Neck Proprioceptive Training for Balance Function in Patients with Chronic Poststroke Hemiparesis: A Case Series

GyounG-Mo Kim, PT, MSc1), Duck-Won Oh, PT, PhD2)*

1) Department of Physical Therapy, Division of Health Science, Baekseok University, Republic of Korea
2) Department of Physical Therapy, College of Health Science, Cheongju University: 298 Daesung-ro, Sangdang-gu, Cheongju 360-764, Republic of Korea

Abstract. [Purpose] This study investigated the effects of neck proprioceptive training on the balance of patients with chronic poststroke hemiparesis. [Subjects] Three patients with chronic stroke were recruited for this study. [Methods] The subjects underwent neck proprioceptive training using the red light of a laser pointer (30 min daily, five times per week for 4 weeks). Outcome measures included the stability and weight distribution indices measured with a Tetrax system and Timed Up and Go (TUG) and proprioception tests. [Results] For all subjects, the stability and weight distribution indices increased by 1.87–9.66% in the eyes-open and eyes-closed conditions, and the TUG and proprioception test scores improved by 2.49–15.27%. [Conclusion] Neck proprioceptive training may be a good option for improving the balance function of patients with chronic poststroke hemiparesis.

Key words: Neck proprioceptive training, Balance, Stroke

INTRODUCTION

Stroke impairs an individual’s motor, sensory, cognitive, and emotional control. An individual’s capability to select sensory information for postural stability and process it suitably in spatial and temporal templates may be remarkably impaired by a stroke, leading to delayed balance reactions in various situations1). These problems make postural control difficult and consequently contribute to disturbed performance of functional activities and walking2). Furthermore, inappropriate somatosensory information arising from the affected side likely contributes to postural instability3).

Recent concepts require the understanding of trunk and neck controls that are required to maintain static and dynamic balance, although the proprioceptive feedback mechanism within the lower limbs has been traditionally considered an important component of optimal balance4). In impaired proprioceptive processes of the lower limbs, compensation by the vestibulospinal reflexes and proprioceptive input from the cervical region may be inevitable for maintaining appropriate body balance5). With the high density of proprioceptors such as muscle spindles and the Golgi tendon organ, the cervical region plays an essential role in an individual’s ability to recognize their spatial orientation and body position and maintain equilibrium in changing environments during daily activities6). That is, its contributions to maintenance of static and dynamic balance may be responsible for the regular connection between afferent inputs from joint and muscle proprioceptors and those from visual and vestibular systems.

Although some studies have investigated the effects of sensory feedback for improving balance and postural control, their findings have failed to provide sufficient evidence7, 8). Therefore, in this field, studies should focus on exploring novel methods to reinforce the balance control mechanism in patients with chronic poststroke hemiparesis, which increases functional performance, rather than investigating the efficacy of current therapeutic strategies. To our knowledge, proprioceptive training using neck movements has received little attention in the management of patients with chronic poststroke hemiparesis, despite its easy application and comfort of use for clinicians. Hence, this study aimed to investigate a proprioceptive training procedure using cervical movement and report the results.

SUBJECTS AND METHODS

The subjects included three patients with chronic post-stroke hemiparesis. The inclusion criteria were as follows: first onset of stroke and onset duration of >6 months, no cognitive impairment (>24 points on the mini-mental state examination-Korean version)9), ability to stand and walk 10 meters independently without supervision; and no orthopedic or other neurological disorders that impede balance.
function. Prior to initiation of the study, detailed information about the experimental procedure and safety were provided to the subjects, each of whom signed a written consent form. All subjects agreed to the publishing of their study data. General subject characteristics are summarized in Table 1.

Outcome measures included the stability and weight distribution indices under the eyes-open and eyes-closed conditions measured by a Tetrax system (Sunlight Medical Ltd., Ramat Gan, Israel) using four force plates to detect the ground reaction force for both feet during standing. Timed Up and Go (TUG), and proprioception tests.

The Tetrax system measures the pressure transferred to the force plates during standing and analyzes the data after amplification and filtering. Measurements were performed under eyes-open and eyes-closed conditions. The stability index represents the extent of postural sway and an individual’s ability to compensate for it, and greater instability is indicated by greater values\(^{10}\). Further, the weight distribution index suggests the extent of weight distribution to both sides when standing on the force plates, and a higher score indicates a more severe pathological condition\(^{10}\). The test-retest reliability of measurements obtained with the Tetrax system is reportedly high (\(r = 0.88\))\(^{10}\). The TUG is an assessment tool that is used to evaluate a subject’s mobility and dynamic balance. In the TUG, subjects are instructed to rise from a chair, walk 3 m, turn around, return to the chair, and sit down\(^{12}\). The intra- and inter-test reliabilities were \(r = 0.99\) and \(r = 0.98\), respectively\(^{13}\). The proprioception test was performed using a method that blindly assesses the repositioning error of the cervicoclephic region\(^{9}\). For this test, subjects sat on a chair with a backrest facing a screen placed 1 m in front of them. A laser pointer was positioned at the middle top of the head to indicate the movement of the neck on the screen with a red dot. The first step was to identify the neutral head position by maintaining the red dot within a 1-cm\(^2\) area for 3 s, and then the subjects rotated their heads 30° to the right. The subjects were then asked to return to the neutral head position. The outcome was determined by measuring the error interval between the neutral position and the repositioning point. Data were averaged over three trials.

Subjects received a daily conventional therapy program, which comprised strengthening and stretching exercises for the upper and lower limbs and therapist-guided functional training, followed by proprioception training. Proprioception training included a self-detection effort to trace a neutral position from various directions of cervical movement\(^{5}\). The initial step, in which the subjects sat on a chair with a backrest, was the same as that for the proprioception test procedure. During the training, the trajectory of the red dot projected from the laser pointer offered real-time feedback about cervical movement. Prior to the training, a round area with a 30-cm diameter was marked on the screen at head height. All training procedures were performed with the eyes covered with an eye patch. To recognize the neutral position of the neck, the subjects maintained a neck position and then directed the red point to the round target on the screen for 3 s. After this procedure, the neck was positioned at the end range of flexion, extension, and rotation for 3 s each, the order of which was randomly generated using Microsoft Excel. The patients were then instructed to return to the neutral position. When they managed to successfully aim the laser pointer at the target area for 3 s, verbal feedback was provided. The training was performed for 30 min daily, 5 times a week for 4 weeks (for a total of 20 sessions).

This study was a case series with the aim of reporting the treatment findings of a very small population with chronic stroke. Thus, to illustrate the intervention effects directly, outcome data were provided as actual pre- and post-test scores without the use of statistical analysis.

### RESULTS

Table 2 represents the changes in the stability index, weight distribution index, TUG test score, and proprioception test score. The stability indices for subjects 1, 2, and 3 decreased by 4.17%, 3.96%, and 3.54% under the eyes-open conditions, respectively, and by 6.16%, 9.66%, and 1.87% under the eyes-closed conditions, respectively. The weight distribution index was reduced by 3.45%, 4.81%, and 1.39% under the eyes-open conditions, respectively, and by 7.63%, 11.41%, and 9.61% under the eyes-closed conditions, respectively. The TUG test scores of all subjects showed improvements of 3.32%, 3.62%, and 2.49% respectively, and the proprioception test scores increased by 15.57%, 3.24%, and 11.45%, respectively.

### DISCUSSION

It is generally accepted that systematic processing and integration of visual, vestibular, and proprioceptive information from each part of the body has a great influence on maintaining optimal postural stability and movement control in space during daily activities. Hence, impaired sensorimotor perceptions after stroke may be among the greatest challenges for maintaining postural control and stable balance patterns\(^{5}\). The pathological changes of the nervous system, the lack of movement and asymmetrical posture, contribute to decreased proprioceptive function after stroke.

Our results focused on the feasibility of neck proprioceptive training for improving the balance function of patients after stroke and demonstrated favorable effects on static and dynamic balance function. Asymmetrical posture in stroke may be closely associated with a biased weight distri-
Table 2. Comparison of pre- and post-training outcomes for all subjects

<table>
<thead>
<tr>
<th></th>
<th>Subject 1</th>
<th>Subject 2</th>
<th>Subject 3</th>
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<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
<td>Pre-test</td>
</tr>
<tr>
<td>Stability index</td>
<td></td>
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<td></td>
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<tr>
<td>eyes-open</td>
<td>23.51</td>
<td>22.53</td>
<td>24.52</td>
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<tr>
<td>eyes-closed</td>
<td>48.67</td>
<td>45.67</td>
<td>48.98</td>
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<tr>
<td>Weight distribution index</td>
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<td></td>
<td></td>
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<tr>
<td>eyes-open</td>
<td>7.82</td>
<td>7.55</td>
<td>8.32</td>
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<tr>
<td>eyes-closed</td>
<td>10.48</td>
<td>9.68</td>
<td>11.57</td>
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<td>TUG (sec)</td>
<td>15.05</td>
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<td>17.12</td>
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<td>Proprioception test (cm)</td>
<td>8.93</td>
<td>7.54</td>
<td>8.96</td>
</tr>
</tbody>
</table>

TUG: Timed Up and Go test

REFERENCES