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Original Article

The effects of isometric trunk exercises and dynamic trunk exercises on gait in elderly people

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Abstract. [Purpose] The purpose of this study was to compare the effects of dynamic trunk exercises and isometric trunk exercises on gait in elderly people. [Subjects] This study randomly allocated 20 elderly people to an isometric trunk exercise group (n=10) and a dynamic trunk exercise group (n=10). The exercises were performed for 30 minutes three times a week for 12 weeks. Gait speed, stride length, cadence, and step width were measured at a normal pace using GAITRite. All groups were evaluated before and after 12 weeks. [Results] The isometric exercise group showed a significant change in gait velocity, cadence, and left and right step lengths. The dynamic trunk exercise group showed a significant change in gait velocity, cadence, left and right step lengths, left and right step times, and left and right stride lengths. Moreover, a comparison of the exercise effect between the two groups showed a significant difference in gait velocity. [Conclusion] The results of this study suggest that isometric trunk exercises and dynamic trunk exercises have a positive effect on gait function in elderly people. In particular, isometric trunk exercises are recommended to promote gait velocity.
Key words: Isometric trunk exercise, Dynamic trunk exercise, Gait

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INTRODUCTION

Posture adjustment, a complex process that involves balance, motor ability, endurance, scope of exercise, sensory function, and muscle strength, is intrinsically linked to falls[1, 2)]. Falls are related to abnormal gait and poor balance[3)]. They are mainly caused by the symptoms of aging and a decline in balance ability and muscle strength. Loss of postural control performance, which is caused by a decline in flexibility, and loss of the ability to maintain postural balance during gait, which is due to a decline in lower extremity strength, also contribute to falls[4)]. The progression of aging causes a decline in muscle strength and balance, which in turn cause movement and gait disorders. Reductions in lower extremity strength and flexibility decrease gait velocity, shorten step stride, and increase the risk of falls[5)].

In general, the progression of aging results in delayed reactions to stimulation, increased brain volume loss rates, a decline in the production of neurotransmitters like dopamine, a decline in the sense of hearing and the sense of equilibrium, decreased vision and somatosensory system function, and decreased cognitive ability[6, 7)]. In addition, loss of balance ability due to musculoskeletal disorders such as degenerative joint disease can lead to changes in gait[8)]. Aging causes gait characteristics to change. To compensate for the decline in the ability to balance and maintain stability, the distance between the feet, stance phase, and double support time are increased, stride length, gait velocity, and range of motion are decreased, and the swing phase is shortened[9)].

Isometric trunk exercises, by reacting to given resistances, cause tension and strength to develop in muscles but do not result in any visible joint movement. Stabilization exercises are the most representative type of this exercise. Dynamic trunk exercises cause muscles to contract and stretch within one's scope of exercise to dynamically react to given resistances[10, 11)]. Trunk stability exercises, or isometric trunk exercises, train muscles such as the transversus abdominis muscles, multifidus muscles, and obliquus internus abdominis muscles. As tension and postural muscles, these muscles are closely related to balancing during gait, as they are responsible for the stability of the lumbar spine and related postural control when performing full body exercises[12)].

Strength exercises, balance training, and flexibility training have been studied as exercise methods that improve the gait ability of elderly people. It has been reported that lower extremity strength improvement exercises and balance and

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flexibility training reduce the risk of falls and improve gait ability[13–15].

In this study, the effects of isometric trunk exercises and dynamic trunk exercises on gait in elderly people were established to help develop gait ability improvement exercise programs for elderly people.

SUBJECTS AND METHODS

This study involved 20 elderly subjects who had been deemed able to participate in exercise programs and who agreed to participate in the study. It was conducted in a senior citizen center in Yeongdeok-gun, Gyeongbuk Province, South Korea. The participants were randomly assigned to a dynamic trunk exercise group and a isometric trunk exercise group. The general characteristics of the subjects are shown in Table 1.

To analyze the gait of the subjects, a GAITRite system (CIR Systems Inc., Sparta, NJ, USA) was used. The tests were each conducted three times before and after the 12-week program. The tester gave the study subjects a verbal signal to start walking on a 5 m walkway board at the speed they found most comfortable. After the completion of the 5 m of walking, the cadence, cycle time, gait velocity, step time, double support time, stance time, stride length, and functional ambulation performance score of each study subject were measured. The reliability of the measurer for this test was r = 0.90, and the correlation coefficients of all the gait measurements at comfortable gait speeds were 0.96 or greater[5]. All of the subjects were given an overview of this study and participated after providing consent. The Ethics Committee of Namseoul University, South Korea also approved the study. The IRB approval number is Research-NSU-141013-3.

Exercise programs according to trunk exercise type, i.e., the isometric trunk exercise and dynamic trunk exercise programs, were applied to the subjects for 12 weeks, after which changes in gait ability were investigated. The isometric trunk exercise program and dynamic trunk exercise program ran for 30 minutes each; they consisted of: five minutes of warm-up exercises, 20 minutes of main exercises, and five minutes of cooldown exercises (Tables 2, 3). The isometric trunk exercise program consisted of the following exercises: isolated contraction of the transversus abdominis muscles in the lying-down position, simultaneous contraction of the transversus abdominis and multifidus muscles, slowly extending each bent knee in succession, pushing each elbow downward in succession, slowly lifting both arms above the head, lifting each knee in succession, opposite arm and leg lift exercises, maintaining stabilizer contraction while sitting on a ball, sitting on a ball with the eyes open and feet together, sitting on a ball with the eyes closed and feet apart, sitting on a ball with the eyes closed and feet together, moving the arms with the eyes closed and feet together, moving

Table 1. General characteristics of the subjects

	IREG (mean±SD)	DREG (mean±SD)
Gender (male/female)	2/8	2/8
Age (years)	73.0	73.5
Height (cm)	159.4	159.1
Weight (kg)	55.9	57.4
BMI	22.0	22.1
BBS	38.0	38.6

Values are shown as the mean±SD. $p<0.05$.
IREG: isometric trunk exercise group, DREG: dynamic trunk exercise group, BMI: body mass index, BBS: Berg Balance Scale score

Table 2. Static resistance exercise program for the trunk

Classification	Exercise program	Duration of exercise	Duration of rest
Warm-up exercises	Stretching exercises	5 minutes	
Main exercises	Isolated contraction of transversus abdominis muscles	20 minutes	30 seconds after each set
	Simultaneous contraction of transversus abdominis and multifidus muscles		
	Extend each knee in succession		
	Push each elbow downward in succession		
	Slowly lift both arms above the head		
	Lift each knee in succession		
	Opposite arm and leg lift		
	Maintain stabilizer contraction while sitting on a ball		
	Sit on a ball with the eyes open and feet together		
	Sit on a ball with the eyes closed and feet apart		
	Sit on a ball with the eyes closed and feet together		
	Move arms with the eyes closed and feet together		
	Move both arms up and down while sitting on a ball with the eyes closed		
	Lift both arms and one leg while sitting on a ball with the eyes closed		
Cooldown exercises	Breathing and stretching exercises	5 minutes	

both arms up and down while sitting on a ball with the eyes closed, and lifting both arms and one leg while sitting on a ball with eyes closed. Yellow and red elastic bands were used during the dynamic trunk exercise program. The maximum strength of all the exercise movements was set at 10 RM (repetition maximum). In view of the fact that the subjects were elderly, the exercise intensity was set at around 13–14 on the rating of perceived exertion (RPE) scale.

PASW Statistics 18.0 was used to analyze the data. To determine the differences in gait change between the two groups, an independent t-test was conducted. To examine the differences within the groups before and after the programs, a paired t-test was conducted. The statistical significance level was $p<0.05$.

RESULTS

The results of analysis of the gait characteristic changes between before and after the isometric trunk exercise program showed that there were statistically significant differences in gait velocity, left step length, right step length, left stride length, and right stride length ($p<0.05$) (Table 4). The results of analysis of the gait characteristic changes between before and after the dynamic trunk exercise program showed that there were statistically significant differences in gait velocity, cadence, left step time, right step time, left step length, right step length, left stride length, and right stride length ($p<0.05$) (Table 4). The results of analysis of the effect differences of the isometric trunk exercise and dynamic trunk exercise programs showed that the gait velocity change of the isometric trunk exercise group was statistically significantly greater than the gait velocity change of the dynamic trunk exercise group ($p<0.05$) (Table 4).

DISCUSSION

The weakening of muscle strength due to aging has an effect on posture and gait and can cause falls[1]. With the progression of aging, gait patterns change. The decline in one's sense of balance causes gait velocity to drop and step stride to narrow, and thus the risk of falls increases[16]. Elderly people with insufficient exercise are especially likely to experience an accelerated decline in endurance and ability to balance along with amyotrophia, and this affects their everyday lives[4].

Previous papers on prevention of the decline in gait function resulting from weakening of the trunk muscles in have reported results similar to this study's findings. Park reported that a trunk exercise program using elastic bands caused gait velocity to increase[17], while Kim described how the gait performance of elderly women improved through a trunk stabilization exercise program[18]. Chung et al. reported that gait velocity and stride length improved significantly in stroke patients that participated in a core stabilization exercise program[19].

In this study, 12-week isometric trunk exercise and dynamic trunk exercise programs were designed and implemented to improve the gait ability of elderly people.

Table 3. Dynamic resistance exercise program for the trunk

Classification	Exercise program	Period of exercise	Period of rest
Warm-up exercises	Stretching exercises	5 minutes	
Main exercises	Trunk flexion	20 minutes	30 seconds per set
	Trunk extension		
	Trunk rotation to the right		
	Trunk rotation to the left		
	Lateral trunk bending		
Cooldown exercises	Breathing and stretching exercises	5 minutes	

Table 4. Comparison of the gait performance of the isometric resistance exercise group and dynamic resistance exercise group

	IREG		DREG	
	Before	After	Before	After
Gait velocity (cm/sec)	76.3±5.2	95.3±7.1†‡	84.9±5.9	90.6±10.1†
Cadence (steps/min)	103.1±9.4	99.8±5.3	110.0±7.0	97.6±3.9†
Step time L (sec)	0.5±0.0	0.6±0.0	0.5±0.0	0.6±0.0†
Step time R (sec)	0.5±0.0	0.6±0.0	0.5±0.0	0.6±0.0†
Step length L (cm)	44.7±4.0	57.6±4.7†	46.7±3.1	55.9±4.3†
Step length R (cm)	44.5±4.6	56.9±4.8†	45.9±2.4	55.1±4.8†
Stride length L (cm)	89.6±8.3	114.7±9.2†	92.8±5.4	111.7±9.0†
Stride length R (cm)	89.0±8.7	114.0±9.6†	92.7±5.5	110.8±8.8†

Values are shown as the mean±SE, *$p<0.05$. † Significant difference between before and after the exercise programs within group ($p<0.05$), $p<0.05$.
‡ Significant difference between the two group ($p<0.05$).

Analyses of the effects of the exercise programs on gait ability factors, gait velocity, cadence, step time, step length, and stride length revealed interesting results. The changes in gait characteristics resulting from the isometric trunk exercises brought about significant improvements in gait velocity, left and right step times, left and right step lengths, and left and right stride lengths. The changes in gait characteristics resulting from the dynamic trunk exercises brought significant improvements in gait velocity, left and right step times, left and right step lengths, and left and right stride lengths, and a significant drop in cadence. In addition, the gait velocity of the isometric trunk exercise group improved significantly compared with that of the dynamic trunk exercise group. A number of previous studies have been conducted regarding isometric trunk exercises. Kim reported that a 12-week isometric trunk exercise program designed to study the gait variables in elderly women caused step length and stride length in the temporal and spatial gait patterns to increase significantly[18]. A four-week isometric trunk exercise program conducted on a group of elderly women by Choi et al. resulted in a significant improvement in gait velocity[20]. Approximately 80% of the swing phase during gait is dependent on one's ability to support the body on one foot; however, the state of one's body becomes unstable if the body's center of mass shifts to the outer edge of the supporting foot. The major muscles used during this phase are the erector muscle of the spine, the gluteus medius muscle, and the gluteus minimus muscle, the musculus tensor fasciae latae, among others, all of which play an important role during trunk exercises[21]. Grabiner et al. studied the factors that play roles in recovering the body's balance when postural balance is suddenly lost during gait. They found that the ability to control lower extremity strength and the angle of trunk flexion is important[22]. The isometric trunk exercises in this study employ the muscles that are associated with control of the trunk flexion angle. These isometric trunk exercises are thus considered effective for improving the balancing ability and gait stability of elderly people.

Previous research on dynamic trunk exercises generally supports the findings of this study. Park conducted a four-week trunk muscle strengthening exercise program using elastic bands on patients with hemiparalysis due to stroke or traumatic brain injury, and found that the step length and gait velocity of the patients increased significantly[17]. Kim et al. conducted an eight-week resistance exercise program designed to study how the lumbo-pelvic region and lower extremity muscles in elderly people react, and reported that gait ability improved significantly[23]. This supports the results of this study in that dynamic trunk exercises improve the gait ability of elderly people. Increased step length and increased gait velocity are thought to improve balance ability through improvement of trunk stability[17]. Hosseini et al. conducted six-week muscle strength exercise and core stabilization exercise programs[24]. They ascertained that the dynamic gait in the core stabilization exercise group increased significantly compared with the dynamic gait in the muscle strength exercise group. This supports the results of this study in that isometric trunk exercises are more effective in improving gait velocity than dynamic trunk exercises. It is thought that balance ability is improved through stabilization exercises and that this leads to an increase in gait velocity[17].

In this study, an isometric trunk exercise program and a dynamic trunk exercise program were conducted. Both programs improved gait ability, although the results showed that the isometric trunk exercise program was more effective in increasing gait velocity than the dynamic trunk exercise program. Isometric trunk exercises and dynamic trunk exercises are both effective in improving gait ability. Further research on various body exercise programs to compare the differences between exercise programs of varying periods and their effect on the gait ability of elderly people are required.

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