Effects of a Task-specific Exercise Program on Balance, Mobility, and Muscle Strength in the Elderly

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Abstract. [Purpose] The aim of this study was to investigate the effects of a task-specific exercise program based on motor learning on balance ability and strength of the lower extremity in the elderly with/without falling experiences. [Subjects and Methods] Individuals who had experiences of falling over 2 times within the past 6 months were included in the falling group. The task-specific exercise program consisted of 3 stages (weeks 1–2, 3–4, and 5–6) and was conducted according to the level of difficulty in this study. [Results] The scores of the Korean version of the Activities-Specific Balance Confidence Scale and Performance-Oriented Mobility Assessment were significantly changed in both the falling group and non-falling group after the task-specific exercise program. In comparisons between the falling group and non-falling group, there were also significant differences in the Korean version of the Activities-Specific Balance Confidence Scale and muscle strength of the semitendinosus and gastrocnemius. [Conclusion] The task-specific exercise program has a positive effect on balance ability and muscle strength related to falls in the elderly.

Key words: Falling, Task-specific exercise, Elderly people

INTRODUCTION

Falling can occur anytime in life, especially in the elderly over 65 years old. Thirty to 50% of elderly individuals have experienced falling, and 40% of them have been injured by falling1. Muscle strength in the lower extremities is well known as an important factor for falling, and muscle endurance and balance ability are also known to be necessary in order to prevent falling2.

Interventions such as exercise, education, and complex programs have been widely used to prevent falling. In a previous study, multifactorial intervention combining an exercise program and education was introduced as the most effective way to prevent falling, because falling is comprehensively affected by many factors such as physical, psychological, environmental, and social factors3.

However, in previous studies, the exercise focused on only one specific task, and the effects of exercise hardly relate to the improvement of ADL. Furthermore, there are not many studies about the effect of multi-factorial intervention. Thus, the purpose of this study was to investigate the effect of task-specific exercise program, which is one of multifactorial interventions, on muscle strength and balance ability.

SUBJECTS AND METHODS

Subjects

Thirty elderly individuals over 65 of age were randomly recruited and divided into two groups (FG = falling group, nFG = non-falling group) based on their responses to a questionnaire survey. That is, those that had fallen more than 2 times in the past 6 months were included in FG. The inclusion criteria were as follows: 1) able to normally perform ADL, 2) scored over 21 in the Korean Version of the Mini-Mental State Examination (MMSE-K), 3) no orthopedic disease, and 4) no participation in an exercise program within 3 months. All the subjects understood the purpose of this study and provided written informed consent prior to participation according to the ethical standards of the Declaration of Helsinki (Table 1).

Methods

The task-specific exercise program consisted of 3 stages (weeks 1–2, 3–4, and 5–6) and was conducted according to the level of difficulty in this study. The next level of the program was performed only after the earlier level had been completed and all subjects performed the program for an hour a day, three times a week for 6 weeks. Warming up mainly consisted of self-stretching exercises, and the method of performing and purpose of the task were demonstrat-
ed to subjects during the warm-up period. A modified task-specific exercise program consisting of balance training, gait training, and strengthening was applied in this study. The warm-up exercises included trunk elevation, trunk rotation, trunk flexion and knee flexion/extension while standing. Sufficient time to rest was provided according to the subjects’ conditions and the subjects were instructed to immediately stop performing an exercise if they felt any pain. Joint stretching (extension) was also performed for 10 minutes to cool down after the exercise.

The task-specific exercise program was conducted under the careful monitoring of 3 physical therapists who had more than 5 years of clinical experience. The exercise program was as follows:

1. Stage 1 (weeks 1–2): sit-to-stand, steps (anterior/posterior, right/left), 10 m of walking (anterior/posterior, right/left), squat exercise, standing on the tiptoes.
2. Stage 2 (weeks 3–4): Stage 1 + 10 m walk from sitting position on a chair and back, toe extension while squatting.
3. Stage 3 (weeks 5–6): Stage 2 + tandem walking, kicking a ball and retrieving the ball.

The Activities-specific Balance Confidence Scale (ABC) was developed by Power and Myer\(^5\). It consists of a total of 16 specific items that demonstrate whether a subject is able to maintain their balance and confidently perform the activities or not. The score is divided from 0 to 100%, and the scores of each item are summed to calculate the total score.

The Performance-Oriented Mobility Assessment (POMA) was conducted to evaluate mobility and the risk of falls. The POMA which was developed by Tinetti, is a 3-point scale and is helpful on measuring falling risk, balance ability and mobility\(^5\). POMA-T (POMA total) consists of two parts, POMA-balance (max score: 16 score) and POMA-gait (max score: 12 score).

A myotonometer (Neurogenic Technologies Inc., Missoula, MT, USA) was also used to measure the lower muscle strength in this study. A myotonometer can measure muscle strength by digitizing the muscle activation and muscle strength. In this study, the middle of each muscle was measured by compressing it with 1.5 kg of pressure applied by pressing on it with the myotonometer during maximum isometric contraction of the muscle. The vastus medialis, vastus lateralis, semitendinosus, biceps femoris, tibialis anterior and gastrocnemius were measured in this study. The isometric contraction of the muscle. The vastus medialis, vastus lateralis, semitendinosus, and gastrocnemius in FG but also in the vastus lateralis, tibialis anterior, and gastrocnemius in nFG (Table 2).

In comparison between FG and nFG, there were also significant differences in K-ABC and muscle strength of the semitendinosus and gastrocnemius (Table 3).

### DISCUSSION

The task-specific program reflects the concept of neuroplasticity and motor learning\(^6\). These programs are well known as effective approaches, since activities consisting of functional tasks could interact with the related organs in the programs. In a previous study, it was reported that a task-specific program was effective for improvement of standing, functional movement, balance, muscle endurance, and gait\(^7\).

In this study, the K-ABC and POMA were used to evaluate balance ability. The K-ABC scores significantly from 53.8±7.8 and 73.5±5.8 to 59.4±6.3 and 76.7±7.3 in FG and nFG. Respectively, after the intervention, The POMA scores were also increased from 17.3±4.6 to 22.8±3.9 in FG and from 19.6±3.4 to 23.6±3.2 in nFG after the intervention. These results are in line with the results of the study of Leroux, who investigated the effects of task-specific exercise on balance ability in patients with stroke\(^8\). Furthermore, Kim et al.\(^9\) also reported that dynamic balance was increased after task-specific exercise. These results support our study, which found that a task-specific exercise program may positively affect the balance ability in the elderly population.

A previous study reported that muscle weakness is the main factor for falls and closely related to balance and gait ability\(^10\). That is, quality of life and activities of daily living could be influenced by muscle weakness in the elderly. In this study, there were significant changes not only in the vastus medialis, vastus lateralis, semitendinosus, and gastrocnemius in FG but also in the vastus lateralis, tibialis anterior, and gastrocnemius in nFG after the 6-week task-specific exercise program. In addition, the increase in muscle strength was smaller in FG, compared with nFG. That is, the task-specific exercise program is effective for

### Table 1. General characteristics of the subjects (mean±SD)

|                     | Falling group (n=15) | Non-falling group (n=15) |
|---------------------|----------------------|--------------------------|
| Age (yrs)           | 47.5±7.2             | 48.2±8.4                 |
| Height (cm)         | 164.3±10.9           | 163.5±11.9               |
| Weight (kg)         | 58.8±8.4             | 58.1±8.9                 |
| MMSE-K (score)      | 27.9±2.4             | 27.8±1.9                 |

MMSE-K = Korean version of the Mini Mental State Examination
lower muscle strength in elderly individuals who have experienced falls, and a program for prevention of falls has to include muscle strengthening exercise for the semitendinosus and gastrocnemius. Krebs reported lower muscle strength increased by 26% after 6 weeks of task-specific exercise, and Yang reported a 61.5% increase in lower muscle strength after a 4-week program. These results would be caused by improvement of lower muscle strength and balance as a result of the positive effects of repeated movements in a task-specific exercise program.

There are some limitations in this study. First, it is a little difficult to generalize the results because of the small number of subjects. Second, continuous effects of the program were not evaluated. Third, the difficulty level was not controlled because the exercise program which was designed for CNS impairment, was applied to normal elderly individuals. Thus, further study compensating for these limitations will be needed.

This study was implemented to investigate the effect of a task-specific exercise program based on motor learning on balance ability and strength of the lower extremity in elderly people with/without falling experiences. The K-ABC and POMA scores, which used for analysis of balance ability, were significantly increased in both groups. Thus, the task-specific exercise program is thought to be effective for improvement of balance in the elderly. In FG, the extensor and flexor muscles of the hip joint were significantly increased, and in nFG, the dorsiflexor and plantar-flexor muscles were also significantly increased. Furthermore, there were significant differences in the K-ABC and lower muscle strength (semitendinosus and gastrocnemius) between FG and nFG. That is, the task-specific exercise program has a positive effect on balance ability and muscle strength related to falls in the elderly strength in the elderly related to falls.

### REFERENCES

1. Sherrington C, Lord SR, Close JC, et al.: A simple tool predicted probability of falling after aged care inpatient rehabilitation. J Clin Epidemiol, 2011, 64: 779–786. [Medline] [CrossRef]
2. Spiridou WO, Francis KL, MacRae PG: Physical dimensions of aging, 2nd ed. Champaign: Human Kinetics, 2005.
3. Vaapio S, Salminen M, Vahlberg T, et al.: Effects of risk-based multifactorial fall prevention on health-related quality of life among the community-dwelling aged: a randomized controlled trial. Health Qual Life Outcomes, 2007, 5: 20. [Medline] [CrossRef]
4. Powell LE, Myers AM: The activities-specific balance confidence (ABC) scale. J Gerontol A Biol Sci Med Sci, 1995, 50A: M28–M34. [Medline] [CrossRef]
5. Tinetti ME: Performance-oriented assessment of mobility problems in elderly patients. J Am Geriatr Soc, 1986, 34: 119–126. [Medline]
6. Bayona NA, Bitensky J, Salter K, et al.: The role of task-specific training in rehabilitation therapies. Top Stroke Rehabil, 2005, 12: 58–65. [Medline] [CrossRef]
7. Sullivan KJ, Brown DA, Klassen T, et al. Physical Therapy Clinical Research Network (PTClinResNet): Effects of task-specific locomotor and strength training in adults who were ambulatory after stroke: results of the STEPS randomized clinical trial. Phys Ther, 2007, 87: 1580–1602. [Medline] [CrossRef]
8. Leroux A, Pinet H, Nadeau S: Task-oriented intervention in chronic stroke: changes in clinical and laboratory measures of balance and mobility. Am J Phys Med Rehabil, 2006, 85: 820–830. [Medline] [CrossRef]
9. Kim JW, Kim SM, Park RJ: The effects of task-oriented functional training on standing balance in stroke patients. J Kor Soc Ther, 2003, 15: 65–81. [Medline] [CrossRef]
10. Moreland JD, Richardson JA, Goldsmith CH, et al.: Muscle weakness and falls in older adults: a systematic review and meta-analysis. J Am Geriatr Soc, 2004, 52: 1121–1129. [Medline] [CrossRef]
11. Krebs DE, Jette AM, Assmann SF: Moderate exercise improves gait stability in disabled elders. Arch Phys Med Rehabil, 1998, 79: 1489–1495. [Medline] [CrossRef]
12. Yang YR, Wang RY, Lin KH, et al.: Task-oriented progressive resistance strength training improves muscle strength and functional performance in individuals with stroke. Clin Rehabil, 2006, 20: 860–876. [Medline]
13. Park JH, Lee SH, Ko DS: The effects of the Nintendo Wii exercise program on chronic work-related low back pain in industrial workers. J Phys Ther Sci, 2013, 25: 985–988. [Medline] [CrossRef]
14. Kim JH, Lee LK, Lee JU, et al.: A pilot study on the effect of functional electrical stimulation of stroke patients in a sitting position on balance and activities of daily living. J Phys Ther Sci, 2013, 25: 1097–1101. [Medline] [CrossRef]

### Table 2. Comparison of the K-ABC, POMA, and muscle strength between before and after the intervention

|                          | Falling group (n=15) | Non-falling group (n=15) |
|--------------------------|----------------------|--------------------------|
|                          | Before | After | Before | After |
| K-ABC                    | 53.8±7.8 | 59.4±6.3* | 73.5±5.8 | 76.7±7.3* |
| POMA                     | 17.3±4.6 | 22.8±3.9* | 19.6±3.2 | 23.6±3.2* |
| Vastus medialis          | 8.5±0.4 | 7.2±0.6* | 7.5±0.6 | 7.2±0.8 |
| Vastus lateralis         | 7.3±0.8 | 6.4±0.6* | 7.5±0.2 | 6.2±0.6* |
| Semitendinosus           | 6.8±0.2 | 7.7±0.4* | 7.8±0.5 | 7.6±0.2 |
| Biceps femoris           | 8.8±0.5 | 8.5±0.7 | 8.8±0.2 | 8.6±0.8 |
| Tibialis anterior        | 6.7±0.4 | 6.6±0.9 | 6.4±0.2 | 5.6±0.5* |
| Gastrocnemius            | 8.2±0.6 | 7.1±0.5* | 6.9±0.4 | 6.2±0.5* |

*p<0.05, Mean±SD, Unit = score

### Table 3. Comparison of the K-ABC, POMA, and muscle strength between groups

|                          | Falling group (n=15) | Non-falling group (n=15) |
|--------------------------|----------------------|--------------------------|
|                          | Before | After | Before | After |
| K-ABC                    | −6.46±3.8 | −3.34±3.6* | −4.97±1.8 | −4.73±1.8 |
| POMA                     | 0.24±0.4 | 0.23±0.6 | 0.69±0.4 | 0.74±0.5 |
| Vastus medialis          | 0.75±0.5 | 0.34±0.5* | 0.28±0.4 | 0.14±0.8 |
| Semitendinosus           | 0.14±0.8 | 0.13±0.6 | 0.63±0.8* |

*p<0.05, Mean±SD, Unit = score

*5) Tinetti ME: Performance-oriented assessment of mobility problems in elderly patients. J Am Geriatr Soc, 1986, 34: 119–126. [Medline]
6) Bayona NA, Bitensky J, Salter K, et al.: The role of task-specific training in rehabilitation therapies. Top Stroke Rehabil, 2005, 12: 58–65. [Medline] [CrossRef]
7) Sullivan KJ, Brown DA, Klassen T, et al. Physical Therapy Clinical Research Network (PTClinResNet): Effects of task-specific locomotor and strength training in adults who were ambulatory after stroke: results of the STEPS randomized clinical trial. Phys Ther, 2007, 87: 1580–1602. [Medline] [CrossRef]
8) Leroux A, Pinet H, Nadeau S: Task-oriented intervention in chronic stroke: changes in clinical and laboratory measures of balance and mobility. Am J Phys Med Rehabil, 2006, 85: 820–830. [Medline] [CrossRef]
9) Kim JW, Kim SM, Park RJ: The effects of task-oriented functional training on standing balance in stroke patients. J Kor Soc Ther, 2003, 15: 65–81. [Medline] [CrossRef]
10) Moreland JD, Richardson JA, Goldsmith CH, et al.: Muscle weakness and falls in older adults: a systematic review and meta-analysis. J Am Geriatr Soc, 2004, 52: 1121–1129. [Medline] [CrossRef]
11) Krebs DE, Jette AM, Assmann SF: Moderate exercise improves gait stability in disabled elders. Arch Phys Med Rehabil, 1998, 79: 1489–1495. [Medline] [CrossRef]
12) Yang YR, Wang RY, Lin KH, et al.: Task-oriented progressive resistance strength training improves muscle strength and functional performance in individuals with stroke. Clin Rehabil, 2006, 20: 860–876. [Medline]
13) Park JH, Lee SH, Ko DS: The effects of the Nintendo Wii exercise program on chronic work-related low back pain in industrial workers. J Phys Ther Sci, 2013, 25: 985–988. [Medline] [CrossRef]
14) Kim JH, Lee LK, Lee JU, et al.: A pilot study on the effect of functional electrical stimulation of stroke patients in a sitting position on balance and activities of daily living. J Phys Ther Sci, 2013, 25: 1097–1101. [Medline] [CrossRef]