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Original Article

The Effect of Somatosensory and Cognitive-motor Tasks on the Paretic Leg of Chronic Stroke Patients in the Standing Posture

Sung-kwang Ju[1)], Won-gyu Yoo[2)*]

[1)] Department of Physical Therapy, The Graduate School, Inje University, Republic of Korea
[2)] Department of Physical Therapy, College of Biomedical Science and Engineering, Inje University: 607 Obangdong, Gimhae, Gyeongsangnam-do 621-749, Republic of Korea

Abstract. [Purpose] The purpose of this study was to investigate how different standing surfaces alter somatosensory input and how postural control is affected by these changes during the performance of a dual task with a cognitive-motor aspect. [Subjects] The subjects were 20 chronic stroke patients: 18 males, 2 females. [Methods] COP total distance, sway velocity, and the weight load on the paretic leg were measured while subjects performed the following three tasks (somatosensory task, cognitive-motor task, and dual task). [Results] Both COP total distance and sway velocity significantly decreased during the performance of all tasks. COP total distance and sway velocity significantly decreased during the somatosensory task and the dual task. The weight load significantly increased during performance of the somatosensory task and the dual task. [Conclusion] Compensatory mechanisms in the non-paretic leg were limited by placing it on an air cushion, and we observed an increase in somatosensory input from the paretic leg due to an enhanced weight load.
Key words: Cognitive motor task, Dual task, Somatosensory task

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INTRODUCTION

The after-effects of stroke commonly include muscle weakness on one side of the body, and due to this muscle imbalance of the paretic side, stroke patients often exhibit an asymmetrical posture and an imbalance in weight load during standing[1)]. The appearance of abnormal postural sway during the maintenance of a standing posture is also evident in chronic stroke patients[2)]. Important training goals for their functional recovery are improvements in balance ability and postural control[3)]. Postural control relies on somatosensory input from the foot which, in the rehabilitation of stroke patients, is placed on an unstable support surface that increases postural sway[4)]. Postural control is an automatic response of the body which is elicited by unconscious or reflexive processes[5)]. However, studies using a dual task have found that cognitive attentional systems within the brain influence postural control during maintenance of a standing posture[6)]. Therefore, the aim of the present study was to investigate how different standing surfaces alter somatosensory input and how postural control is affected by these changes during the performance of a dual task with a cognitive-motor aspect.

*Corresponding author. Won-gyu Yoo (E-mail: won7y@inje.ac.kr)

SUBJECTS AND METHODS

The study subjects were 20 stroke patients (18 males, 2 females) with a mean time since stroke onset of 28.08 ± 17.93 months, who were aged 57.56 ± 11.17 years (mean ± SD) and had a mean weight and height of 67.35 ± 10.01 kg and 168.90 ± 5.97 cm, respectively. The subjects provided their informed consent before participating in this study which was approved by the Inje University Faculty of Health Sciences Human Ethics Committee. Two force-plates (AMTI, Newton, MA, USA) were used to collect data which was sampled at 200 Hz. The surfaces used to provide somatosensory input were a Togu Dyn-Air (TOGU Gebr., Germany) and a wood board. Initially, all subjects were instructed to look forward with their feet shoulder-width apart for 30 seconds while COP total distance, sway velocity, and the weight load on the paretic leg were measured. Next, all subjects performed the following three tasks in a random order: a somatosensory task, a cognitive-motor task, and a dual task. The somatosensory task involved standing while facing toward the front with the non-paretic leg placed on the air cushion and the paretic leg on the wood board. In the cognitive-motor task, all subjects were asked to stand and hold a tray with a cup that was two-thirds full of water without spilling the water. In the tray-holding posture, the arms were held forward and elevated to 90° with the elbows extended at 0° and the forearm in mid-position[5)]. The dual task involved placing the non-paretic leg on the air cushion and the paretic leg on the wood board in the same posture as in the somatosensory task while holding a tray with a

Table 1. Postural sway and weight loading during the various tasks

Tasks	Dual	Somatosensory	Cognitive motor	Standing
Distance (cm)	206.9±16.7	221.2±18.7	233.5±14.3	245.0±16.7
Velocity (cm/s)	6.9±0.5	7.3±0.6	7.7±0.4	8.1±0.5
Weight-load (kg)	42.0±2.8	41.5±3.5	34.6±3.4	32.9±4.2

cup of water as in the cognitive-motor task. Each task was performed three times for 30 seconds separated by a rest interval of 10 seconds. Data analyses were performed using SPSS 20.0 for Windows. One-way repeated analysis of variance was conducted to identify significant differences among the performances of the tasks. A post hoc least significance difference analysis with a significance level of $\alpha = 0.05$ was performed to evaluate differences among tasks.

RESULTS

Both COP total distance and sway velocity significantly decreased during the performance of all tasks compared with during the maintenance of a quiet standing posture ($p < 0.05$). COP total distance and sway velocity significantly decreased during the somatosensory task compared with the cognitive-motor task, and during the dual task compared with the somatosensory and cognitive-motor tasks ($p < 0.05$). The weight load significantly increased during performance of the dual task and the somatosensory task compared with during performance of the cognitive-motor task and quiet standing ($p < 0.05$) (Table 1).

DISCUSSION

Somatosensory input from the foot and ankle is important for postural control when maintaining a quiet standing posture and is incorporated into the automatic maintenance of balance through the contraction of postural muscles[7]. High levels of pressure on the plantar surface can reduce postural sway via stimulation of mechanoreceptors[8]. In the present study, afferent sensory information from the plantar surface of the non-paretic side was reduced when participants maintained their posture with the non-paretic leg placed on the air cushion, and more pressure was placed on the plantar surface of the paretic leg situated on the wood board. Thus, postural sway was likely reduced due to enhancement of somatosensory information from the paretic leg. Our present findings reveal that COP total distance and sway velocity decreased during performance of a cognitive-motor task relative to while maintaining a quiet standing posture. The performance of a cognitive task while maintaining a standing posture serves to reduce internal focus and redirect focus to external stimuli, which enhances the automatic processes supporting postural control[9]. In the present study, the cognitive-motor task, that required stroke patients to lift a tray with a cup of water on it, reduced postural sway. This was likely due to external focus on the movement of the water, which would have identified sway, and less internal focus on actively maintaining the posture. Moreover, COP total distance and sway velocity were reduced during performance of the dual task relative to the performance of either single task. A dual task performed in a standing posture decreases focus on postural control and results in a reduction of postural sway via a greater focus on external factors[10]. Furthermore, the weight load of the paretic leg increased during performance of the somatosensory task. In the present study, compensatory mechanisms in the non-paretic leg were limited by placing it on an air cushion, which resulted in an increase in somatosensory input from the paretic leg due to enhanced weight load.

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