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ORIGINAL

Effect of 12-week Exercise Programs for Posture Correction on Standing Postural Alignment in Elderly Women

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Objective: The purpose of this study was to compare the effect of different 12-week exercise programs for posture correction on postural alignment in elderly women.

Method: The study included 36 elderly women who were randomly divided into 3 groups: Group A (core exercise, n=12), Group B (combined exercise, n=12), and Group C (Pilates exercise, n=12). Postural alignment was measured using 6 variables in frontal and sagittal planes. Two-way mixed analysis of variance was used to compare the effect of exercise program types on postural alignment and a paired *t*-test was used to compare differences in postural alignment after exercise.

Results: The core exercise group showed statistically significant improvement ($p<.05$) in multiple upper and lower body postural alignment measurements. The combined exercise and Pilates exercise groups showed statistically significant improvement ($p<.05$) in upper body measurements alone.

Conclusion: Core exercise, combined exercise, and Pilates exercise improved postural alignment in elderly woman through improvement in muscle strength and ligament flexibility around the spine and pelvis.

Keywords: Core exercise, Combined exercise, Pilates exercise, Body postural alignment, Shisei innovation

INTRODUCTION

Normal posture is characterized by laterally symmetrical balance in the frontal plane and linear alignment of the ear canal, center of the shoulder, anterior knee, and ankle in the sagittal plane (Gauchard, Gangolff, Jeandel & Perrin, 2003; Kendall, 2005). A primary cause of falls in the elderly is asymmetrical posture (Rose, 2010). It has been reported that asymmetrical posture increases the risk of falls, as asymmetrical muscles and flexibility imbalance bias the center of mass toward one side (Yi, Choi & Kim, 2014). Because postural change and body imbalance lead to falls (Cheng, Wu, Liaw, Wong & Tang, 2001), improving posture and balance ability through exercise that is effective and appropriate to the characteristics of the elderly is essential for the prevention of falls (Son, Yi & An, 2017).

Muscle strength and flexibility decrease with aging, creating a vicious cycle of decreased physical functioning by limiting physical activities such as motion and locomotion. Thus, not only falls but also various diseases can develop (Sinaki et al., 2010). Specifically, because muscles weaken and flexibility in the spine and the range of motion decrease, the elderly characteristically assume a slouched posture (Studenski, Duncan & Chandler, 1991). In addition, somatic sensation (i.e., the ability to perceive a change in the body) is decreased, thereby decreasing the ability to maintain posture (Bae, Um & Kim, 2009) and react to proprioceptive perception (Gauchard et al., 2003), resulting in unstable posture. Imbalance in the body causes problems in the feet and thighs, and causes imbalance between the pelvis and other body segments. Such imbalance induces pain, the body leans to one side, and body balance is impaired. Leaning the body to one side may be interpreted as a compensatory mechanism triggered by a permanent or long-term postural change (Park, Lee, Han, Park & Lee, 2008).

As aging progresses, posture becomes fixed and certain body parts become stiff, degenerative, and deformed (Lee & Kim, 2017). Because bone density is low and bones are weak in elderly women, the incidence of falls and fractures is higher than in elderly men (Lee, 2016; Hsu, Chen, Tsauo & Yang, 2014). Vertebral compression fractures frequently occur in women with osteoporosis, as their bone density is low. Such fractures may even affect posture through development of a spinal deformity (Hasserius, Karlsson, Jonsson, Redlund-Johnell & Johnell, 2005). Characteristic postural changes in elderly women include anterior deviation of the center of the head from the shoulders, kyphotic curvature in the thoracic spine, excessive lordosis in the lumbar spine, and curvature in the lower limbs including the hips and knees (Kendall, 2005). These postural characteristics may be the consequences of linked systems in the human body, and induce excessive stress in the lower limb joints during maintenance of erect position and balance (Anacker & Di Fabio, 1992).

Research on posture in the elderly has mainly addressed the functioning and characteristics of gait (Kim & Kim, 2013; Hong, 2015), postural stability, and balance ability (Kang & Park, 2014; Lee, Yi & Yoo, 2002), with reports that posture and balance ability are critical in the prevention of falls. As musculoskeletal factors play a particularly important role in posture in the elderly, extension exercises and those that maintain structural balance are effective for correcting poor posture (Son, Lee & Kim, 2014). Trunk and spine stabilization exercises provide trunk balance and stability, enabling maintenance of erect position, and are currently highlighted as a main trend in exercise rehabilitation to retain body balance (Hwang, Cho & Lee, 2010). Combined exercise can result in a favorable change in body shape, by facilitating the growth of muscle cells and increasing muscle strength (Hunter, McCarthy & Bamman, 2004). Pilates is reported to develop flexibility and balance, correct poor posture, and increase muscle strength, while helping to control weight and relieving back pain (Herrington & Davies, 2005; Maher, 2004). Exercise programs with low risk of injury that are easy to perform indoors with simple or no equipment are necessary for elderly women. Accordingly, this study was conducted to compare the effects of trunk stabilization exercise, combined exercise, and Pilates on posture in elderly women, and to provide basic data for use in developing an effective exercise program for good posture and balance.

METHODS

1. Participants

The study included 36 women aged 65 or older attending the senior academy at S University in B City, who were randomly divided into 3 12-week exercise groups, i.e., trunk stabilization exercise (Group A), combined exercise (Group B), and Pilates exercise (Group C). The study objectives and procedures were explained, and participants provided written consent before the study began. Physical characteristics of the subjects are presented in (Table 1).

Table 1. Physical characteristics of the subjects

Group	Age (yrs)	Height (cm)	Weight (kg)
	M ± SD	M ± SD	M ± SD
Group A (n=12)	72.62±3.97	153.22±4.06	55.37±8.36
Group B (n=12)	72.00±5.01	153.49±3.85	57.55±7.27
Group C (n=12)	70.17±3.48	153.46±4.72	58.57±7.47

2. Measurements

The Shisei Innovation System (PA200, The Big Sports Co., Japan) was used to measure postural alignment (Kim et al., 2017; Oh & Lee, 2016; Son et al., 2014; Son & Lee, 2016; Woo, Kwak & Yang, 2016). To minimize measurement error, the subjects were instructed to wear clothing made of Spandex fabric. To analyze postural alignment, 15 markers were attached in the frontal and sagittal (right side) planes and each subject was photographed in frontal and sagittal views while looking to the front in a comfortable posture (Oh & Lee, 2016).

A total of 12 variables (6 each on the frontal and sagittal planes), were measured for further analysis (Table 2). In measurements (mm) obtained for each area of the body, with the exception of angle (°), the closer to 0 the distance from the center of axis (CoA), the better the posture. A pelvic angle close to 11.3±4.3° was considered within normal range (Levine & Whittle, 1996).

3. Exercise programs

The trunk stabilization, combined, and Pilates exercises were conducted twice a week for 12 weeks. The total duration of an exercise session was 60 min, consisting of 10 min for warm-up, 40 min for main workout, and 10 min for cool-down. The warm-up and cool-down exercises were identical across the groups. For warm-up, stretching was used as well as line dancing to induce interest, and static stretching was performed for cool-down. To increase the effectiveness, exercise intensity was gradually increased in all programs by applying the rate of perceived exertion (RPE). RPE was 7~8 in weeks 1 through 4, 9~10 in weeks 5 through 8 and 11~12 in weeks 9 through 12. Details of each exercise program are presented in (Table 3).

4. Statistical analysis

The data were analyzed using Windows SPSS Version 24.0. Descriptive statistics (means and standard deviations) were computed for 12 variables of postural alignment in elderly women, and the deltas (△) were computed for differences between the measurements of postural alignment after exercise in each of the groups. To test the effects of the exercise programs and time (after exercise) on postural alignment measurements, two-way mixed analysis of variance was used with Bonferroni post hoc testing. To analyze the within-group change in postural alignment after exercise, a paired t-test was conducted. Statistical significance was set at α=.05 in all cases.

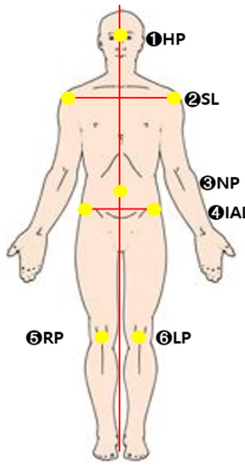
RESULTS

1. Postural alignment in the frontal plane

The effects of exercise type on postural alignment in the frontal plane are shown in (Table 4). For LP, the interaction between time and exercise type was statistically significant [F=8.511, p=.001], and for HP [F=9.273, p=.005] and NP [F=5.385, p=.027], the effect of time was statistically significant. Regarding the difference after exercise in each group, SL [t=2.996, p=.012], NP [t=4.735, p=.001], and LP [t=4.427, p=.001] in the trunk stabilization group, and HP [t=2.927, p=.014] in the combined group were statistically significant. However, the statistically significant difference for LP [t=-2.578, p=.026] in the Pilates group indicates that postural alignment was worse after exercise.

Table 2. Body alignment measurement

Plane	Measurement	Content
Frontal plane	Head Position (HP)	❶ Distance between CoA and glabella
	Shoulder Level (SL)	❷ Height of right acromion relative to left acromion
	Navel Position (NP)	❸ Distance between CoA and navel
	Inter-ASIS Level (IAL)	❹ Height of right ASIS relative to left ASIS
	Right Patella (RP)	❺ Distance between CoA and right patella
	Left Patella (LP)	❻ Distance between CoA and left patella
Sagittal plane	Earhole Position (EP)	❶ Distance between CoA and earhole
	Head Angle (HA)	❷ Angle of lines between earhole and C7 and between right acromion and C7 in the sagittal plane
	Acromial Position (AP)	❸ Distance between CoA and right acromion
	Pelvic Angle (PA)	❹ Tilt angle of line between Inter-ASIS and PSIS in the horizontal plane
	Greater Trochanter (GT)	❺ Distance between CoA and GT
	Knee Position (KP)	❻ Distance between CoA and knee



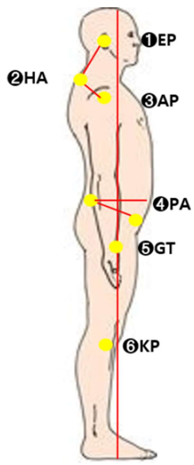


Table 3. 12-week exercise program contents

Order		Exercise	Intensity	Frequency
Warm-up (10 min)		Stretching & Line dancing	–	2 times/week
Main exercise (40 min)	Core exercise	Pelvic lift, Cat & Camel, Side bending, Lower abdominal, Backward bending, Aero-step, Gym ball	10~20 times (3~5 sets)	
	Combined exercise	Treadmill, Bicycle ergometer, Plantar flexion, Squats, Leg press, Stand to sit, Modified push-up, Biceps curl, Triceps extension	Weeks 1~4 (RPE 7~8) Weeks 5~8 (RPE 9~10) Weeks 9~12 (RPE 11~12)	
	Pilates exercise	Leg stretch (single & double), Straight leg stretch (single & double), Lunging (triceps, biceps, rhomboids, chest expansion), Half moon	10~20 times (3~5 sets)	
Cool-down (10 min)		Static stretching	–	

2. Postural alignment in the sagittal plane

The effects of exercise type on postural alignment in the sagittal plane are shown in (Table 5). For EP [F=4.210, p=.024] and GT [F=5.966, p=.006], interaction between time and exercise type was statistically significant, and the main effect of exercise type was statistically signifi-

Table 4. Postural alignment in the frontal plane

Variable		Group	Before	After	Δ	Two-way ANOVA	
			M±SD	M±SD		*F*	*p*
Head	HP (mm)	A	11.25±10.26	7.17±6.25	4.08	Time: 9.273	.005**
		B	10.58±8.11	6.33±6.21	4.25^{+}	Group: .211	.811
		C	9.42±9.47	5.50±4.72	3.92	Time×Group: .005	.995
Upper body	SL (mm)	A	9.75±9.21	5.17±5.20	4.58^{+}	Time: 2.400	.131
		B	8.08±4.81	8.58±6.72	-0.50	Group: .120	.887
		C	9.42±8.25	7.58±5.21	1.84	Time×Group: 1.332	.278
	NP (mm)	A	9.17±5.56	2.42±2.39	6.75^{+}	Time: 5.385	.027*
		B	9.17±5.57	8.25±5.29	0.92	Group: 2.279	.118
		C	8.92±5.32	8.00±6.38	0.92	Time×Group: 2.487	.099
Lower body	IAL (mm)	A	3.75±2.11	1.67±1.15	2.08	Time: .437	.513
		B	3.92±2.48	5.25±2.74	-1.33	Group: 1.349	.273
		C	4.17±2.17	3.25±2.74	0.92	Time×Group: 1.424	.255
	RP (mm)	A	83.75±7.21	87.92±9.03	-4.17	Time: .004	.952
		B	89.08±8.86	86.25±7.46	2.83	Group: .255	.776
		C	88.17±7.83	86.50±11.14	1.67	Time×Group: 1.375	.267
	LP (mm)	A	84.92±13.53	73.00±9.72	11.92^{+}	Time: .006	.939
		B	90.58±13.32	92.50±9.35	-1.92	Group: 2.521	.096
		C	94.92±12.24	104.42±9.78	-9.50^{+}	Time×Group: 8.511	.001**

*p<.05, **p<.01, +Significantly different after exercise (p<.05). Abbreviations: HP-head position; SL-shoulder level; NP-navel position; IAL-inter-ASIS level; RP-right patella; LP-left patella. A: Core exercise, B: Combined exercise, C: Pilates exercise. Δ indicates the difference after exercise. Negative Δ values indicate improvement in postural alignment after exercise

cant for AP [F=5.579, p=.008], PA [F=3.582, p=.039], and GT [F=7.265, p=.002]. GT [t=4.673, p=.001] in the trunk stabilization exercise group and EP [t=2.798, p=.017] in the Pilates exercise group showed a positive, statistically significant difference in postural alignment after exercise.

DISCUSSION

The aim of the present study was to develop an exercise program effective for correction of postural alignment and maintenance of balance in elderly women by comparing the effects of 12-week postural correction exercise programs. Trunk muscles around the spine, abdomen, and pelvis are referred to as core muscles. Whenever the body moves, core muscles increase equilibrium sensory function by centering the body and strengthening muscles around the hip (Nadler, 2002). Core exercise has been shown to stabilize the proximal area by strengthening muscles mainly used to maintain balance, i.e., muscles around the abdomen, pelvis, and hip, and can induce body stability by strengthening the proximal area via balance pad exercise that creates as much instability as possible in the feet and leg muscles (Lee & Lim, 2012). In addition, core exercise has been reported to have a positive effect on postural stability by improving proprioceptive function and developing overall coordination of sensory and motor systems to maintain balance, as shown in the core excises used in the present study (Seo, Park & Kim, 2016). The subjects in the 12-week trunk stabilization exercise group showed statistically significant differences after exercise for the core areas of NP and GT. The findings are believed to be a positive consequence of strengthened muscles and increased stability in the proximal area of the body with use of an exercise program that aimed to strengthen core muscles. In addition, assuming the linkage of body systems, the significant positive changes observed for SL in the upper body and LP in the lower body in the measurements after exercise are believed to reflect a positive change in postural alignment in the lower body through strengthening of core muscles. Moreover, although not statistically significant, the positive changes observed in the measurements after exercise in all areas except for RP and PA support a previous study finding that core exercise helped posture and balance maintenance.

A previous study reported that an 8-week combined exercise program consisting of stretching using a foam roller and a ball and muscle workout improved forward head posture and rounded shoulders in swimmers (Stephanie, Charles, Jason, William, & Darin, 2010). Another

Table 5. Postural alignment in the sagittal plane

Variable		Group	Before	After	Δ	Two-way ANOVA		
			M ± SD	M ± SD		*F*	*p*	Post-hoc
Head	EP (mm)	A	12.58±8.17	22.42±15.39	-9.84	Time: .004	.951	
		B	21.42±7.51	20.33±13.33	1.09	Group: .459	.636	
		C	22.42±16.44	13.17±11.53	9.25^{+}	Time×Group: 4.210	$.024^{*}$	
	HA (°)	A	81.17±9.76	79.33±7.25	1.84	Time: .178	.675	
		B	79.17±10.14	80.42±6.26	-1.25	Group: .145	.865	
		C	79.92±8.82	78.00±7.42	1.92	Time×Group: .279	.758	
Upper body	AP (mm)	A	12.25±10.05	9.67±6.29	2.58	Time: 1.526	.225	A>C
		B	17.75±12.28	12.17±11.51	5.58	Group: 5.579	$.008^{**}$	
		C	22.92±13.75	20.25±14.84	2.67	Time×Group: .144	.893	
Lower body	PA (°)	A	11.30±2.95	12.59±2.82	-1.29	Time: .238	.629	B>A
		B	8.84±5.21	8.59±3.80	0.25	Group: 3.582	$.039^{*}$	
		C	9.86±5.14	10.13±3.49	-0.27	Time×Group: .253	.778	
	GT (mm)	A	18.41±11.78	9.58±8.12	8.83^{+}	Time: .001	.970	A, B>C
		B	11.83±5.94	10.75±4.54	1.08	Group: 7.265	$.002^{**}$	
		C	18.42±12.52	28.08±15.30	-9.66	Time×Group: 5.939	$.006^{**}$	
	KP (mm)	A	17.67±16.10	15.08±10.08	2.59	Time: .023	.880	
		B	11.58±8.16	10.67±6.84	0.91	Group: 2.196	.127	
		C	15.67±9.98	20.25±12.17	-4.58	Time×Group: .836	.442	

$^{*}p<.05$, $^{**}p<.01$, +Significantly different after exercise ($p<.05$). Abbreviations: HP-head position; SL-shoulder level; NP-navel position; IAL-inter-ASIS level; RP-right patella; LP-left patella. A: Core exercise, B: Combined exercise, C: Pilates exercise. Δ indicates the difference after exercise. Negative Δ values indicate improvement in postural alignment after exercise

study found that a 10-week combined exercise program consisting of neck and chest stretching and a muscle strengthening workout, and a 4-week stretching exercise program performed by 14 subjects, were effective in improving forward head posture (Lee, 2011). Moreover, compared to a single exercise, combined exercise consisting of stretching and a muscle workout somewhat improved the height and width of the pelvic and kyphotic angles, and significantly improved balance in the lower body (Shin & Cho, 2011). Of the items used for combined exercise in the present study, the goal of modified push-ups, biceps curls, triceps extensions, and crunches was to develop muscles in the upper body and abdomen simultaneously. The positive changes following the workouts observed for HP and NP on the frontal plane and EP and AP on the sagittal plane seem to suggest that the exercise was effective in improving postural alignment. In contrast, the goal of squats, lunges, and lying leg raises was to influence postural alignment in the lower body; however, postural alignment was maintained or only slight change was observed. The elderly have musculoskeletal disorders such as desensitized sensory function, reduced muscle strength in the lower limbs, and joint contractures (McGibbon, Krebs & Puniello, 2001) and experience decreased ability to adjust posture because of reduced lower limb muscle strength (Owings, Pavol & Grabiner, 2001; Pavol, Owings, Foley & Grabiner, 2002). However, it has been shown that resistance exercise induces a change in the musculoskeletal structure and that long-term gradual resistance exercise brings changes in muscle strength and structure, affecting muscle volume, pennation angle, and fascicle length (Reeves, Narici & Maganaris, 2004). Accordingly, a positive effect may be occurring in the combined exercise group, based on the finding that gradual exercise for lower limb muscle strength retained postural alignment in the frontal and sagittal planes.

Pilates is effective in treatment and rehabilitation to correct posture and to stabilize balance and the center of mass in the body, and improves the ability to control equilibrium by stimulating the muscles around the pelvis and spine (Lee, Lee & Yoo, 2014). In addition, Pilates enhances chest posture, muscle strength, and endurance in the abdomen, and flexibility of the biceps femoris (Emery, De Serres, McMillan & Cote, 2010; Yoon, Park & Yoon, 2007), and generally improves the angle of the spine by strengthening muscles around the spine and ameliorating scoliosis (Lee, Kim & Choi, 2007). In addition, Pilates is a reinforcement exercise that efficiently corrects spinal deformities and strengthens the surrounding muscles, while relieving stress in the body, balancing and correcting posture, and stabilizing the body center of mass (Shin & Cho, 2011). As shown in the current study, the Pilates exercise group showed positive changes for HP, SL, and NP around the pelvis in the frontal plane, and EP, HA, and AP in the sagittal plane.

Based on previous findings of increased stability of the muscles around the spine and pelvis, Pilates exercise is believed to positively affect the postural alignment of the upper body, by strengthening muscles near the spine (Harrington & Davies, 2005). Moreover, Pilates exercise reduced pain and improved spinal function in patients with scoliosis. However, LP in the frontal plane showed a statistically significant difference, indicating a negative effect on postural alignment after exercise. The finding that Pilates showed little effect in correcting posture although leg stretch workouts were included suggests that stiffness, degeneration, and deformity had progressed in the knee with aging. Accordingly, additional research should be conducted to investigate the effect of Pilates on posture correction by utilizing light exercise equipment and braces while performing leg stretching.

CONCLUSION

The present study aimed to investigate the effects of different 12-week exercise programs for posture correction in 36 elderly women aged 65 or older, who were assigned to a trunk stabilization exercise group (n=12), a combined exercise group (n=12), or a Pilates exercise group (n=12); postural alignment in the frontal and sagittal planes was analyzed. Statistically significant improvement was observed for SL, NP, and LP in the frontal plane and GT in the sagittal plane in the trunk stabilization group, HP in the frontal plane in the combined exercise group, and EP in the sagittal plane in the Pilates exercise group. Based on these findings, trunk stabilization, combined, and Pilates exercise programs positively affected postural alignment by improving flexibility of muscles and ligaments around the spine and pelvis and strengthening upper and lower limb muscles.

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