Research Article

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# Effects of light touch on balance in patients with stroke

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**Abstract**: Light touch is the combination of cutaneous and kinesthetic inputs. The literature suggests that light touch compensates for a reduced amount of center of pressure information in older peoples, blind subjects and patients with neurological disorder. This study investigated the effects of light touch applied to an external bar, on the postural sway in individuals with hemiparetic stroke. We used a cross sectional study, fifteen individuals with stroke and 15 healthy age-matched adults stood as still as possible on a force plate. Experimental trials (duration, 30 s) included two visual conditions (open eyes and closed eyes), two somatosensory conditions (no touch and light touch) and two support surface conditions (firm and foam surfaces). The area of center of pressure (COP) and the mean velocity of COP in the medio-lateral and anterior-posterior directions were assessed. For both groups, COP velocity and area decreased with light touch regardless of the visual or surface conditions. The effects of light touch were similar in both groups. In addition, results show that the effectiveness of light touch in reducing postural sway was greater on a foam surface than on a firm surface. Our findings indicate that light touch could be beneficial in postural control for individuals with hemiparetic stroke

**Keywords:** Balance; Light touch; Stroke

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## 1 Introduction

Because the center of mass (COM) is high in an upright bipedal stance and there is a small support base, constant postural adjustments are required to maintain balance [1]. Problems such as restricted range of motion in joints, weakened muscles, changes in myo-tonus, and sensory deficits, may cause deterioration in balance in stroke patients [2], and their postural sway while standing in place may be greater than that of a normal person [3].

Haptic sense is the combination of cutaneous and kinesthetic inputs from the mechanoreceptors embedded in the skin, muscles, and joints [4], and is essential to complex sensorimotor skills [5]. Recently, haptic sense plays an important role in maintaining postural control [6]. Holden et al. [7] reported that light touch from the fingertip was found to reduce postural sway in blind subjects by providing additional somatosensory information to the postural control system. In subjects with somatosensory dysfunction, somatosensory feedback from a finger touch may compensate for a reduced amount of center of pressure (COP) information being transmitted from the feet in a standing position, contributing to increased postural control [8]. According to Barela et al., the threshold for detection of passive ankle-joint movement is higher in older adults than younger adults [9]. It is related to the age-associated decline in proprioception in older adults. In this study, it is presumed that interventions using touch compensated for the decline in proprioception, thereby reducing postural sway.

To date, the effects of light tough on postural sway have been shown in patients with vestibular dysfunction [10], diabetic polyneuropathy [11], anterior cruciate ligament injury [12], cerebellar dysfunction [13] and stroke

[14]. Lackner et al. [10] reported that both healthy adults and subjects with a loss of vestibular function showed a greater reduction in postural sway with the provision of light touch than when we provided them visual information. Additionally, a study on blind subjects on the postural stabilizing effects based on the differences in applied force found that light touch showed effects comparable to those of heavy touch [15]. Such effect of light touch have been demonstrated while standing on one leg [7], in a tandem position [16], standing on a foam surface [11,17,18], and in a bipedal standing position.

Cunha et al. [14] studied the effect of light touch on stroke patients, and found that light touch reduced postural sway, and that its effects were greater with the eyes closed. However, the differences relating to the supporting surface were not compared. Additionally, it was not studied whether or not a light touch, on a foam surface, can reduce postural sway in stroke patients.

Therefore, this study investigated the effects of light touch under different visual and surface conditions on postural sway in stroke patients.

# 2 Materials and methods

## 2.1 Subjects

Fifteen participants with hemiparetic stroke and fifteen age-matched healthy adults participated in the study. The inclusion criteria for participants were as follows: those who were diagnosed with a first onset of unilateral hemisphere stroke, could stand independently for at least 1 minute, had no neglect of paretic limbs, had no severe sensory or visual deficit, had no vestibular deficit, and were able to understand and follow simple verbal instructions. Using the Mackinnon-Dellon Disk-Criminator, the researchers assessed the somatosensory sensations of the non-affected (dominant) index finger by clinical testing of testing for proprioception and by static two-point discrimination by the palmar aspect of the distal phalanx [18]. Two points between 4 mm was established as the normal limit for two-point discrimination [20,21]. All participants consented before participating in the study. The Institutional Review Board of Gachon University approved the study.

## 2.2 Protocol

The participants stood, barefoot and with their heels separated by a distance about of 16 cm, on a force platform (Wii balance board, Nintendo, Japan) for 30 s. This instrument has been reported to have a high test-retest reliability (intraclass correlation coefficient [ICC]=0.66-0.94) and high construct validity (ICC=0.77-0.89) [22]. The researchers marked foot positions on the force plate and maintained at the distance for each trial. Experimental trials included two visual (open eyes, closed eyes), two somatosensory (no touch, light touch) conditions, and two support surface (firm and foam) conditions. In the eyes open test, the subjects fixated on a point at eye level that is 1 m in front of them. During the light touch test, the participants touched, with their non-affected (dominant) index fingertip, an external bar, while keeping the affected (non-dominant) arm hanging passively at the side of the body. The experimenter checked the amount of force used and the participants reduced it every time when it was higher than 1 N on the bar. The participants could keep their elbow flexed at 90° while the height of bar was adjusted. For trials on the foam surface, subjects stood on balance pad (Airex, Aalen, Germany). Two trials under each condition were performed, with a total of 16 trials. The order of the trial was randomized for all participants. All subjects wore a harness and a therapist stood behind the participant for safety. The effect of muscle fatigue was minimized by providing a 1-min rest between trials. Data was transferred between the Wii balance board and laptop using the built-in Bluetooth and the Balancia v2.0 software (Minto-system, Seoul, Republic of Korea). The sampling rate was set at 50 Hz, and a 12 Hz low pass filtering was applied. The Balancia software has a high interrater reliability (ICC=0.89-0.79) and intrarater reliability (ICC=0.92-0.70) [23]. The measured parameters consisted of the area of COP sway and the mean velocity of COP displacement in the medio-lateral (ML) and anterior-posterior (AP) directions.

## 2.3 Statistical analysis

Repeated measures analyses of variance (ANOVA) were used to examine the effects of groups (stroke and control), surface (firm and foam), somatosensory (no touch and light touch) and visual (open and closed eyes) conditions on COP area. Mixed design multiple analyses of variance (MANOVA) were used to examine the effects of group, surface, somatosensory and visual conditions on COP velocity. The level of significance was set at $p \leq 0.05$. Statis-

**Table 1:** Common and clinical characteristics of the subjects (N=30) MMSE, mini-mental state examination.

| Variables | Stroke group (n=15) | Control group (n=15) |
|---|---|---|
| Sex | | |
| Male/Female | 9/6 | 8/7 |
| Age, years | 54.9 (10.9)a | 55.3 (10.7) |
| Height, cm | 165.7 (8.3) | 168.5 (6.5) |
| Weight, kg | 63.7 (8.0) | 65.4 (7.2) |
| Post-stroke duration, mo | 12.9 (4.7) | - |
| Paretic side | | - |
| Right/Left | 8/7 | - |
| Lesion type | | - |
| Hemorrhage/Ischemia | 7/8 | |
| MMSE | 26.1 (1.9) | 29.7 (0.5) |
| Sensory | | |
| Proprioception | | |
| Normal/reduced/absent | 14/1/- | 15/-/- |
| 2 point discrimination | | |
| Normal/reduced/Absent | 12/3/- | 15/-/- |

[a]mean (standard deviation)

tical analyses were performed using SPSS 18.0 (SPSS Inc., Chicago, IL, USA).

## 3 Results

Table 1 shows the common characteristics of the participants in this study. ANOVA indicated significant effect of group (F=61.268, p<0.001), surface (F=95.029, p<0.001), somatosensory (F=108.130, p<0.001) and visual (F=87.340, p<0.001) conditions on the COP area. However, there was no more double and triple interaction (p>0.05) (Fig 1).

The results of COP velocity were similar to those for COP area (Fig 2). Moreover, significant main effects of group (F=10.072, p=0.001), surface (F=68.730, p<0.001), somatosensory (F=46.688, p<0.001), and visual (F=70.206, p<0.001) conditions, MANOVA also indicated a significant interaction between somatosensory by surface and visual condition (F=3.714; p<0.05 and F=3.442, p<0.05). However, there was no more interaction (p>0.05). Univariate analyses revealed main effects of surface, somatosensory and visual conditions for both ML (F=92.221; p<0.001, F=78.017; p<0.001, and F=78.736; p<0.001, respectively) and AP (F=106.731; p<0.001, F=75.552; p<0.001 and F=105.557; p<0.001, respectively) directions, whereas the group and somatosensory by surface and visual condition interaction was significant only for ML direction (F=15.460; p=0.001, F=5.969; p<0.05, F=5.676; p<0.05). The ML COP velocity was increased in the closed eyes condition or in the foam surface condition. Light touch was more effective in reducing ML COP velocity on foam and in the closed eyes condition.

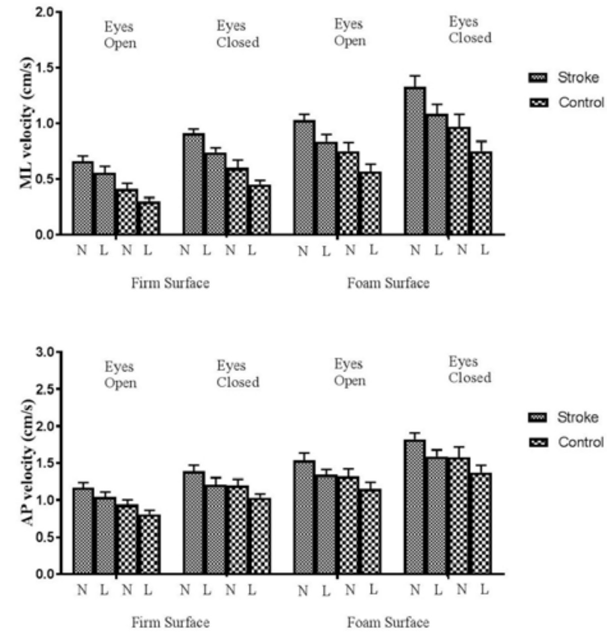


**Figure 1:** The mean velocity of center of pressure in the two groups for each condition. ML, medio-lateral; AP, antero-posterior; N, no touch; L, light touch.

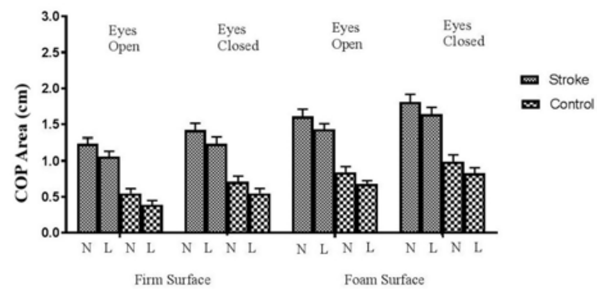


**Figure 2:** The area of center of pressure in the two groups for each condition. N, no touch; L, light touch.

## 4 Discussion

In the present study, we examined postural sway while standing in place for stroke patients and control subjects, under various conditions. The COP velocity was higher in the closed eyes condition than in the open eyes condition, and higher on the foam surface than on the firm surface condition in both groups. The COP velocity in ML direction was significantly greater in the stroke patients than the control group. Also, the results of this study revealed that when investigating the effects of light touch from a finger under different visual conditions on the postural sway of stroke patients, light touch showed similar effects in the COP velocity and area to those found in the control group. Light touch plays a role in stabilizing the standing position by inducing activation of the postural muscles, which results from the cutaneous information from the finger and the proprioceptive information from the configuration of arms, and transmits information about the direction and velocity of postural sway to central nervous system [24-26]. Unlike light touch, which can affect postural control via feed-forward mechanism, heavy touch can provide mechanical support for postural sway and assist with balance regulation through a feedback mechanism [11,27]. A comparative study by Cunha et al. [14] on the effects of light touch under different visual conditions of stroke patients showed that they had a reduction in postural sway relative to that found in the control group, and it was that the effects were greater when the eyes closed. Furthermore, the postural sway decreased with light touch from an unaffected hand applied in the ML direction, when the postural sway results, based on the direction of the touch, were compared. This is because the participants had a hard time maintaining a posture for touch using the affected arm and hand. Thus, in the present study, stroke patients touched using the unaffected hand, while the control group touched using the dominant hand. As a result, both group showed significant reduction in COP velocity and area by light touch. Meanwhile, light touch yielded a greater reduction in ML COP velocity, with eyes closed. ML COP sway is significantly correlated with falls and can be a predictive factor for falls [25,29]. Since subjects might be more dependent on sensory inputs from fingers in the absence of visual information, the amount of reduction of ML COP velocity due to light touch is thought to be increased.

Moreover, the effects of light touch on postural sway based on the support surface were also investigated. The results showed that postural sway on a foam surface increased for the two groups. The effects of light touch while standing on a foam surface were significantly greater than while standing on a firm surface, in ML COP velocity. Martinelli et al. found that postural sway was affected by the interaction between light touch and sensory information manipulation, and that light touch had a more noticeable effect when sway was increased by deprived sensory information [18]. Both distorted foot sensory information and mechanical instability due to an unstable support surface while standing on a foam surface may have increased postural sway [11]. In addition, because it is difficult to generate appropriate ankle torque while standing on a foam surface, the control of the posture is modulated by using a hip strategy [30]. Dickstein et al. [11] reported that when light touch was applied, not only did the postural sway decrease, but trunk velocity also showed a significant reduction. They suggested that this was because the sensory information from the finger and the arm provided references to recognize the alignment of the body, thereby promoting control of the posture using the ankle strategy. In addition, as the time taken for the somatosensory information from the hands and arms to reach the postural control center of the brain stem is shorter than that from the foot and legs, postural response in hands or arms may occur more quickly [31]. A study of recovery of postural stability following unanticipated mechanical perturbation reported that light touch decreased not only postural sway but also muscular activation magnitude, and suggested that an increased in somatosensory information caused by touch induced the postural response of trunk muscles, which led to reduced activation of leg muscles [18]. Although trunk velocity and muscle activation were not measured in the present study, the reduction effect of the COP velocity resulting from the light touch on a foam surface is thought to be due to the enabling of the ankle strategy, thus reducing displacement of COM.

The present study confirmed that light touch under all visual and surface conditions was effective in reducing postural sway in stroke patients. The limitations of this study are that, since the number of subjects was small, the findings are difficult to generalize and that trunk velocity was not determined. We evaluated effects of light touch on postural sway under different conditions in patients with stroke. The light touch can be a beneficial to improve balance in individuals with hemiparetic stroke. Further studies are needed to determine the effects of light touch on trunk velocity under a variety of conditions, and on changes in postural response using electromyography. In addition, there is a need to investigate long-term effects of light touch.

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**Conflict of interests:** The authors declare that there is no conflict of interests regarding the publication of this paper.

## References


[1] Kouzaki M., Masani K., Reduced postural sway during quiet standing by light touch is due to finger tactile feedback but not mechanical support. Exp Brain Res., 2008,188, 153-158

[2] Bonan I.V., Colle F.M., Guichard J.P., et al., Reliance on visual information after stroke. Part I: Balance on dynamic posturography. Arch Phys Med Rehabil., 2004, 85, 268-273

[3] Nichols D.S., Balance retraining after stroke using force platform biofeedback. Phys Ther., 1997, 77, 553-558

[4] Gibson J.J., The sense considered as perceptual systems. Houghton Mifflin, Boston, 1996

[5] Solomon H.Y., Turvey M.T., Haptically perceiving the distances reachable with hand-held objects. J Exp Psychol Hum Percept Perform., 1988, 14, 404-427

[6] Baccini M., Rinaldi L.A., Federighi G., Vannucchi L., Paci M., et al., Effectiveness of fingertip light contact in reducing postural sway in older people. Age Ageing., 2007, 36, 30-35

[7] Holden M., Ventura J., Lackner J.R., Stabilization of posture by precision contact of the index finger. J Vestib Res., 1994, 4, 285-301

[8] Dickstein R., Peterka R.J., Horak F.B., Effects of light fingertip touch on postural responses in subjects with diabetic neuropathy. J Neurol Neurosurg Psychiatry., 2003, 74, 620-626

[9] Barela A.M.F., Caporicci S., de Freitas P.B., Jeka J.J., Barela J.A., Light touch compensates peripheral somatosensory degradation in postural control of older adults. Hum Mov Sci., 2018, 60, 122-130

[10] Lackner J.R., DiZio P., Jeka J., Horak F., Krebs D., et al., Precision contact of the fingertip reduces postural sway of individuals with bilateral vestibular loss. Exp Brain Res., 1999, 126, 459-466

[11] Dickstein R., Shupert C.L., Horak F.B., Fingertip touch improves postural stability in patients with peripheral neuropathy. Gait Posture., 2001, 14, 238-247

[12] Bonfim T.R., Grossi D.B., Paccola C.A., Barela J.A., Additional sensory information reduces body sway of individuals with anterior cruciate ligament injury. Neurosci Lett., 2008, 441, 257-260

[13] Sullivan E.V., Rose J., Pfefferbaum A., Effect of vision, touch and stance on cerebellar vermian-related sway and tremor: a quantitative physiological and MRI study. Cereb Cortex., 2006,16, 1077-1086

[14] Cunha B.P., Alouche S.R., Araujo I.M., Freitas S.M., Individuals with post-stroke hemiparesis are able to use additional sensory information to reduce postural sway. Neurosci Lett., 2012, 513, 6-11

[15] Jeka J.J., Easton R.D., Bentzen B.L., Lackner J.R., Haptic cues for orientation and postural control in sighted and blind individuals. Percept Psychophys., 1996, 58, 409-423

[16] Rabin E., DiZio P., Ventura J., Lackner J.R., Influences of arm proprioception and degrees of freedom on postural control with light touch feedback. J Neurophysiol., 2008, 99, 595-604

[17] Tremblay F., Mireault A.C., Dessureault L., Manning H., Sveistrup H., Postural stabilization from fingertip contact: I. Variations in sway attenuation, perceived stability and contact forces with aging. Exp Brain Res., 2004, 15, 275-285

[18] Martinelli A.R., Coelho D.B., Magalhães F.H., Kohn A.F., Teixeira L.A., Light touch modulates balance recovery following perturbation: from fast response to stance restabilization. Exp Brain Res., 2015, 233, 1399-1408

[19] Mackinnon S,E,, Dellon A,L., Two-point discrimination tester. J Hand Surg Am., 1985,10, 906-907

[20] Desrosiers J., Hébert R., Bravo G., Dutil E., Hand sensibility of healthy older people. J Am Geriatr Soc., 1996, 44, 974-978

[21] Louis D.S., Greene T.L., Jacobson K.E., Rasmussen C., Kolowich P., et al., Evaluation of normal values for stationary and moving two-point discrimination in the hand. J Hand Surg Am., 1984, 9, 552-555

[22] Clark R.A., Bryant A.L., Pua Y., McCrory P., Bennell K., et al., Validity and reliability of the Nintendo Wii Balance Board for assessment of standing balance. Gait Posture., 2010, 31, 307-310

[23] Park D.S., Lee G., Validity and reliability of balance assessment software using the Nintendo Wii balance board: usability and validation. J Neuroeng Rehabil., 2014, 10, 99

[24] Jeka J.J., Lackner J.R., Fingertip contact influences human postural control. Exp Brain Res., 1994, 100, 495-502

[25] Jeka J.J., Lackner J.R., The role of haptic cues from rough and slippery surfaces in human postural control. Exp Brain Res., 1995, 103, 267-276

[26] Jeka J.J., Light touch contact as a balance aid. Phys Ther., 1997, 77, 476-487

[27] Kavounoudias A., Roll R., Roll J.P., The plantar sole is a 'dynamometric map' for human balance control. Neuroreport., 1998, 9, 3247-3252

[28] Maki B.E., Holliday P.J., Topper A.K., A prospective study of postural balance and risk of falling in an ambulatory and independent elderly population. J Gerontol., 1994, 49, M72-84

[29] Mitchell S.L., Collins J.J., De Luca C.J., Burrows A., Lipsitz L.A., Open-loop and closed-loop postural control mechanisms in Parkinson's disease: increased mediolateral activity during quiet standing. Neurosci Lett., 1995, 197, 133-136.

[30] [30] Horak F.B., Kuo A., Postural adaptation for altered environments, tasks and intentions. In: Biomechanics and Neuronal Control of Posture and Movement. Springer, New York, 2000

[31] Marsden C.D., Merton P.A., Morton H.B., Rapid postural reactions to mechanical displacement of the hand in man. Adv Neurol., 1983,39, 645-659