J. Phys. Ther. Sci.
27: 897–900, 2015

Original Article

Effect of blocked vision treadmill training on knee joint proprioception of patients with chronic stroke

Sung-Jun Moon, MSc[1)], Yong-Wook Kim, PhD[2)*]

[1)] *Department of Physical Therapy, Jeonbuk University Hospital of Rehabilitation Medicine, Republic of Korea*

[2)] *Department of Physical Therapy, College of Medical Sciences, Jeonju University: 303 Cheonjam-ro, Wansan-gu, Jeonju, Jeonbuk-do 560-759, Republic of Korea*

Abstract. [Purpose] The purpose of this study was to compare the effect of treadmill training with the eyes closed and eyes open on the joint position sense of chronic stroke patients. [Subjects and Methods] Thirty patients with chronic stroke participated in this study. Patients performed the timed up and go test and were assigned to one of two treadmill training groups with and without visual deprivation. The treadmill gait training for each group lasted 40 minutes, and sessions were held 3 times a week for 4 weeks. The knee joint proprioception was measured using the Biodex System Pro 3 before and after the intervention. [Results] The knee joint proprioception of the treadmill training with blocked vision group showed more significant improvement after the treadmill training sessions than that of the eyes open group. [Conclusion] This study demonstrated that treadmill training with blocked vision may be useful for the proprioceptive sensory rehabilitation of patients with chronic stroke.

Key words: Chronic stroke, Knee joint proprioception, Visual deprivation

(This article was submitted Sep. 29, 2014, and was accepted Nov. 7, 2014)

INTRODUCTION

Balance and gait problems require that stroke patients seek assistance from others and decrease their quality of life[1–3]. Bonan et al.[4] reported that when stroke patients attempted to maintain balance or to walk relying on visual information, they had to use a strategy to compensate for their insufficient proprioceptive and vestibular senses. They also suggested that excessive visual dependence may become a hindrance to the improvement of balance and gait abilities[4]. Recovering balance and gait abilities is an important component of rehabilitation programs aiming to improve the daily activities and quality of life of stroke patients. Such rehabilitation programs should minimize excessive visual dependence and facilitate the proprioceptive and vestibular functions of stroke patients[5, 6].

Whereas normal adults use their visual, vestibular, and proprioceptive senses properly by integrating them systematically, stroke patients control their postures by relying on visual information, due to reduced interaction with sensory stimulation and weakened central integration, instead of maintaining balance by selecting the appropriate sensations[7, 8]. When excessive visual dependence in stroke patients leads to information that contradicts the somatic sensations in the lower limbs, the conflicting afferent information may cause confusion in terms of central sensory integration[8]. Methods to enhance the postural control abilities of stroke patients include blocking visual information[7, 8], using treadmills[9], and providing weight support with visual feedback on a force platform[10]. Treadmill gait training can provide stroke patients with continuous visual and proprioceptive information for control of posture and maintenance of balance. Therefore, it has the advantage of facilitating gait abilities through integration of sensory and motor control in stroke patients[11]. Kim and Krebs[12] reported that treadmill training with visual feedback for stroke patients improved their postural control abilities by facilitating motor learning, whereas treadmill training with distorted visual feedback had negative effects on gait symmetry. In contrast, Zanetti and Schieppati[13] reported that treadmill training with visual feedback blocked was effective at improving gait ability through the improvement of postural control elicited by enhancing proprioceptive and vestibular sensations during visual restriction.

A number of previous studies have reported that blocking visual information during gait training using treadmills is effective at recovering the balance and gait abilities of stroke patients. However, few studies have examined changes in proprioceptive sensation of the knee joint in stroke patients. Therefore, the purpose of this study was to identify the effects of treadmill gait training with and without blocked vision on the perception of knee joint position of stroke patients.

*Corresponding author. Yong-Wook Kim (E-mail: ptkim@jj.ac.kr)

SUBJECTS AND METHODS

Subjects

The subjects in this study were 30 stroke patients who were undergoing comprehensive rehabilitation. Fifteen patients performed treadmill training with their eyes closed (TEC), and the other 15 patients performed treadmill training with their eyes open (TEO). This study was conducted in accordance with the ethical principles of the Declaration of Helsinki, and the local research ethics committee approved the study protocol. The subjects were given a detailed explanation of the study procedure by the researcher before providing their informed consent to participation in this study. The subjects were recruited using the following criteria: subjects who had experienced hemiplegia at least 12 months prior; subjects who were able to perform independent standing and treadmill walking without an aid; and subjects who scored at least 24 points in the Korean version of the Mini-Mental State Examination, indicating an ability to understand and follow the researcher's instructions. The demographic and clinical characteristics of the subjects are shown in Table 1; there were no statistically significant differences between the two groups (p>0.05).

Table 1. Demographic and clinical characteristics of the subjects (N=30)

	Treadmill training with eyes closed (n=15)	Treadmill training with eyes open (n=15)
Age (years)	55.7±11.7[a]	50.1±15.9
Gender		
Male	12 (80%)	11 (73%)
Female	3 (20%)	4 (27%)
Time since stroke (month)	33.3±23.4	36.0±21.8
Type of lesion		
Hemorrhagic	5 (33%)	6 (40%)
Infarction	10 (67%)	9 (60%)
Hemiplegic side		
Right	9 (60%)	7 (47%)
Left	6 (40%)	8 (53%)
Height (cm)	168.6±9.5	169.9±9.9
Weight (kg)	69.6±8.5	66.9±8.6
TUG (sec)	26.0±13.8	24.4±8.2

TUG: Timed up and go test
[a]Mean±SD

Methods

The subjects performed the Timed up and go test before the intervention. Those with similar levels of dynamic balance were placed into the two groups using the matching method. Isokinetic equipment (Biodex System Pro 3, Biodex Medical System, Inc., NY, USA) was used for the joint position sense test.

Both groups received traditional physical therapy and then performed three sets of treadmill gait training lasting for 10 min per set using Gait Trainer 2. Gait training was performed three times a week for 4 weeks. The subjects were given a 5-minute break after each set of exercise to prevent fatigue. Subjects were also allowed to discontinue gait training at anytime while training. Subjects in the TEC group were instructed to perform treadmill gait training with their vision blocked by an eye cover, following the method suggested by Zanetti and Schieppati[13]. The TEO group performed treadmill gait training with their eyes open. For the treadmill gait training, each subject was instructed to stand in the middle of a stopped treadmill in a comfortable manner and to wear a harness that would prevent falls while not disturbing the gait training. Each subject's gait velocity was gradually increased until the maximum speed at which the subject could maintain comfortable walking was reached.

Knee joint proprioception is commonly used to assess passive joint position sense (PJPS)[14, 15]. The PJPS test was conducted without prior practice to exclude testing effects resulting from familiarity with the measuring equipment. The PJPS test required subjects to reproduce a target angle, and the difference between the measured angle and the target angle was calculated. Smaller values were assessed as good joint position sense[15]. To assure the accuracy of these measurements, subjects wore an eye cover and earplugs to prevent input of visual and auditory information. For the PJPS test, the target joint angle was 45° knee flexion. The subjects were instructed to stop for 10 sec and perceive the target joint angle position in advance. The starting angle of the PJPS test was 90° knee flexion, and during passive extension of the knee joint at an angular velocity of 2°/s, each subject was instructed to press a stop button when he or she recognized the target angle. The PJPS test was conducted three consecutive times, and the average of the three measured values was calculated as the value for the subject's joint position sense. The test-retest reliability of the PJPS test in the sitting position has been reported to have an ICC=0.82[16].

The Mann-Whitney U-test, the χ^2-test, and the independent t-test were used before the experiment to assess differences in the general and medical characteristics of the two groups. To examine differences within each group before and after training, the paired t-test was used, and the independent t-test was used to examine differences in the differential PJPS scores between the two groups. IBM SPSS (version 20.0) was used for statistical data processing with a statistical significance level of 0.05.

RESULTS

During the experiment, three patients in the TEC group and four patients in the TEO group could no longer participate in this study due to discharge from the hospital, fractures, or personal reasons. Therefore, they were excluded from data analysis. A comparison of the PJPS test on the knee joint before and after the treadmill gait training showed statistically significant decreases in the error score in both groups after the intervention, with a decrease from 9.81 ± 5.06° to 6.80 ± 3.67°in the TEC group and a decrease from 8.39 ± 5.13° to 7.04 ± 4.41° in the TEO group (p<0.01) (Table 2). The intergroup comparison of PJPS results revealed a significant difference in knee joint position sense. With values of −3.01 ± 2.04° in the TEC group and −1.35 ± 1.25° in the

Table 2. Within group comparison of knee joint position sense between with and without blocked vision treadmill training (N=30)

	Treadmill training with eye closed (n=15)		Treadmill training with eye opening (n=15)	
	Before	After	Before	After
Knee PJPS error	9.81±5.06[a]	6.80±3.67**	8.39±5.13	7.04±4.41**

PJPS: passive joint position sense
[a]Mean±SD, **p<0.01

Table 3. Comparison of the differential value of knee joint position sense between the with and without blocked vision treadmill training groups (N=30)

	Treadmill walking with eye closed (n=15)	Treadmill walking with eye opening (n=15)
Knee PJPS error	−3.01±2.04[a]	−1.35±1.25*

PJPS: passive joint position sense
[a]Mean±SD, *p<0.05

TEO group ($p<0.05$) (Table 3). Compared to the TEO group, the TEC group showed better joint position sense after the intervention.

DISCUSSION

This study was conducted to identify the effects of vision-blocked treadmill gait training on the joint position sense of stroke patients. Proprioception is an essential element in the prior perception of information in various movements, joint position sense, and muscle contraction[17)]. The distortion of proprioception results in unstable posture due to confused sensory input in a standing position[18)].

Westlake and Culham[19)] trained elderly people aged ≥65 years of age to activate their somatosensory system at optimal levels using various changes in sensory conditions. They reported that the experimental group showed a significantly higher level of postural stability than the control group. They suggested that this result was due to the various types of sensory training promoting somatosensory activation which improved postural stability. In particular, they reported that the vibration sense of muscles is important for the perception of muscle length. The present study showed a significant difference in changes in knee PJPS between the two groups after treadmill gait training. In addition, the pre-post comparison within each group showed that both groups had significantly improved PJPS scores after the intervention. The reason for the change in PJPS in the TEC group, whose vision was blocked, may have been treadmill gait training facilitated somatosensory and vestibular sensory input, thereby improving proprioception. Bonan et al.[20)] measured the amount of postural sway according to three types of sensory information to identify the effects of vision, proprioception, and vestibular sense on balance maintenance by stroke patients. Their results suggest that visual, proprioceptive, and vestibular information are important in balance maintenance. Our study results agree with those of previous studies reporting that blocking visual information elicits the use of the proprioceptive and vestibular senses. Our study also revealed that the selection of proper sensory information and training is required for the functional recovery of stroke patients. Treadmill gait training was performed in this study while encouraging the subjects to maintain postural control, motor learning, and symmetric weight support. These processes may have enhanced knee joint proprioception by properly integrating somatosensory, vestibular, and visual stimulation, all of which are necessary for postural control.

The present study had some limitations. First, the number of subjects was insufficient for the generalization of the results to all patients with stroke. Second, during the gait training, the Velcro harness did not support the patients' trunk firmly. Therefore, further studies are required to verify the effects of vision-blocked treadmill gait training on PJPS, balance, gait, and various functions of stroke patients addressing the present study's limitations.

REFERENCES

1) Hesse SA, Jahnke MT, Bertelt CM, et al.: Gait outcome in ambulatory hemiparetic patients after a 4-week comprehensive rehabilitation program and prognostic factors. Stroke, 1994, 25: 1999–2004. [Medline] [CrossRef]
2) Kim TW, Kim YW: Treadmill sideways gait training with visual blocking for patients with brain lesions. J Phys Ther Sci, 2014, 26: 1415–1418. [Medline] [CrossRef]
3) Kim YW: Clinical usefulness of the pendulum test using a NK table to measure the spasticity of patients with brain lesions. J Phys Ther Sci, 2013, 25: 1279–1283. [Medline] [CrossRef]
4) Bonan IV, Colle FM, Guichard JP, et al.: Reliance on visual information after stroke. Part I: Balance on dynamic posturography. Arch Phys Med Rehabil, 2004, 85: 268–273. [Medline] [CrossRef]
5) Richards CL, Malouin F, Wood-Dauphinee S, et al.: Task-specific physical therapy for optimization of gait recovery in acute stroke patients. Arch Phys Med Rehabil, 1993, 74: 612–620. [Medline] [CrossRef]
6) Thaut MH, McIntosh GC, Rice RR: Rhythmic facilitation of gait training in hemiparetic stroke rehabilitation. J Neurol Sci, 1997, 151: 207–212. [Medline] [CrossRef]
7) Bonan IV, Yelnik AP, Colle FM, et al.: Reliance on visual information after stroke. Part II: Effectiveness of a balance rehabilitation program with visual cue deprivation after stroke: a randomized controlled trial. Arch Phys Med Rehabil, 2004, 85: 274–278. [Medline] [CrossRef]

8) Smania N, Picelli A, Gandolfi M, et al.: Rehabilitation of sensorimotor integration deficits in balance impairment of patients with stroke hemiparesis: a before/after pilot study. Neurol Sci, 2008, 29: 313–319. [Medline] [CrossRef]
9) Reisman DS, Wityk R, Silver K, et al.: Locomotor adaptation on a split-belt treadmill can improve walking symmetry post-stroke. Brain, 2007, 130: 1861–1872. [Medline] [CrossRef]
10) Srivastava A, Taly AB, Gupta A, et al.: Post-stroke balance training: role of force platform with visual feedback technique. J Neurol Sci, 2009, 287: 89–93. [Medline] [CrossRef]
11) Knikou M, Rymer Z: Effects of changes in hip joint angle on H-reflex excitability in humans. Exp Brain Res, 2002, 143: 149–159. [Medline] [CrossRef]
12) Kim SJ, Krebs HI: Effects of implicit visual feedback distortion on human gait. Exp Brain Res, 2012, 218: 495–502. [Medline] [CrossRef]
13) Zanetti C, Schieppati M: Quiet stance control is affected by prior treadmill but not overground locomotion. Eur J Appl Physiol, 2007, 100: 331–339. [Medline] [CrossRef]
14) Stillman BC, Tully EA, Mcmeeken JM: Knee joint mobility and position sense in healthy young adults. Physiotherapy, 2002, 88: 553–560. [CrossRef]
15) Lee AJ, Lin WH: Twelve-week biomechanical ankle platform system training on postural stability and ankle proprioception in subjects with unilateral functional ankle instability. Clin Biomech (Bristol, Avon), 2008, 23: 1065–1072. [Medline] [CrossRef]
16) Olsson L, Lund H, Henriksen M, et al.: Test-retest reliability of a knee joint position sense measurement method in sitting and prone position. Adv Physiother, 2004, 6: 37–47. [CrossRef]
17) Kim TW, Kim YW: Treadmill sideways gait training with visual blocking for patients with brain lesions. J Phys Ther Sci, 2014, 26: 1415–1418. [Medline] [CrossRef]
18) Wierzbicka MM, Gilhodes JC, Roll JP: Vibration-induced postural posteffects. J Neurophysiol, 1998, 79: 143–150. [Medline]
19) Westlake KP, Culham EG: Sensory-specific balance training in older adults: effect on proprioceptive reintegration and cognitive demands. Phys Ther, 2007, 87: 1274–1283. [Medline] [CrossRef]
20) Bonan IV, Marquer A, Eskiizmirliler S, et al.: Sensory reweighting in controls and stroke patients. Clin Neurophysiol, 2013, 124: 713–722. [Medline] [CrossRef]