Effect of dual tasks on balance ability in stroke patients

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Abstract. [Purpose] The purpose of this study was to determine the effects of training using dual tasks on balance ability in stroke patients. [Subjects] Forty stroke patients were divided into a dual-task training group (N = 20) and a single task training group (N = 20) randomly. [Methods] The subjects in the single-task training group stood in a comfortable position, faced a therapist, then threw a Swiss ball back and forth. They then performed balance training in which they raised and lowered their ankles while facing forward or moved objects from one table to another. The DTG performed dual tasks, which involved performing a task on an unstable surface using a balance pad. Both groups received training 30 min per day, five times per week, for eight weeks. [Results] The DTG showed significant increases in weight distribution rate, anterior limit of stability, posterior limit of stability, and BBS scores compared with the STG. [Conclusion] According to the results of this study, dual-task training and single-task training were effective in improving balance in stroke patients, dual task training is more effective for increasing balance ability.

Key words: Stroke, Dual-task training, Balance

INTRODUCTION

The ability to maintain balance is the most basic element required for people to lead normal daily lives and perform intended activities1). However, difficulty with balance and postural control in stroke patients leads to defective movement ability, interferes with detailed performance of upper limb functions, and disables walking and activities of daily living2). Therefore, balance is the most basic requirement to prevent falling, undertake the activities of daily living, and maintain an independent life in stroke patients3). To restore the balance of poststroke hemiplegic patients, motor learning methods have been used, such as lateral weight shifting4), a method using balls5), raising the foot of the unaffected side on a board at a certain height6), visual feedback training7), and auditory feedback training8).

Balance training on an unstable surface has also been used. Training on an unstable surface rather than a stable surface can generate more external sway, thus improving postural control ability9), can induce more diverse motions and muscular uses, can increase proprioceptive senses, and can potentially change the neuromuscular mobilization pattern10). The training requires the subject to maintain their balance and posture or shift their weight on unstable surfaces, such as a sling, a rocker board, a Swiss ball, a balance ball, and a balance pad. Furthermore, as another approach to balance training, task-oriented training repeats functional movements that are required for actual living. There are various studies that have found better results for gait or gait-related functions of stroke patients with the application of task-oriented training rather than simply increasing the movement of hemiplegic limbs11). Furthermore, focusing on repeated functional tasks helps to improve the motor functions of stroke patients12).

Many activities of daily living require the performance of more than one task at a time13), and include dual tasks that involve the simultaneous performance of two movement tasks14). Performing one task while simultaneously performing another task or performing two or more tasks continuously and simultaneously is referred to as “dual-task performance”15). When put into a situation of dual-task performance, people whose cognitive or physical functions are not smooth, such as stroke patients and the aged, lose their physical abilities or experience physical injuries, such as falls16, 17). For this reason, studies are being conducted on the application of dual-task performance for subjects such as stroke patients and aged people18–20). Yang et al.17) observed a reduction of actual movements in patients with neurological injuries due to various tasks and emphasized the importance of performing dual tasks through behavior enhancement by performing two exercise tasks simultaneously in a complex environment. Furthermore, Canning et al.21) argued that two exercise tasks must be performed simultaneously to effectively carry out complex tasks, such as the activities...
of daily living, and Erickson et al.\textsuperscript{22} reported that training in dual-task situations resulted in more positive results, such as an increase in cerebral blood flow, than training in single-task situations. Dual-task training methods include performing a cognitive task, such as calculating numbers or guessing an answer while performing a functional task, or simultaneously performing two or more exercise tasks, such as moving things or throwing and holding balls, to promote functional activities\textsuperscript{23}.

In a study by Yang et al.\textsuperscript{18}, the application of exercises based on dual tasks to chronic stroke patients, improved their gait ability. In a study by Schwent et al.\textsuperscript{24}, 12 weeks of dual-task training in dementia patients improved their dual-task performance abilities compared with a control group. Furthermore, Canning et al.\textsuperscript{21} reported that application of multi-task training for 8 weeks to patients with Parkinson's disease resulted in improved confidence in performing multiple tasks, decreased mental and physical fatigue, reduced senses of difficulty and anxiety, and enhanced gait speed in multiple tasks. These results of previous studies were brought about by formation of the ability to integrate multiple exercise tasks into complex environment of daily living. This was achieved by performing exercise tasks while already performing another task\textsuperscript{18}. However, most studies on dual-task training have focused on enhancement of task performance abilities, and there are few studies on the effects of dual-task training on improvement of balance ability.

Therefore, in this study, the effects of dual-task training on the balance ability of stroke patients were investigated.

\textbf{SUBJECTS AND METHODS}

The subjects of this study were 40 patients with hemiplegia resulting from stroke diagnosed by a rehabilitation doctor practicing in N Hospital located in Daegu, South Korea. They were randomly and equally assigned to a dual-task training group (DTG; 9 male, 11 female) and a single-task training group (STG; 12 male, 8 female). The mean ± SD age, height, and weight of the DTG was 55.37 ± 20.6 years, 165.00 ± 9.53 cm, and 64.12 ± 14.12 kg, respectively. Eleven of the patients had right hemiplegia, and nine had left hemiplegia. The onset period was 14.75 ± 6.06 months. The mean ± SD age, height, and weight of the STG was 57.10 ± 7.83 years, 165.00 ± 9.53 cm, and 64.12 ± 14.12 kg, respectively. Eight of the patients had right hemiplegia, and 12 had left hemiplegia. The onset period was 14.30 ± 3.40 months. The inclusion criteria were as follows: no visual field defect, no abnormality in the vestibular organs, no orthopedic disease, an unrestricted range of motion, the ability to understand and perform the exercise as instructed by the researcher, and a score of 24 or higher on the Mini-Mental State Examination—Korean version. This study was approved by the University Institutional Review Board, and all the subjects understood the purpose of the study and provided written informed consent prior to participation, in accordance with the ethical standards of the Declaration of Helsinki.

The training method was as follows. The subjects in the single-task training group stood in a comfortable position on the therapy room floor, faced a therapist, then threw a Swiss ball back and forth. During this training, the therapist adjusted the direction and speed of the ball in such a way that the center of gravity of the patients would move out of the base of support (BOS) and then return to its original position\textsuperscript{25}. Next, the subjects performed balance training, which involved raising and lowering two ankles while facing the forward\textsuperscript{26} or moving objects from one table to another table in a standing position\textsuperscript{25}. Lastly, the subjects performed balance training while facing forward in a tandem standing position. The patients were accompanied by a support therapist or guardian, who simultaneously performed the training near them to ensure that they did not trip or fall. The DTG performed dual tasks, which involved performing a task on an unstable surface using a balance pad (Airex, Sins, Switzerland). Their tasks were identical to those of the STG.

The participants (n = 40) were randomly divided into the STG (n = 20) and the DTG (n = 20). Both groups completed 30 minutes of exercise each day, five times a week for 8 weeks. For measurement of balance ability, a biofeedback analysis system (AP1153 BioRescue, RM Ingenierie, Rodez, France) was used to determine weight bearing, sway length, anterior range LOS (limit of stability), and posterior range LOS on the affected side in a static standing position. For the measurement of dynamic balance, we used the Berg Balance Scale (BBS).

The experimental results were statistically analyzed using SPSS 12.0 KO (SPSS Inc., Chicago, IL, USA). After the general characteristics of the subjects were determined, a paired t-test was used to compare the variations in weight distribution on the affected side when standing, sway length, anterior LOS, posterior LOS, and BBS scores. The significance of differences between the two groups was investigated using an independent t-test. Statistical significance was accepted for values of p < 0.05.

\textbf{RESULTS}

Both the DTG and the STG showed significant differences between before and after the interventions in the weight distribution rate, sway length, anterior LOS, posterior LOS, and BBS scores (p < 0.05).

Furthermore, when the differences between before and after interventions were compared between the DTG and the STG, the DTG showed significant increases in weight distribution rate, anterior LOS, posterior LOS, and BBS scores compared with the STG (p < 0.05) (Table 1).

\textbf{DISCUSSION}

The functional recovery of stroke patients is more effective when their therapies include high-intensity training and appropriate practices that allow voluntary use of specific motions and functions that are similar to actual tasks\textsuperscript{27}.

Furthermore, adjusting the patient’s pelvic movement is critical because dynamic balance is controlled by the harmonious movement between the pelvis and the upper body as well as by the muscles around the hip joint; the weights of the head, upper limbs, and trunk are transferred to the lower limbs through the pelvis\textsuperscript{28}. As a therapeutic method for restoration of this function, dual-task training is very popular, and active research is being conducted on the performance
of dual tasks that reduce postural sway and improve postural stability. Therefore, in this study, stroke patients were classified into two groups: an STG that performed various training exercises on the floor, and a DTG that balanced on a balance pad and performed various training exercises. As a result, both the DTG and the STG showed improvements in static balance and dynamic balance. This result agrees with the report of Sackley and Bagulya, who showed that the amount of body sway significantly decreased in hemiplegic patients trained to shift their weight to a target that moved within the range of the individual’s stability limit. The reason for this is the increase in weight shifting and dynamic balance movements, which effectively restore dynamic balance, as a result of the various training methods performed in the STG, such as moving the center of the body out of the base of support and then returning it to its original position.

Furthermore, the results of this study suggest that the balance ability of the DTG increased more significantly compared with the STG. This was similar to the results of Irion, who reported that a balancing exercise on an unstable surface promoted postural control and dynamic balance compared with training on a stable surface. Smania et al. reported that stroke patients who had performed a balancing exercise on a stable surface for 2 weeks followed by a balance exercise on an unstable surface showed significant differences in balance and gait speed after their experiment. Furthermore, a study that compared a group that performed a balance exercises on an unstable surface with a control group reported that there were significant differences in BBS and BBS (scale) and then returning it to its original position.

The most fundamental goal of treatment in stroke patients is to return the patients to society. For this reason, the recovery of balance ability in stroke patients has been a very important goal of physical therapy and has been regarded as having a high research value. Furthermore, enhancement of the balance ability of patients through dual tasks has clinical significance in several areas. As patients show diverse reactions to the level of dual tasks, assessment of dual tasks can be very important for stroke patients and can contribute to the individual therapy plans of patients.

Furthermore, compared with the traditional single-task exercise task, dual tasks are performed in activities of daily living and, therefore, they can be a better indicator of functional daily living in the stroke patient.

Table 1. Comparison of the change in balance ability in the training groups with values presented as the mean ± standard deviation

|                         | Before  | Post   | Before  | Post   |
|-------------------------|---------|--------|---------|--------|
| Affect side WD (%)      | 43.6 ± 3.8 | 47.2 ± 2.0** | 43.0 ± 6.0 | 44.5 ± 8.3* |
| Sway length (mm)        | 37.0 ± 16.8 | 29.5 ± 9.4* | 36.1 ± 11.3 | 33.3 ± 10.1* |
| Anterior LOS (mm)       | 2701.8 ± 3111.4 | 6209.9 ± 3992.9* | 2361.6 ± 2472.5 | 3956.9 ± 3140.7* |
| Posterior LOS (mm)      | 1755.0 ±1611.4 | 2688.0 ± 1870.0* | 1216.4 ± 1014.9 | 1670.2 ± 1143.2* |
| BBS (scale)             | 37.5 ± 10.5 | 45.5 ± 6.3** | 42.3 ±7.7 | 45.9 ± 7.2* |

*Significant difference compared with before therapy at <0.05. **Significant difference in gains between the two 196 groups at <0.05. DTG: Dual task Training Group; STG: Single task Training Group; WD: weight distribution; LOS: Limit of Stability; BBS: Berg Balance Scale

REFERENCES

1) Horak FB: Clinical measurement of postural control in adults. Phys Ther, 1987, 67: 1881–1885. [Medline]
2) Carr JH, Shepherd RB, Nordholm L, et al.: Investigation of a new motor assessment scale for stroke patients. Phys Ther, 1985, 65: 175–180. [Medline]
3) Ahn WH, Jeong MK, Kim CK: The training effect of balance pad in stroke. J Sport Leis Stud, 2008, 32: 803–811.
4) Davies PM: Steps to follows. A guide to the treatment of adult hemiplegia. Berlin: Springer-Verlag, 1985.
5) Edwards S: Neurological Physiotherapy. A problem-solving approach. New York: Churchill Livingstone, 1996.
6) Bohannon RW, Leary KM: Standing balance and function over the course of acute rehabilitation. Arch Phys Med Rehabil, 1995, 76: 994–996. [Medline] [CrossRef]
7) Woollacott MH, Shumway-Cook A, Nashner LM: Aging and posture control: changes in sensory organization and muscular coordination. Int J Aging Hum Dev, 1986, 23: 97–114. [Medline] [CrossRef]
8) Cheng PT, Wu SH, Liaw MY, et al.: Symmetrical body-weight distribution training in stroke patients and its effect on fall prevention. Arch Phys Med Rehabil, 2001, 82: 1650–1654. [Medline] [CrossRef]
9) Shumway-Cook A, Horak FB: Assessing the influence of sensory interaction of balance. Suggestion from the field. Phys Ther, 1986, 66: 1548–1550.
10) Franklin DW, Osu R, Burdet E, et al.: Adaptation to stable and unstable dynamics achieved by combined impedance control and inverse dynamics model. J Neurophysiol, 2003; 90: 3270–3282. [Medline] [CrossRef]

11) Kim BH, Lee SM, Bae YH, et al.: The effect of a task-oriented training on trunk control ability, balance and gait of stroke patients. J Phys Ther Sci, 2012; 24: 519–522. [CrossRef]

12) Saito M, Asaka T, Fukushima J: Effects of motor imagery combined with repetitive task practice on sitting balance of hemiplegic patients. J Phys Ther Sci, 2013; 25: 183–188. [CrossRef]

13) O’Shea S, Morris ME, Iansek R: Dual task interference during gait in people with Parkinson disease: effects of motor versus cognitive secondary tasks. Phys Ther, 2002; 82: 888–897. [Medline]

14) Canning CG: The effect of directing attention during walking under dual-task conditions in Parkinson’s disease. Parkinsonism Relat Disord, 2005, 11: 95–99. [Medline] [CrossRef]

15) Pellecchia GL: Dual-task training reduces impact of cognitive task on postural sway. J Mot Behav, 2005; 37: 239–246. [Medline] [CrossRef]

16) Pettersson AF, Olsson E, Wahlund LO: Effect of divided attention on gait in subjects with and without cognitive impairment. J Geriatr Psychiatry Neurol, 2007, 20: 58–62. [Medline] [CrossRef]

17) Yang YR, Chen YC, Lee CS, et al.: Dual-task-related gait changes in individuals with stroke. Gait Posture, 2007, 25: 185–190. [Medline] [CrossRef]

18) Yang YR, Wang RY, Chen YC, et al.: Dual-task exercise improves walking ability in chronic stroke: a randomized controlled trial. Arch Phys Med Rehabil, 2007, 88: 1236–1240. [Medline] [CrossRef]

19) Kim HA, Lee HM, Seo KC: The effects of dual-motor task training on the gait ability of chronic stroke patients. J Phys Ther Sci, 2013, 25: 317–320. [CrossRef]

20) Kim GY, Han MR, Lee HG: Effect of dual-task rehabilitative training on cognitive and motor function of stroke patients. J Phys Ther Sci, 2014, 26: 1–6. [Medline] [CrossRef]

21) Canning CG, Ada L, Woodhouse E: Multiple-task walking training in people with mild to moderate Parkinson’s disease: a pilot study. Clin Rehabil, 2008, 22: 226–233. [Medline] [CrossRef]

22) Erickson KJ, Colcombe SJ, Wadwa R, et al.: Training-induced functional activation changes in dual-task processing: an FMRI study. Cereb Cortex, 2007, 17: 192–204. [Medline] [CrossRef]

23) Melzer I, Goldring M, Melzer Y, et al.: Voluntary stepping behavior under single- and dual-task conditions in chronic stroke survivors: A comparison between the involved and uninvolved legs. J Electromyogr Kinesiol, 2010, 20: 1082–1087. [Medline] [CrossRef]

24) Schwenk M, Zieschang T, Oster P, et al.: Dual-task performances can be improved in patients with dementia: a randomized controlled trial. Neurology, 2010, 74: 1961–1968. [Medline] [CrossRef]

25) Jang YS, Baek JY, Oh MH, et al.: The effect of dual task performance on the trunk control ability and upper extremity function of patients with stroke. J Rehabil Res, 2012, 16: 311–331.

26) Lee YJ, Kim YS, Kim JS, et al.: The effects of balance in stroke patients after exercise. J Rehabil Sci, 2010, 28: 27–38.

27) Sullivan KJ, Knowlton BJ, Dobkin BH: Step training with body weight support: effect of treadmill speed and practice paradigms on poststroke locomotor recovery. Arch Phys Med Rehabil, 2002, 83: 683–691. [Medline] [CrossRef]

28) Yavuzer G, Iser F, Karakus D, et al.: The effects of balance training on gait late after stroke: a randomized controlled trial. Clin Rehabil, 2006, 20: 960–968 [Medline] [CrossRef]

29) Sackley CM, Baguly BI: Visual feedback after stroke with balance performance monitor: two single case studies. Clin Rehabil, 1993, 7: 189–195. [CrossRef]

30) Ison JM: Use of the gym ball in rehabilitation of spinal dysfunction. J Am Orthop Phys Ther Clinic, 1992, 1: 375–398.

31) 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]

32) Bae SC, Kim KJ, Yoon IH: The effects of the balancing training on the unstable surface for the CVA patients. Journal of Korean Academy of Orthopaedic Manual Therapy, 2001, 7: 5–22.

33) Granacher U, Gollhofer A, Strass D: Training induced adaptations in characteristics of postural reflexes in elderly men. Gait Posture, 2006, 24: 459–466. [Medline] [CrossRef]

34) Dennis A, Dawes H, Elsworth C, et al.: Fast walking under cognitive-motor interference conditions in chronic stroke. Brain Res, 2009, 1287: 104–110. [Medline] [CrossRef]

35) Kramer AF, Larish JF, Strayer DL.: Training for attentional control in dual task settings: a comparison of young and old adults. J Exp Psychol Appl, 1995, 1: 50–76. [CrossRef]