

The Effect of Lightly Gripping a Cane on Sit-to-stand Transfer in Post-stroke Patients

Young-eun Choi¹, PhD, PT, Duk-hyun An², PhD, PT

¹Dept. of Physical Therapy, Kaya University

²Dept. of Physical Therapy, College of Healthcare Medical Science & Engineering, Inje University

Abstract

Background: Light touch cue is a sensory input that could potentially help in the control of posture. The immediate stimulatory effect of light touch cues using a cane during gait is associated with postural stability. This strategy can help post-stroke individuals regain their ability to perform the sit-to-stand (STS) transfer safely.

Objects: The effects of light grip on postural control during the STS transfer in post-stroke subjects were investigated.

Methods: Eleven participants (6 men, 5 women) with hemiplegia due to stroke were recruited in the study. The subjects with hemiparesis performed STS transfer in three randomly assigned conditions (1) without a cane (2) light grip with a cane (3) strong grip with a cane.

Results: The difference in weight-bearing distribution between the left and right feet, when the subjects were instructed to stand up, was $52.73 \pm 2.13\%$ without a cane, $42.75 \pm 3.26\%$ with a strong grip, and $43.00 \pm 2.55\%$ with a light grip ($p < .05$). The rate of rise in force indicates the peak power provided by subjects during their STS transfers. The rate of rise in force was statistically significantly lower without a cane than that with a light grip or a strong grip ($p < .05$). The subjects' centers of pressure sway on the mediolateral side during STS transfers statistically significantly declined with a light grip or a strong grip when compared to those without a cane ($p < .05$).

Conclusion: When the subjects with hemiparesis used a cane during STS transfers, their duration, center of pressure sway, and difference in weight-bearing distribution were all reduced. The subjects also exhibited similar results during STS transfers with a cane gripped lightly. This result may provide guidelines for the use of assistive devices when patients with hemiparesis practice STS transfers in clinical settings.

Key Words: Cane; Rehabilitation; Sit-to-stand; Stroke.

Introduction

Somatosensory input through the hands and fingers assists with postural control. Lightly touching a rigid fixed object during quiet standing is known to decrease postural sway (Clapp and Wing, 1999; Krishnamoorthy et al, 2002). This is also observed when one lightly touches an unstable object, such as a mobile stick or the upper part of one's own thigh. Lightly touching an object provides information on the relative movement of body segments and helps

the trunk, arms, and thighs to sense their movements relative to one another (Jecka and Lackner, 1994; 1995).

Studies have been conducted on the association between postural sway and light touch during quiet standing (Johannsen et al, 2007; Reginella et al, 1999; Rogers et al, 2001). Some studies investigated the effects of light touch during dynamic postural control, including extending one arm reaching as far forward as possible without stepping, taking a single-leg stance, and walking (Boonsinsukh et al, 2009;

Oshita and Yano, 2015). Compared to using a cane with contact force, light touch allows for the greater activation of the paretic weight-bearing leg muscles (Boonsinsukh et al, 2009).

Although gait is important to study in the rehabilitation of stroke patients, an essential prerequisite of walking is the ability to stand up from the sitting position on a chair. It is difficult for post-stroke individuals to recover their ability to safely rise from a chair (Boukadida et al, 2015). Their center of mass deviates to the affected side, and the displacement of their center of pressure increases in the anterior and mediolateral directions (Cheng et al, 1998; Duclos et al, 2008). The immediate stimulatory effect of light touch cues using a cane during gait is associated with postural stability (Boonsinsukh et al, 2009). This strategy can help post-stroke individuals regain their ability to perform the sit-to-stand (STS) transfer safely. However, some patients are unable to perform light touch contact with a cane even after a large amount of practice, as they cannot control the amount of cane force required to achieve the light touch threshold (Oshita and Yano, 2015).

Light grip sufficiently improves sway independent from a support, such as a cane. Thus, light grip improves postural stability when contact force is provided to the fingers. This is useful and can be applied to activities of daily living. The association between light touch and postural control during the STS transfer has not been fully examined; therefore, in this study, the effects of light grip on postural control during the STS transfer in post-stroke subjects were investigated.

Methods

Subjects

Eleven participants (6 men, 5 women) with hemiplegia due to stroke were recruited in the present study. Subjects were included in the study if they

(1) were more than 6 months post-stroke, (2) were able to stand up independently from a standard chair without using their arms or hands (3) were able to tolerate two hours of testing with appropriate rest periods, (4) had residual muscular weakness and motor impairment of the paretic lower limb (Chedoke-McMaster Stroke Assessment leg and foot score of <12), and (5) were able to maintain standing independently for at least 60 sec. Subjects were excluded from the study if they (1) had cognitive or language impairment, (2) had severe hemineglect, (3) had bilateral cerebral impairment, (4) had brainstem and cerebellar lesions, (5) had impaired touch and pressure sensation on the non-paretic hand, or (6) had a musculoskeletal disorder. Before starting this experiment, we explained the purpose of the study and obtained voluntary consent from all subjects.

Procedures

Kinetic data were obtained by two force plates (Kistler 9260AA6, Kistler Instruments AG, CH-8408 Winterthur, Switzerland). The sampling frequency was 1000Hz. The two force plates were used to measure the force under each foot. The subjects were seated on a chair with adjustable height and no backrest or armrest. The height of the chair was adjusted to the distance from the floor to the knee joint center of each subject. Their feet were placed parallel with one foot on each force plate, with a 10~15 cm spacing based on the medial border of the

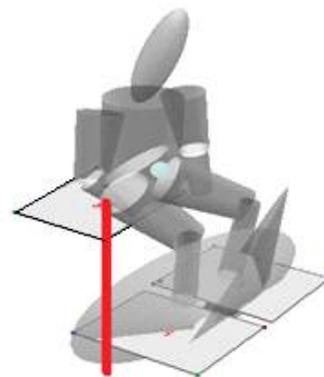


Figure 1. The set up for sit-to-stand with cane.

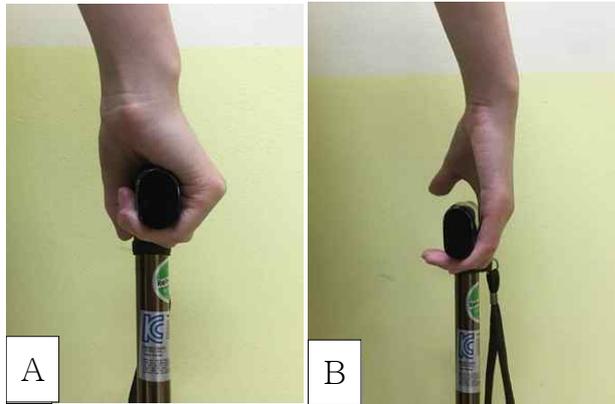


Figure 2. Methods of cane use (A) Depend on grip (B) Light grip

feet. The ankle was positioned at 10° of dorsiflexion, and the knee angle was flexed at 100~105°. The subjects performed three STS transfer at their self-selected comfortable speed (Figure 1). The first task was to perform the STS transfer and generate a strong muscular force to support their body weight while strongly gripping a standard cane with their non-paretic hand. The second task was to perform the STS transfer without generating muscular force while lightly touching or gripping a standard cane with their non-paretic hand, in which the touching force would be insufficient to provide mechanical body support (Figure 2). The third task was to perform a natural STS transfer. This task was initiated by the word start and was considered complete when the subject's body weight became equal to the

vertical force at the end of the rising phase. The length of the cane was adjusted to be 15cm away from the border of the fifth toe when each subject was in the standing position holding a cane with their elbow joint flexed at 20~30°. Each subject performed each of the three STS transfer five times with a light grip, with a strong grip, and without a cane. The order of STS transfer was randomly decided, and each subject performed the STS transfer 15 times in total. To prevent fatigue, the subjects were allowed to rest for 5~10 min after each trial.

Data analysis

The peak vertical force during the STS transfer was calculated as a percentage of each subject's total body weight. The difference in total weight bearing between the subject's paretic and non-paretic legs and the change in force over time were calculated, and the force of each variable was represented by the peak power of the subject. The center of pressure sway for the whole body was calculated by the mediolateral displacement and the anteroposterior displacement.

Statistical analysis

Statistical analysis was performed using a one-way repeated measures analysis of variance. Significant differences between the three different conditions of the STS were evaluated with post-hoc

Table 2. Comparison of body weigh distribution, rate of rise, and COP sway during the sit to stand movement in the three task (N=11)

	WC ^a	FG ^b	LG ^c	p	F
Duration (sec)	5.48±.25 ^{ij}	3.66±.16 ^j	3.71±.17 ⁱ	<.001	10.417
LR-VF-Diff ^d (%BW ^e)	52.73±2.13 ^{ij}	42.75±3.26 ^j	43.00±2.55 ⁱ	<.001	17.818
Max VF ^f (%BW)	102.82±4.10 ^{ij}	107.00±3.52 ^j	106.84±3.02 ⁱ	<.001	7.413
Rate of rise in force (%BW/sec)	37.18±1.85 ^{ij}	46.97±1.46 ^j	46.74±1.43 ⁱ	<.001	5.512
COP ^g X (cm)	23.67±1.57 ^{ij}	14.20±.95 ^j	14.03±1.03 ⁱ	<.001	12.270
COP Y (cm)	13.60±.84	14.37±.94	14.40±.89	.080	3.082

^awithout a cane, ^bforce grip with a cane, ^clightly grip with a cane, ^dvertical force difference between left and right, ^ebody weight, ^fpeak vertical force, ^gcenter of pressure, ^hsignificantly different compared with WC, ⁱsignificantly different compared with FG, ^jsignificantly different compared with LG.

multiple comparison using Bonferroni test. Values of $p < .05$ were considered statistically significant. These analyses were performed using PASW 18.0.

Results

The subjects were 52.1 ± 9.0 years of age, 69.3 ± 12.3 kg in weight, and 1.7 ± 0.7 m in height. Other clinical characteristics are presented in Table 1. The subjects' motor and sensory deficits ranged from mild to moderate levels. When the subjects were instructed to stand up at their self-paced speeds, the mean time for the movement was $5.48 \pm .25$ sec without a cane, $3.71 \pm .17$ sec with a cane gripped lightly, and $3.66 \pm .16$ sec with a cane gripped strongly ($p < .05$). While performing STS transfers, the subjects' weight-bearing distribution was asymmetric. The difference in weight-bearing distribution between the left and right feet, when the subjects were instructed to stand up, was $52.73 \pm 2.13\%$ without a cane, $42.75 \pm 3.26\%$ with a strong grip, and $43.00 \pm 2.55\%$ with a light grip ($p < .05$). The rate of rise in force indicates the peak power provided by subjects during their STS transfers. The rate of rise in force was statistically significantly lower without a cane than that with a light grip or a strong grip ($p < .05$). The subjects' centers of pressure sway on the mediolateral side during STS transfers statistically significantly declined with a light grip or a strong grip when compared to those without a cane ($p < .05$).

Discussion

Standing up from a sitting position is one of the most common activities in daily life, but one-third of stroke patients experience a fall during this movement (Barreca et al, 2004; 2007). Therefore, it is useful to refer to information on compensatory maneuvers during STS transfers and to the effects of different ways of using a cane on dynamic postural balance.

Table 1. Characteristics of subjects (N=11)

Characteristics	Values
Number (N)	11
Sex (female/male)	5/6
Age (year)	52.1 ± 9.0^a
Side affected (right/left)	4/7
Type of stroke (hemorrhage/infarction)	3/8
Duration of stroke (month)	27.1 ± 32.0
Body weight (kg)	69.3 ± 12.3
Body height (m)	1.7 ± 0.7
CM ^b leg	5(3~6)
CM foot	4(2~5)
CM postural control	5(4~6)

^amean±standard deviations, ^bChedoke-McMaster Stroke Assessment.

STS transfers in a naturally sitting position without a cane resulted in an overall longer movement time than STS transfers with a light or strong grip. A faster movement time provides advantages such as increased movement speeds, joint moments, quadriceps activation, and mobility (Pai et al, 1994; Yoshioka et al, 2009). In other studies, the mean movement time of stroke patients during STS transfers was 6.15 secs without a cane and 5.30 sec with a cane, showing a decline in the movement time when a cane was used (Hu et al, 2013). While the patients' mean movement time with a cane gripped lightly was longer than the equivalent with a cane gripped strongly, no statistically significant difference was observed. When the cane was gripped lightly, feedforward mechanisms may have been activated in the cutaneous receptors of the fingers and palms and in the proprioceptive receptors of the fingers, wrists, and shoulder joints, and therefore, this may have helped with postural control during the STS transfers (Johannsen et al, 2007). This is because tactile sensations which are entered via light contacts provide information on relative changes to the body segments, and postural maintenance becomes easier in the presence of tactile information than it is in the absence of such information (Tremblay et al, 2004; 2005).

The difference in the subjects' body-weight distribution between the nonparetic and paretic legs was smaller during STS transfers with a cane gripped lightly or strongly when compared to the difference without a cane. Patients with hemiparesis showed obviously higher levels of weight-bearing asymmetry than healthy adults (Brunt et al, 2002; Cheng et al, 1998; Engardt, 1994; Roy et al, 2006). In other studies, the asymmetry showed a statistically significant decline during STS transfers with a cane when compared to without a cane. In a study by Hu et al (2013), when the subjects performed STS transfers with a cane, the sum of their hip and knee joint moments in the paretic leg increased by 0.44 N·m/kg compared to the sum without a cane (Hu et al, 2013). The present study also confirmed the beneficial effect of canes, since the asymmetry decreased during STS transfers with a cane. This result was also similar to that of a previous study in which the use of a cane by stroke patients improved their standing balance and gait in a standing position.

The asymmetry in patients also decreased during STS transfers with a cane gripped lightly compared to that without a cane, which was similar to the result when a cane was gripped strongly. Hesse et al (1994) and Mazzà et al (2006) reported that subjects with hemiparesis showed trunk displacement toward the non-affected side before seat-off. In relation to this finding, Duclos et al (2008) explained that there is a correlation between the asymmetrical weight bearing of stroke patients during STS transfers and their trunk translation toward the non-affected side. While the body cannot be mechanically supported when a cane is gripped lightly, increased tactile sensations entered by the touched surface may have activated the postural control system.

The results of the present study showed that the centers of pressure sway declined under the conditions of light and strong grips. In stroke patients, large centers of pressure sway appear in the medio-lateral direction, which indicates poor dynamic postural stability and a high risk of falling.

This study has some limitations. First, since it involved 11 subjects who did not use a cane on a regular basis, large data of various types could not be produced. Second, the study used a small number of samples. Therefore, future studies are required to compare subjects at different stages of recovery using greater numbers of samples.

Conclusion

When the subjects with hemiparesis used a cane during STS transfers, their duration, center of pressure sway, and difference in weight-bearing distribution were all reduced. The subjects also exhibited similar results during STS transfers with a cane gripped lightly. This result may provide guidelines for the use of assistive devices when patients with hemiparesis practice STS transfers in clinical settings.

References

- Barreca S, Sigouin CS, Lambert C, et al. Effects of extra training on the ability of stroke survivors to perform an independent sit-to-stand: A randomized controlled trial. *J Geriatr Phys Ther.* 2004;27(2):59-64.
- Barreca SR, Masters L, Sigouin CS. Sit-to-stand training improves standing performance and quality of life in residents living in long-term care homes following a stroke. *Stroke.* 2007; 38(2):474.
- Boonsinsukh R, Panichareon L, Phansuwan-Pujito P. Light touch cue through a cane improves pelvic stability during walking in stroke. *Arch Phys Med Rehabil.* 2009;90(6):919-926. <http://doi.org/10.1016/j.apmr.2008.12.022>
- Boukadida A, Piotte F, Dehail P, et al. Determinants of sit-to-stand tasks in individuals with hemiparesis post stroke. *Ann Phys Rehabil Med.* 2015;

- 58(3):167-172. <http://doi.org/10.1016/j.rehab.2015.04.007>
- Brunt D, Greenberg B, Wankadia S, et al. The effect of foot placement on sit to stand in healthy young subjects and patients with hemiplegia. *Arch Phys Med Rehabil.* 2002;83(7):924-929.
- Cheng PT, Liaw MY, Wong MK, et al. The sit-to-stand movement in stroke patients and its correlation with falling. *Arch Phys Med Rehabil.* 1998;79(9):1043-1046.
- Clapp S, Wing AM. Light touch contribution to balance in normal bipedal stance. *Exp Brain Res.* 1999;125(4):521-524.
- Duclos C, Nadeau S, Lecours J. Lateral trunk displacement and stability during sit-to-stand transfer in relation to foot placement in patients with hemiparesis. *Neurorehabil Neural Repair.* 2008;22(6):715-722. <http://doi.org/10.1177/1545968308316000>
- Engardt M. Rising and sitting down in stroke patients. Auditory feedback and dynamic strength training to enhance symmetrical body weight distribution. *Scand J Rehabil Med Suppl.* 1994; 31:1-57.
- Hesse S, Schauer M, Malezic M, et al. Quantitative analysis of rising from a chair in healthy and hemiparetic subjects. *Scand J Rehabil Med.* 1994;26(3):161-166.
- Hu PT, Lin KH, Lu TW, et al. Effect of a cane on sit-to-stand transfer in subjects with hemiparesis. *Am J Phys Med Rehabil.* 2013; 92(3):191-202. <http://doi.org/10.1097/PHM.0b013e318282c8f0>
- Johannsen L, Wing AM, Hatzitaki V. Effects of maintaining touch contact on predictive and reactive balance. *J Neurophysiol.* 2007;97(4):2686-2695.
- Krishnamoorthy V, Slijper H, Latash ML. Effects of different type of light touch on postural sway. *Exp Brain Res.* 2002;147(1):71-79.
- Mazzà C, Stanhope SJ, Taviani A, et al. Biomechanical modeling of sit-to-stand to upright posture for mobility assessment of persons with chronic stroke. *Arch Phys Med Rehabil.* 2006;87(5): 635-641.
- Oshita K, Yano S. The effect of lightly gripping a cane on the dynamic balance control. *Open Biomed Eng J.* 2015;23(9):146-150. <http://doi.org/10.2174/1874120701509010146>
- Pai YC, Naughton BJ, Chang RW, et al. Control of body centre of mass momentum during sit-to-stand among young and elderly adults. *Gait Posture.* 1994;2(2):109-116.
- Reginella RL, Redfern MS, Furman JM. Postural sway with earth-fixed and body-referenced finger contact in young and older adults. *J Vestib Res.* 1999;9(2):103-109.
- Rogers MW, Wardman DL, Lord SR, et al. Passive tactile sensory input improves stability during standing. *Exp Brain Res.* 2001;136(4):514-522.
- Roy G, Nadeau S, Gravel D, et al. The effect of foot position and chair height on the asymmetry of vertical forces during sit-to stand and stand-to-sit tasks in individuals with hemiparesis. *Clin Biomech(Bristol, Avon).* 2006;21(6):585-593.
- Tremblay F, Mireault A, Dessureault L, et al. Postural stabilization from fingertip contact: I. Variations in sway attenuation, perceived stability and contact forces with aging. *Exp Brain Res.* 2004;157(3):275-285.
- Tremblay F, Mireault A, Dessureault L, et al. Postural stabilization from fingertip contact II. Relationships between age, tactile sensibility and magnitude of contact forces. *Exp Brain Res.* 2005;164(2):155-164.
- Yoshioka S, Nagano A, Hay DC, et al. Biomechanical analysis of the relation between movement time and joint moment development during a sit-to-stand task. *Biomed Eng Online* 2009;8:27. <http://doi.org/10.1186/1475925x-8-27>
-
- This article was received October 15, 2017, was reviewed October 15, 2017, and was accepted November 15, 2017.