity and ultimately have positive effects on their quality of life.

References

1. Ness LL, Field-Fote EC (2009) Whole-body vibration improves walking function in individuals with spinal cord injury: a pilot study. Gait Posture 30: 436-440.
2. Ahn MC, Song CH (2016) Immediate Effects of Local Vibration on Ankle Plantar Flexion Spasticity and Clonus of both the Gastrocnemius and Soleus in Patients with Spinal Cord Injury. J Korean Soc Phys Med 11: 1-11.
3. Welmer AK, von Arbin M, Widén Holmqvist L, Sommerfeld DK (2006) Spasticity and its association with functioning and health-related quality of life 18 months after stroke. Cerebrovasc Dis 21: 247-253.
4. Lundström E, Smits A, Borg J, Trérent A (2010) Four-fold increase in direct costs of stroke survivors with spasticity compared with stroke survivors without spasticity: the first year after the event. Stroke: 41: 319-324.
5. Bae SH, Kim KY (2011) Effects of Vibration Stimulation Method on Upper Limbs Spasticity in Patients with Brain Lesion. J Korea Academia-Industrial Cooperation Society 12: 3109-3116.
6. Adams MM, Hicks AL (2005) Spasticity after spinal cord injury. Spinal Cord 43: 577-586.

7. Gracies JM, Nance P, Elovic E, McGuire J, David M (1997) Traditional pharmacological treatments for spasticity. Part II: General and regional treatments. Muscle Nerve Suppl 20: 92-120.

8. Burchiel KJ, Hsu FP (2001) Pain and spasticity after spinal cord injury: mechanisms and treatment. Spine 26: S146-S160.

9. Noma T, Matsumoto S, Etoh S, Shimodozono S, Kawahira K (2009) Anti-spastic effects of the direct application of vibratory stimuli to the spastic muscles of hemiplegic limbs in post-stroke patients. J Rehabil Med 23: 623-631.

10. Cardinale M, Wakeling J (2005) Whole body vibration exercise: are vibrations good for you? J Sports Med 39: 585-589.

11. Rittweger J, Just K, Kautzsch K, Reeg P, Felsenberg D (2002) Treatment of chronic lower back pain with lumbar extension and whole-body vibration exercise: a randomized controlled trial. Spine 27: 1829-1834.

12. Ageranoti SA, Hayes KC (1990) Effects of vibration on hypertonia and hyperreflexia in the wrist joint of patients with spastic hemiparesis. Physiother Can 42: 24-33.

13. Shirahashi I, Matsumoto S, Shimodozono M, Etoh S, Kawahira K (2007) Functional vibratory stimulation on the hand facilitates voluntary movements of a hemiplegic upper limb in a patient with stroke. Int J Rehabil Res 30: 227-230.

14. Ahlborg L, Andersson C, Julin P (2006) Whole-body vibration training compared with resistance training: effect on spasticity, muscle strength and motor performance in adults with cerebral palsy. J Rehabil Med 38: 302-308.

15. Desmedt JE (1982) Mechanisms of vibration-induced inhibition or potentiation: tonic vibration reflex and vibration paradox in man. Adv Neurol 39: 671-683.

16. Schieppati M (1987) The Hoffmann reflex: a means of assessing spinal reflex excitability and its descending control in man. Prog Neurobiol 28: 345-376.

17. Kohn AF, Floeter MK, Hallett M (1997) Presynaptic inhibition compared with homosynaptic depression as an explanation for soleus H-reflex depression in humans. Exp Brain Res 116: 375-380.

18. Ness LL, Field-Fote EC (2009) Effect of whole-body vibration on quadriceps spasticity in individuals with spastic hypertonia due to spinal cord injury. Restor Neurol Neurosci 27: 623-633.

19. Lee G, Cho Y, Beom J, Chun C, Kim CH, et al. (2014) Evaluating the differential electrophysiological effects of the focal vibrator on the tendon and muscle belly in healthy people. Ann Rehabil Med 38: 494-505.

20. Desmedt JE, Godaux E (1978) Mechanism of the vibration paradox: excitatory and inhibitory effects of tendon vibration on single soleus muscle motor units in man. J Physiol 285: 197-207.

21. Lapole T, Canon F, Perot C (2012) Acute postural modulation of the soleus H-reflex after Achilles tendon vibration. Neurosci Lett 523: 154-157.

22. Iles JF, Roberts RC (1987) Inhibition of monosynaptic reflexes in the human lower limb. J Physiol 385: 69-87.

23. Roll JP, Vedel JP, Ribot E (1989) Alteration of proprioceptive messages induced by tendon vibration in man: a microneurographic study. Exp Brain Res 76: 213-222.

24. Dindar F, Verrier M (1975) Studies on the receptor responsible for vibration induced inhibition of monosynaptic reflexes in man. J Neurol Neurosurg Psychiatry 38: 155-160.

25. Narita T, Liang N, Morishita T, Ninomiya M, Morisaki K, et al. (2010) Spinal neuronal mechanisms explaining the modulation of soleus H-reflexes during sustained passive rotation of the hip joint. Clin Neurophysiol 121: 1121-1128.

26. Seo HG, Oh BM, Leigh JH, Chun C, Park C, et al. (2016) Effect of Focal Muscle Vibration on Calf Muscle Spasticity: A Proof-of-Concept Study. PM R 8(3):1482-1487.