

# Influence of light touch using the fingertips on postural stability of poststroke patients

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**Abstract.** [Purpose] The purpose of this study was to investigate the influence of fingertip light touch on the postural control in poststroke patients. [Subjects] In the study, the subjects were recruited through a rehabilitation hospital, and 21 patients were screened from among 30 volunteers. [Methods] The subjects participated in an experiment that measured postural sway during the static standing posture without light touch and postural sway during the static standing posture with light touch as follows: visual information not blocked without light touch, visual information blocked without light touch, visual information blocked with light touch using fingertips, and visual information not blocked with light touch using fingertips. The measurements were performed using a force platform. The variables measured by the force platform included sway velocities of the COP in the anterior and posterior directions and, medial and lateral directions and sway velocity moments. [Results] In the results of the study, there were significant differences between the state without light touch and state with light touch in terms of the postural sway velocity and velocity moment under all conditions. The rate of decrease of the sway velocity and moment velocity under the eyes closed condition were higher compared with those under the eyes open condition. [Conclusion] Through this study, we confirmed the influence of fingertip light touch on the decrease in postural sway. The results show that active light touch may be supplemental means of improving postural sway in stroke patients.

**Key words:** Light touch, Stroke, Postural sway

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## INTRODUCTION

It is difficult to determine the center of mass of the human body while in the standing posture, as the base of support is narrow; therefore, it is hard to maintain the standing posture, and this posture is fundamentally unstable<sup>1)</sup>. In order to maintain the upright posture, the ability to control posture is constantly required<sup>2)</sup>. While maintaining posture, sensory information from the vestibular, visual, and somatosensory systems is integrated in the central nervous system<sup>2)</sup>. The upright standing posture is maintained when afferent information is integrated in the central nervous system through the vestibular, visual, and somatosensory systems and induces

reflexive control of eye and extremity movement<sup>3)</sup>. All three sensory systems are required for optimal postural stability; thus, impairment of any of these sensory systems may increase sway while standing. Dysfunction in the vestibular system results in postural instability<sup>4, 5)</sup>. Postural sway increases by 20–70% under visually blocked conditions, as the ability to control posture declines under these blocked conditions<sup>6)</sup>. Additionally, postural sway may increase with loss of the somatosensory system<sup>7)</sup>.

Impaired postural control is a common problem that stroke patient encounter<sup>8)</sup>. Stroke patients usually experience impairments such as motor paralysis, sensory loss, and muscle tone change<sup>9)</sup>, and these impairments usually occur in the trunk and extremity of the affected side, causing imbalance with the unaffected side. The imbalance between the affected and unaffected sides results in asymmetric weight distribution, with 60–90% of the weight supported by the unaffected side<sup>10, 11)</sup>, and this increases postural sway, thus disturbing postural control<sup>10)</sup>. This imbalance affects gait, causes an abnormal gait pattern, and restricts functional activities<sup>12)</sup>. Therefore, it is important to improve postural

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**Table 1.** Characteristics of the subjects

N	Gender (male/female)	Age (years)	Etiology (I/H)	Affected side (R/L)	Disease duration (month)
21	11/10	72.2±7.8	14/7	11/10	109.7±59.1

Values are frequencies or means±SD. I: Infarction; H: Hemorrhage; R: Right; L: Left

control using these methods that improve the elements described above<sup>9</sup>).

A previous study found that pelvic stability of stroke patients improved with light cane support<sup>13</sup>). Additionally, previous studies have suggested that light support with a fixed handrail using fingers improves postural stability while walking on an unstable support<sup>14</sup>). Tactile sensation involves light touching with the fingers<sup>15</sup>). This sensory information, called the light touch cue, may provide latent support to postural control<sup>16</sup>). Previous studies reported that light touch cue increases sensory feedback about body movement during postural control<sup>17</sup>). In particular, light touch with a force under 1 N provides tactile stimulation instead of mechanical support that decreases postural sway<sup>18</sup>). Many previous studies have reported on the effects of active touch, which reduces postural sway and improves postural stability. Another study found that active touch reduces perturbation not only during normal standing posture but also during the Romberg posture<sup>1</sup>). Additional studies have applied active touch to healthy adults with muscle fatigue<sup>19</sup>), patients with muscle vibration in the neck and lower extremity<sup>20, 21</sup>), the elderly<sup>22</sup>), patients with peripheral neuropathy<sup>23</sup>), patients with vestibular dysfunction on both sides<sup>4</sup>), and patients with visual dysfunction<sup>2</sup>). However, studies on the effect of light touch instead of mechanical support on postural sway during the static standing posture in stroke patients and the range of the relevant effects are limited.

Therefore, the current study aimed to investigate the influence of light tactile stimulation under 1 N, instead of mechanical support, on the stability or postural sway in stroke patients. The current study investigated whether tactile feedback from a fingertip cue, regardless of mechanical support, decreases postural sway caused by active touching during the static standing posture and the extent of improvement in postural sway.

## SUBJECTS AND METHODS

Stroke patients from D Rehabilitation Center participated in the study. The subjects were recruited through the hospital bulletin board, and 21 patients were screened from among 30 volunteers. The inclusion criteria were patients who were diagnosed with a stroke in the past 6 months, those with hemiparesis, those who could walk 10 m independently without assistive devices, those without hearing and visual impairments, those without neurologic or orthopedic diseases that may influence the results of the experiment, and those not taking medicines that may affect their stability. Patients with diabetes or a pacemaker were excluded from the study. The characteristics of the subjects are shown in Table 1. After screening the subjects, the aim and procedure were thoroughly explained to the subjects, and written con-

sent forms were signed.

The current study was a cross-sectional study design. The characteristics of the subjects were obtained from interviews and medical charts. The subjects participated in an experiment that measured postural sway during the static standing posture and postural sway during the static standing posture with light touch. The assessor provided an adequate explanation about the procedure of the fingertip cue to all the subjects and asked them to practice. Additionally, all the subjects practiced the standing posture five times on the ground in order to learn the process and procedure before measurement and took adequate rest after the practice. Before measurement, reference points were marked on the force platform in order to minimize changes in reference points that might occur during repeated measurements. The subjects stood on the force platform after the calibration was performed. When the “ready” signal was given, the subjects were to stand on the force platform in an upright posture. The 4 conditions used were as follows: visual information not blocked without light touch, visual information blocked without light touch, visual information blocked with light touch using fingertips, and visual information not blocked with light touch using fingertips. Measurements were repeated three times. Each trial took 30 seconds, and subjects had a 3-min break between each trial to minimize the adaptation effect on the measurement occurring through the test-retest process. For the light touch with the fingertips, the subjects stood upright, abducted the upper extremity slightly to the side of the trunk, flexed the elbow to 90°, and flexed all the fingers except the index finger to touch a piece of fabric with the index finger. The subjects stood focusing on the fingertip and maintained the position of touching the fabric for 30 seconds. The pressure of the light touch was set under 1 N because external force under 1 N is at the non-mechanically supportive force level that does not affect postural sway<sup>21</sup>). All subjects wore eye patches in order to eliminate confounding variables for the measurement conditions with blocked vision. The assessor and subjects were alone in the experiment room to control variables that may influence the subject.

Changes in postural sway during the light fingertip touch were measured using a force platform that records the center of pressure (COP) (Good Balance, Metitur Ltd, Finland). The force platform used in the study was composed of a triangular board connected to 3 amplifiers and a computer with built-in Bluetooth. The signals recorded on the force platform were amplified into measurable signals through the amplifier. The signals were transferred to the computer through Bluetooth and digitalized through a 12-bit converter so that data could be saved on the computer. The computer transformed the signals using a 50 Hz sampling rate, performed filtering using a 12 Hz low frequency filter, and

**Table 2.** Comparison of the postural sway in without light touch and with light touch

Variable		Without light touch	With light touch	Changes
Eyes open (mm/s)	AP sway velocity	7.0±3.0	2.0±0.9	5.0*
	ML sway velocity	8.9±3.5	4.3±1.5	4.6*
	Velocity moment	16.7±8.4	3.8±2.4	12.9*
Eyes closed (mm/s)	AP sway velocity	10.5±3.4	3.1±1.3	7.4*
	ML sway velocity	13.8±5.4	6.1±3.4	7.7*
	Velocity moment	25.8±12.6	5.9±3.4	19.8*

Values are frequencies or means±SD. AP: anteroposterior; ML: mediolateral

\* Statistically significant at  $p < 0.05$  between without light touch and with light touch

analyzed the saved values. The variables of postural sway include sway velocities of the COP in the anterior and posterior directions and medial and lateral directions, and sway velocity moments. The reliabilities of the force platform were found to be 0.51 and 0.74 in the anterior and posterior directions, respectively, and 0.63 and 0.83 in the medial and lateral directions, respectively<sup>24</sup>.

SPSS 15.0 was used for statistical analysis in the study. Normality tests of the variables were performed by using the Kolmogorov-Smirnov method, and descriptive statistics were used to analyze the mean and standard deviation of all the variables. An independent t-test was used to compare the influence of the light fingertip touch. The level of statistical significance ( $\alpha$ ) was set at 0.05.

## RESULTS

The results of the study are shown in Table 2. The sway velocity of the COP and moment velocity under the eyes open and closed conditions were significantly decreased in the state with light touch compared to the state without light touch ( $p < 0.05$ ) (Table 2). The rates of decrease of the sway velocity and moment velocity under the eyes closed condition were higher compared with those under the eyes open condition (Table 2).

## DISCUSSION

The present study aimed to investigate the influence of active light touch on the improvement of postural stability in chronic stroke patients. The study showed that the sway velocity of the COP and moment velocity improved significantly during active light touch compared with without light touch. This result is similar to the results of previous studies. Cunha et al.<sup>13</sup> found that the COP decreased because of light touch provided additional sensory information for decreasing postural sway of patients with hemiparesis resulting from stroke. Dickstein et al.<sup>23</sup> found a significant decrease in the COP of 32 patients with peripheral neuropathy compared with a control group because of fingertip touch that was used for improvement in postural stability.

The decrease in postural sway due to tactile feedback through active touch also occurs during the application of passive touch such as rubbing the lower extremity or shoulder in the standing position<sup>25</sup>. The tactile stimulation from passive touch may provide additional sensory input for de-

creasing postural sway. Previous studies found that passive touch at various parts of the lower extremity improved postural stability while standing through tactile stimulation<sup>26</sup>.

The equipment used for passive touch was for tactile feedback rather than for mechanical support. Considering this, the study of Menz et al.<sup>26</sup> suggested that postural sway may be controlled by tactile feedback. The decrease in tactile feedback from tactile stimulation without mechanical support increased postural sway<sup>27</sup>. Active light fingertip touch can also provide tactile feedback such as passive touch. These previous studies found that compressive ischemia in the upper arm during active light touch decreased tactile feedback, which then increased postural sway. A few studies found that haptic cues input through a fingertip touch decreased postural sway<sup>19, 28</sup>. For stability while in the standing posture, in terms of mechanical aspects, strong supports are needed<sup>1</sup>, but various studies found that a light touch cue can decrease postural sway in a manner similar to a strong touch cue<sup>23, 29</sup>. The results of previous studies and the current study confirm that an increase in tactile feedback, instead of mechanical support, through active touch with a force under 1 N may change postural sway.

Additionally, the current study results showed higher rates of decrease of sway velocity and moment velocity under the eyes closed condition compared with under the eyes open condition with and without active touch. Although inferential statistics were not performed, the descriptive statistical analysis showed a decrease of 4.98 mm/s in the anterior and posterior directions, a decrease of 4.57 mm/s in the medial and lateral directions, and a decrease of 12.92 mm/s in the velocity moment under the eyes open condition, as well as a decrease of 7.42 mm/s in the anterior and posterior direction, a decrease of 7.68 mm/s in the medial and lateral directions, and a decrease of 19.84 mm/s during velocity moment under the eyes closed condition. Balance is the ability to maintain the center of gravity in the body with minimum postural sway on the base of support<sup>6</sup>. The ability to maintain balance may decrease due to increased postural sway under the eyes closed condition when visual information is blocked<sup>30</sup>. Horvat et al.<sup>31</sup> and Ray et al.<sup>32</sup> found that patients with visual dysfunction had increased postural sway compared with healthy adults, which resulted in an increased risk of falls. The result showed that the rate of decreased of postural sway was higher when light touch was available under the eyes closed condition. Patients were highly dependent on the somatosensory system in order to compensate for impaired

vision, and the increased somatosensory system improved the efficiency of light touch<sup>28</sup>). In addition, when people with visual impairment tightly held a cane, an assistive device, and when people held a cane lightly, static postural sway decreased, which supports the assertion that the effect of light touch on postural sway under the eyes closed condition is greater<sup>2</sup>). Stroke patients were to perform a light fingertip touch with a force under 1 N while postural sway with and without touch was measured for comparison. The results of the current study were similar to the results of previous studies that found that light touch decreases postural sway<sup>16, 28</sup>). Light fingertip touch does not act as a mechanical support, rather it creates tactile feedback that improves balance<sup>2</sup>).

The present results show that active light touch contributes to improvement of balance and decreases postural sway. However, the current study has limitations; that is, due to the small sample size, it is difficult to generalize the results, and we did not investigate the changes in postural sway with touch involving various other body parts. Therefore, future studies should be conducted in order to provide useful information to patients with neurologic diseases.

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