

Effects of Neck and Trunk Stabilization Exercise on Balance in Older Adults

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Purpose: This study was conducted to evaluate the effects of neck and trunk stabilization exercise on static and dynamic balance in older adults.

Methods: A total of 30 older adults participated in this study. Participants were randomly assigned to the neck and trunk stabilization exercise group (NTSG) (n = 15) or the trunk stabilization exercise group (TSG) (n = 15). The NTSG performed a trunk stabilization exercise added to a neck stabilization exercise that included biofeedback. Both groups received training for 30 minutes per day three times per week for eight weeks. The anterior, posterior limit of stability and sway length was used to measure static balance ability, while the timed up and go (TUG) test was used to measure dynamic balance ability.

Results: Participants showed significant differences in sway length, anterior limit of stability, posterior limit of stability, and the results of the TUG test between their pre- and post mediation evaluations ($p < 0.05$). The NTSG showed a more significant increase than the TSG ($p < 0.05$).

Conclusion: According to the results of this study, both exercises effectively improved static and dynamic balance ability. However, the neck and trunk stabilization exercise is more efficient for increasing the balance ability of older adults.

Keywords: Neck and trunk stabilization exercise, Balance, Older adults

INTRODUCTION

Recent advancements in medicine and economic development have increased the average life expectancy, which has led to an increase in the proportion of elderly people in the population. As the number of elderly people has increased, the aging of the population has become an important social issue. Korea has already become an aging society; in 2000, elderly people accounted for 7.2% of the total population, and this figure is expected to reach 14.4% by 2019.¹ An aging population entails both social and psychological problems; many elderly people feel socially isolated and face economic hardships while suffering physical conditions, such as those resulting from chronic or degenerative diseases, and mental conditions, such as depression and a sense of isolation.² Function degradation of the elderly causes injuries in them, which take a great economic toll not

only on the elderly but also on society as a whole. In order to alleviate this toll, solutions to function degradation in the elderly population must be found.³

Aging causes functional and structural changes in elderly people. These changes cause muscle weakness that results from a reduction of muscle area and size, which leads to a decline in physical function.^{4,5} Physical and functional changes in the elderly affect their ability to carry out daily activities.⁶ In particular, muscle weakness of the trunk and pelvic limbs and decreased proprioceptive sensibility might hamper mobility and balance.⁷ These changes increase the risk of injury from falls.⁸

Balance can be divided into static balance and dynamic balance. Static balance is the ability to maintain center of gravity and the same posture so that the body does not move. Dynamic balance is the ability to maintain a desired posture by maintaining center of

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gravity while the body is moving.⁹ Maintaining balance requires vestibular function, visual information, proprioceptive sense, musculoskeletal function, stability of the trunk, and cognitive ability. Aging deteriorates these functions and can lead to falls.¹⁰

Many forms of exercise, such as muscle strengthening exercise, flexibility exercise, and aerobic exercise, can enhance the balance of elderly people and help them maintain or build muscle mass. The usefulness of these exercises has been proven.¹¹ The trunk stabilization exercise based on the strengthening of the core muscle for static body position.¹² Hess and Woollacott¹³ said that high-intensity muscle strengthening exercise is effective for elderly people whose balance ability is impaired and that this exercise effectively reduces the risks of getting hurt from a fall. Horak et al.¹⁴ said that the elderly use a hip strategy to keep balance, and since this hip strategy uses proximal muscles like abdominal muscles, and Granacher et al.¹⁵ said that trunk muscle strength are associated with variables of static/dynamic balance, functional performance, and falls. Hodges and Richardson¹⁶ conducted a study using an electromyogram and found that trunk muscle activities are essential for maintaining the stability of the lumbar and that transverse abdominal muscle and the multifidus muscle each have shorter a muscle contraction on-set time than the muscles that move the limbs. They also found that the contraction of trunk muscles, such as the musculus transversus abdominis, and the stability of the trunk, which refers to a person's ability to control the movement of joints both consciously and unconsciously, are important for a person's ability to move in a certain way.¹⁷ In addition, they also found that the ability to control one's head is important for controlling posture and balance.¹⁸ Gorden and Ghez¹⁹ emphasized that while the neck muscles are shorter and thicker than other muscles, the neck muscles have the highest concentration of muscle spindle out of all human muscles and exchange information through nervous system networks, such as the vestibulospinal reflex, the vestibulocollic reflex, and the vestibuloocular reflex, which control the arrangement of the head and trunk. Neck muscles help to support the head in a stable way, to hold one's gaze,²⁰ and to maintain whole-body activity.²¹ Based on the findings of these previous studies, the stability of the trunk and neck are clearly important for maintaining balance and posture, and both trunk stabilization and neck stabilization exercises are required to enhance the balance of the elderly.

A limited number of studies emphasize the effect of neck, trunk

stability on posture control. Research into the correlation of neck stability with trunk is currently insufficient especially for elderly people. Therefore, studies on the impact of trunk and neck stabilization exercises on the static and dynamic balance of the elderly need to be conducted in order to fill a gap in knowledge on the subject.

METHODS

1. Subjects

A total of 30 senior citizens who were over 65 years old from the K Senior Welfare Center in K City were selected for the study. Each participant was randomly allocated to either the neck and trunk stabilization exercise group (NTSG) (n = 15) or the trunk stabilization exercise group (TSG) (n = 15). The selection standards for the participants were those who had not fallen over during the previous year, those who had not suffered serious pain and musculoskeletal or neurological damage, those who were not on medication that might impair balance, those who had not participated in a regular trunk or neck stabilization exercise, those who were capable of independent walking, those whose Korean Mini-Mental State Examination (K-MMSE) score was over 24, and those who fully understood the purpose of this study. The general characteristics of the participants are listed in the Table 1.

This study was performed in compliance with the ethical principles of the Declaration of Helsinki. The subjects agreed to participate in the study after receiving explanations of the purpose and procedures of the experiment, and they signed an informed consent statement before participation. The protocol for this study was approved by the ethics committee.

2. Experimental methods

1) Interventions

For the trunk stabilization exercise, three exercises were conducted.

Table 1. General characteristics of subjects (M±SD)

	NTSG (n = 15)	TSG (n = 15)	t	p
Gender (male/female)	6/9	6/9		
Age (year)	73.4±5.8	74.7±7.8	-0.531	0.60
Height (cm)	163.4±7.3	166.8±5.3	-1.485	0.15
Weight (kg)	62.2±7.9	63.4±6.0	-0.463	0.65
MMSE (score)	28.8±1.3	28.5±1.2	0.744	0.46

M±SD: mean±standard deviation, NTSG: neck and trunk stabilization exercise group, TSG: trunk stabilization exercise group.

First, a participant lay back with their knees bent and tightened their stomach by pressing the navel down. Second, they put their knees and feet apart at the shoulder width, put their feet on the floor, raised the pelvis off the floor to form a straight line from the knees to the chest, paused, and slowly pulled the pelvis down. Third, they lay back with their knees bent, lifted the feet about 10 cm off the floor, tried to stick their shoulder on the floor, kept the trunk, and slowly moved the pelvic limbs from side to side.^{22,23}

For the trunk and neck stabilization exercise, each participant was asked to conduct craniocervical flexion training while carrying out the trunk exercises in a supine position to contract their deep neck flexor muscles when their trunk muscles were contracted. For the craniocervical flexion training, a pressure biofeedback unit (PBU) (Chattanooga, USA) that was filled with air was placed on the back of the head and upper neck of each participant. The pressure gauge was set to 20 mmHg, and the participants were fully relaxed. The superficial muscle of the neck remained relaxed and their deep neck flexors were contracted to flex the craniocervical region so that the cervical lordosis would be reduced. The jaw was drawn and the head was pushed down to the floor so the gauge of the pressure biofeedback unit went up. The pressure gauge of the PBU was checked and the participant's neck was laid down flat. The pressure was increased by 2 mmHg from 22 mmHg to 30 mmHg.^{24,25}

Both groups received training for 30 minutes per day three times per week for eight weeks. A preliminary evaluation of each patient was conducted before starting the program and reevaluation was conducted after eight weeks.

2) Measures

(1) Balance analysis system

To measure balance, a biofeedback analysis system (AP1153 Biorescue, France), which measures the static and dynamic balance of patients, healthy people, and athletes, was used. The participants were asked to stand and keep their eyes forward, were informed of the measuring method through a monitor, and were shown a demonstration before the measurement was taken. The participants were asked to stand for one minute as they maintained balance and kept their eyes forward to measure sway length based on pressure. They maintained balance by using an ankle strategy, following directions from the monitor. Then anterior limit of stability and posterior limit of stability were measured to compare balance.

(2) The timed up and go test

The timed up and go (TUG) test is a method used to measure a person's basic mobility and balance by measuring the amount of time it takes a person to go from a sitting to standing position, walk three meters, turn around, return to the chair, and sit back down. Studies say that this series of activities usually takes less than 10 seconds for healthy adults and 11-20 seconds for the feeble elderly or the elderly with disabilities. A person who takes more than 20 seconds to complete these activities is regarded as having a functional movement impairment. The interrater reliability of the study was $r = 0.99$ and the intrarater reliability was $r = 0.98$.²⁶ The measurements of the TUG test were made three times to calculate the average results.

(3) Pressure biofeedback unit (PBU)

A PBU (Chattanooga Group Inc., Hixson, USA) was used for the neck stabilization exercise. The PBU consisted of a measuring instrument, an air bag, and pneumatic pumps.

3. Statistical analysis

Statistical processing of the data was conducted using SPSS ver. 12.0, and descriptive statistics were used to analyze the subjects' general characteristics. An independent t-test was used to examine the homogeneity of the participants. Two-way repeated ANOVA was used to compare of balance ability according to training period and type on groups. Training group was set as the factor of between-subject, and Period was set as the factor of within-subject. And Variables of balance ability were set dependent variable. An independent t-test was conducted to examine the differences between the two groups. A statistical significance level was set at $p < 0.05$.

RESULTS

In results of two-way repeated ANOVA to compare of balance ability according to training period and type on groups, for sway length, anterior limit of stability, posterior limit of stability and TUG, there were no significant difference in between-subjects effect ($p > 0.05$). But, there were significant difference in within-subject effect according to period and in interaction of group and period (Table 2). For sway length, anterior limit of stability, posterior limit of stability and TUG, two-way repeated ANOVA didn't show significant effects of group ($p > 0.05$). But, two-way repeated ANOVA showed signifi-

Table 2. Comparison of balance ability according to training period and type on groups (M±SD)

		Pre	Post	Difference Value		F(p)
Sway Length (cm)	NTSG	36.10±17.51	28.39±9.89	-7.71±10.45	G ^a	0.04 (0.843)
	TSG	33.90±10.66	32.32±9.84	-1.58±2.63	P ^b	11.143 (0.002*)
	t	0.416	-1.090	-0.202	PxG ^c	4.85 (0.036*)
	p	0.681	0.285	0.043*		
Anterior LOS (mm)	NTSG	2,590.27±2,592.42	6,119.20±3,565.39	3,528.93±2,510.22	G	1 (0.326)
	TSG	2,556.60±2,685.39	4,022.47±3,438.39	1,465.87±1,604.18	P	42.168 (<0.000*)
	t	0.035	1.639	2.682	PxG	7.194 (0.012*)
	p	0.972	0.112	0.012*		
Posterior LOS (mm)	NTSG	1,761.53±1,700.71	2,607.60±2,023.58	846.07±778.93	G	1.201 (0.283)
	TSG	1,376.73±1,093.44	1,773.73±1,204.27	397.00±327.06	P	32.476 (<0.000*)
	t	0.737	1.371	2.059	PxG	4.238 (0.049*)
	p	0.467	0.181	0.049*		
TUG (sec)	NTSG	17.37±6.61	7.61±1.24	-9.76±6.29	G	0.697 (0.411)
	TSG	14.02±3.09	9.19±1.74	-4.83±3.03	P	65.411 (<0.000*)
	t	1.776	-2.872	-2.736	PxG	7.485 (0.011*)
	p	0.087	0.008*	0.011*		

M±SD: mean±standard deviation, NTSG: neck and trunk stabilization exercise group, TSG: trunk stabilization exercise group, LOS: limit of stability, TUG: timed up and go test, G: Group, P: period.

^aBetween-subjects effect; ^bWithin-subjects effect; ^cInteraction effect of group and period.

*p<0.05.

cant effects of period and significant interaction of group and period. In results of independent t-test, significant differences were found between the two groups (p<0.05) (Table 2).

DISCUSSION

Aging is accompanied by degradation of the body, such as muscle atrophy, muscle weakness, and musculoskeletal system degradation,²⁷ and this degradation causes reduced balance and difficulties carrying out daily activities.²⁸ Many studies have been conducted on the musculoskeletal system to help the elderly maintain or enhance their balance. According to these studies, the reaction time of the ankle muscles, which maintain balance, of the elderly was longer than that of young people. A significant reduction in the muscle strength of the ankle has been observed among the elderly. In order to maintain balance, elderly people can carry out hip joint and trunk exercises.¹⁴ Hodges and Richardson,¹⁶ and Choi et al.²⁹ reported that trunk muscle strength is essential for the elderly in order to maintain body posture and plays a role in maintaining the stability of the spine, performing body functions, and moving the arms and legs.

The present study aimed to examine the impact of the trunk stabilization exercise and the combined neck and trunk stabilization

exercise on the balance of the elderly. Park and Hwangbo³⁰ reported that both trunk stabilization exercises using a sling and trunk stabilization exercises on mat significantly decreased the sway area and the sway length of the center of the pressure in a standing position of stroke patients. In a study of elderly women conducted by Choi et al.,³¹ Functional Reach Test (FRT), One Leg Stand Test with Open Eye (OLSTOE), One Leg Stand Test with Closed Eye (OLSTCE), Timed Up and Go Test (TUG) and 6m Walking Test (6MWT) have significantly improved after a trunk stabilization exercise using swiss ball and core stabilization exercise were performed. In a study of stroke patients conducted by Yoon et al.,³² more significant improvements were observed in an experiment group than in a control group in an modified Forward Reach Test after carrying out an abdominal draw-in maneuver. In the present study, significant improvements in sway length of center of pressure in the standing position, anterior limit of stability, and posterior limit of stability were found in participants who underwent the trunk stabilization exercise, and these findings were similar to those of previous studies. Since the TUG times of the participants were significantly reduced after the exercise was completed, the exercise likely enhanced the balance of the participants. Based on these findings, the trunk stabilization exercise can likely be used to enhance the static and dynamic balance of the elderly.

External information from the surrounding environment and internal information from within the body are delivered to the trunk and neck, allowing the limbs, including the neck, to coordinate with each other. Among them, the head and neck set body standards for the surrounding environment and provide information that allows posture to be controlled.³³ To enhance the mobility of the distal parts of the body, including the neck, the trunk stabilization exercise should be conducted. The significance of the trunk stabilization exercise has been confirmed by previous studies.³⁴ Since the elderly experience degradation of general body structure and functions, the effects of which negatively affect their balance, recovering the stabilization and balance of the neck and trunk is important for the elderly. Since muscle strength and the stability of neck muscles are related to the stabilization of the trunk, it was believed that these two factors might influence the stabilization of the trunk and balance.

In this study, the NTSG showed more significant improvements in their static and dynamic balance than the TSG. In addition, the TUG time decreased significantly after the exercise. These findings, along with previous study results, support the idea that strengthening the neck muscles enhances the stability of the head, which has positive effects on people suffering imbalance due to a lack of body stability and mobility.³⁵ In a previous study conducted by Falla,³⁶ the neck stabilization exercise was carried out for those with neck pain and those who did not have neck pain in order to compare changes in neck pain and the cervical vertebral and thoracic vertebrae alignment. The results of this study showed that the neck stabilization exercise group reported enhanced neck muscle strength and sitting balance. Shim et al.³⁷ said arranging body posture in the supine position, carrying out the neck stabilization exercise, flexing the front and side parts of the trunk, doing bridge posture, and carrying out exercises that include a pelvic inclination exercise in the sitting position activate various muscles in the trunk. Controlling posture requires support, stabilization, and balance. To maintain a proper body posture against gravity, the head, trunk, arms, and legs should cooperate with each other.

While many studies on the elderly reported that exercise improved their muscle strength, flexibility, balance, and mobility and therefore enhanced their ability to carry out daily activities, effective exercise programs have not been introduced to the elderly because of their tendency to perform only limited activities as they age. Since

more than 50% of the elderly over 65 years old fear falling, they avoid active and functional activities. Considering these factors, it is believed that the trunk and neck stabilization exercises in the present study can be used to enhance the static and dynamic balance of the elderly. Many elderly people participated in the study because the exercises used in this study can easily be carried out in a lying position on a broad foundation, which prevents them from falling, at home by themselves. More studies need to be conducted not only on the balance of the elderly but also on their walking abilities and how to prevent their falls.

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