

The Effect of Motor Dual-task Balance Training on Balance and Gait of Elderly Women

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Abstract. [Purpose] This study investigated the effect of a motor dual-task balance program on balance and gait of elderly women to suggest a more effective balance exercise method. [Subjects] Twenty elderly Korean women who could walk independently were recruited from the community dwelling. [Methods] The motor dual-task balance training (experimental) group stood on an Aero-step, and performed gym ball bouncing, catching, and throwing, while the simple task balance training (control) group merely stood on the Aero-step. Participants performed 45 minutes of training, 2 times a week for 6 weeks. Balance (fall index) was measured using a TETRAX. Gait variables were recorded on a GAITRite walkway at self-determined walking speed. [Results] The fall index of the experimental group was significantly lower than that of the control group. Step length, stride length, velocity, and cadence of the experimental group improved significantly more than those of control group. [Conclusions] We found that motor dual-task balance training improved balance and walking ability more than simple balance training. Further studies should investigate motor dual-task training with kinematic and kinetic data, and muscle activation based on motor strategies.

Key words: Balance, Elderly, Motor dual-task

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INTRODUCTION

Balance control is a necessary component of stable walking. Many adults change their walking pattern as they age, and this is expressed as decreases in walking velocity, step length, and adaptive responses that ensure safe gait¹⁾. Falls greatly restrict functioning and reduce the quality of life of older people²⁾. Falls often lead to physical injury, such as fractures, and cause considerable morbidity and mortality^{3, 4)}. Activities of daily living (ADL) require balance maintenance during the concurrent performance of two or more tasks. Older people who perform poorly under dual-tasks are at increased risk of falls⁴⁾.

Dual-task training is defined as the ability to perform two or more cognitive and motor activities simultaneously while maintaining postural control⁴⁾. The dual-task methodology is the primary approach used to investigate interactions between cognitive processing and motor performance⁵⁾. Bowen et al.⁶⁾ compared walking speed and balance of stroke patients between performance with and without a verbal cognitive task. Kizony et al.⁷⁾ introduced cognitive load and dual-task training during locomotion for

stroke patients using a functional virtual environment. A number of studies have examined the ability of older adults to concurrently perform motor function and task demanding cognitive attention. Most studies have shown decreases in walking ability related to changes in postural stability, gait velocity, cadence, and stride length⁵⁻⁸⁾. The ability to divide one's attention between two or more concurrent tasks is an important aspect of functional movement during ADL. The functional capacity of older people is stressed when performing several tasks simultaneously, due to their limited capacity to perform the tasks, either because they require greater attention resources, or due to limitations in their information processing capacity of older peoples⁹⁾.

Silsupadol et al.⁴⁾ emphasized the importance of balance training based on dual-task conditions. They suggested that interventions to improve dual-task balance performance are essential components of fall prevention programs for the elderly. Several authors have researched dual-task balance training^{4, 10)}. None of these studies investigated the effects of motor dual-task balance training on the balance and gait of elderly women. Therefore, the purpose of the present study was to investigate the effect of a motor dual-task balance program using a gym ball on the balance and gait of elderly women, as well as to suggest a more effective balance exercise method for their well-being life.

SUBJECTS AND METHODS

Twenty elderly women who could walk independently were recruited from community dwellers in Gyeongsang-

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nam-do, Republic of Korea. The selection criteria were as follows: the ability to walk independently without an assistive device; and a score of more than 24 on the Korean Version of the Mini-Mental State Exam (KMMSE). The exclusion criteria were as follows: past or present neurologic disorder; a musculoskeletal disease that might have interfered with a daily activities; significant visual or auditory impairments; taking drugs that would have influenced the results of this study; and a participation in regular exercise programs within the last six months. Ethical approval was obtained from the Inje University Faculty of Health Science Human Ethics Committee, and all subjects signed an informed consent form prior to their participation.

Subjects of the experimental group were aged 78.6 ± 5.58 years (mean \pm SD), and had a height of 147.71 ± 6.11 cm, body weight of 50.06 ± 9.64 kg, and KMMSE score of 26.1 ± 1.45 . Subjects of control group were aged 79.8 ± 3.58 years, and had a height of 146.17 ± 5.28 cm, body weight of 48.67 ± 5.35 kg, and KMMSE score of 25.4 ± 0.97 .

Balance (fall index) was measured using a TETRAx (Sunlight Medical Ltd., Ramat Gan, Israel). The fall index score shows the degree of risk of falling, which is measured on a 0–100 point scale (0–35: low risk, 36–58: moderate risk, 59–100: high risk). A higher index score means a more unstable posture. Eight different postures were evaluated in the test and each posture was measured for 32 seconds. Gait parameters were recorded using the GAITRite system (CIR System Inc, Easton, PA, USA). Velocity, cadence, step length and stride length were recorded subjects' self-determined walking speeds. Participants started and finished walking 2 m before and after the start and end of the mat to avoid the effects of acceleration and deceleration. After one practice trial, participants performed five measurement trials¹¹.

All subjects participated in the 45-minute training sessions, 2 times a week for 6 weeks. Exercise programs were composed of a warm-up, the main exercises, and a cool-down period. Stretching was used for the warm-up and cool-down exercises. The main exercise employed in this test was the modified dual-task program of Yang et al.¹² The motor dual-task balance training (MDBT) group stood on an Aero-step (TOGU, Germany Inc., Germany) and performed gym ball (diameter: 45 cm) bouncing (right hand, left hand, and both hands), catching, and throwing. Two participants caught and threw the gym ball separated by a distance of 1.5 m. If they successfully performed the task over 80% of the time (eight out of ten times), the distance was increased to 2 m. The simple task balance training (SBT) group simply stood on the Aero-step. Statistical analysis was performed using the SPSS statistical package (version 18.0 for Windows, Chicago, IL, USA). The differences in balance and gait parameters were analyzed using the independent t-test for comparisons between groups and the paired-t test for comparisons within groups. Significance was accepted for values of $p < 0.05$.

Table 1. Comparison of post-intervention of balance and gait parameters between SBT and MDBT group (n=20)

	SBT Group (n=10)		MDBT Group (n=10)	
	Mean \pm SD		Mean \pm SD	
Fall Index	75.00 \pm 21.97		51.40 \pm 21.75*	
Velocity (cm/sec)	60.64 \pm 6.57		93.46 \pm 9.76**	
Cadence (step/min)	90.23 \pm 8.54		113.52 \pm 13.85**	
Step Length (cm)	L	42.67 \pm 4.71	49.19 \pm 6.38*	
	R	41.80 \pm 5.59	50.34 \pm 5.31**	
Stride Length (cm)	L	84.88 \pm 9.80	99.93 \pm 11.23**	
	R	85.02 \pm 9.21	99.92 \pm 11.53**	

MDBT: motor dual-task balance training, SBT: simple task balance training, L: left, R: right
* $p < 0.05$, ** $p < 0.01$

RESULTS

The results for the fall index and gait parameters of the MDBT group and the SBT group after training are presented in Table 1. The fall index value of the MDBT group was significantly better than that of the STB group and before training ($p < 0.05$). The parameters of gait between the groups were significantly different in terms of step length, stride length, velocity, and cadence between the groups ($p < 0.05$). All the measured gait parameters of the MDBT group were significantly improved following the training ($p < 0.05$).

DISCUSSION

This study compared the effects of SBT and MDBT conditions on balance and gait of elderly women who could walk independently without any assistive device. The post-intervention balance of the MDBT group was significantly better than that of the SBT group. Walking ability also showed a significant improvement when compared to that of the STB group. Performance of a dual-task requires information processing capacity that allows the efficient allocation of attention between the two tasks. Focusing on body movements (i.e., adopting a so-called internal focus) during the execution of a motor skill is relatively ineffective because it interferes with automatic control processes¹³. This study used MDBT based on the external focus method. Significantly increased balance ability and decreased postural sway were evident, indicating that attention was effectively allocated between balance and the second task.

Achieving effective postural control while bouncing, catching, and throwing a ball, and standing on the Aero-step involve complex interactions among the visual, somatosensory, and vestibular systems, which control the relationships between the different body segments, and spatial aspects with respect to gravity and the body and the environment⁹. The sole of the foot is one of the important areas of proprioceptive input for postural control¹⁴. Oh¹⁵ also showed that proprioceptive exercise on the Aero-step resulted in improved balance, and that is in agreement with

our present results.

Viswanathan and Sudarsky¹⁶⁾ reported that balance and gait disturbances in the elderly are particularly important, because they compromise independence and increase the risk of fall and injury. Gait characteristics of older people are influenced by balance control, leg muscle strength, ankle range of motion, and the availability of sensory information¹¹⁾. The present study showed that balance was improved in MDBT group after the intervention. We consider that walking ability improved due to improved balance, and our results support the hypothesis that changes in gait patterns are influenced by balance ability.

We also found that performing a proprioceptive-balance motor dual-task using a ball led to increased ankle mobility through center-of-weight shifting and reaction forces occurring during rapid upper limb movement. For this reason, the gait velocity also increased. Westlake et al.¹⁷⁾ examined the effects of sensory-specific balance training for older people. The tasks were performed standing or walking on different support surfaces, and their results suggest that there were improvements in velocity sensing. The study by Yang et al.¹²⁾ examined the effect of a dual-task program on the gait performance of chronic stroke patients, and found that all measured gait parameters of the motor dual-task group significantly improved.

In contrast to our findings, the study by Bond et al.¹⁸⁾ reported decreased walking ability during performance of a motor dual-task in patients with Parkinson's disease (PD). The reason for the differences in the walking velocity results may be due to the fact that subjects in our study were older adults, while the subjects in the study of Bond et al.¹⁸⁾ were patients with PD. Many people with PD have difficulty in automatically regulating their movement. If the basal ganglia are disordered, then automatic movement becomes tardy, or reduced in amplitude, or both aspects deteriorate. The other reason for the differences in walking velocity may be due to that the present study having had a dual-task intervention lasting 6 weeks, while the study of Bond et al. did not perform an intervention.

This study had several limitations. First, there was no follow-up period. We do not know whether the subjects in the experimental group were able to maintain the improvements we observed in their gait. Second, the sample size used in this trial was small, which implies that caution should be exercised when interpreting or generalizing the results. Third, this study only measured standing balance under specific sensory conditions in eight positions. No measurements were made of motor strategies during a perturbed stance. Therefore, we do not know the effect of dual task on motor strategy patterns.

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