

The Effects of Pilates Mat Exercises on Elderly Women's Basic Physical Strength and Lumbar Muscle Strength

The purpose of this study is to examine the changes on lumbar muscle strength in relation to 12-week pilates mat exercise of elderly women. The participants are chosen for 17 people who is an experimental group and 14 people who is an comparison group who except wastage and pilates mat exercise program was gradually intensify applied three times a week, during 12 weeks. The peak torque of flexion was increased($p < .01$) and the difference of ratio of agonist to antagonist was decreased($p < .001$). The total work of flexion and extension had significant increased($p < .001$) at 120° /sec. As a result of all these, it was judged as positive effect for body composition, basal physical fitness and lumbar muscle strength after pilates mat exercise in 12 weeks. These positive effects showed that pilates mat exercise could got conclusions that mitigated the musculoskeletal disorders, slow down the progress of disorders, helped as a functions of physical.

Key words: *Pilates Mat Exercise; Physical Fitness; Body Composition; Lumbar Muscle Strength*

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INTRODUCTION

In modern society, the average life spans of people are being extended thanks to rapid economic growth, improvement in living standards, and medical technology development. The ratio of elderly persons to the entire population that was 11.0% in 2010 is expected to become 14.3% in 2018 so that our society becomes a 'aged society' and become 20.8% in 2026 so that our society becomes a 'super-aged society'. Therefore, population aging is coming to the fore as a serious social problem(1).

Such rapid increases in aged populations can cause major social problems in many aspects of the society such as decreases in the working population resulting from aging and increases in medical expenses and welfare budgets. In addition, various elderly person problems will occur including physical, social, and psychological problems. Out of the entire aged population, 81.5% have pain and body parts where pain mainly occurs are the knee at a ratio of 62.3% and the lumbus at a ratio of 60.6% indicating that musculoskeletal system problems account for a large portion of elderly person problems(2).

Due to the aging phenomenon appearing in elderly persons' musculoskeletal systems, calcification occurs in tendons and ligaments and the widths or sizes of muscles decrease so that muscle strength and muscle endurance decline(3). Muscle strength gradually decreases by approximately 10% in 50s, by approximately 15% per decade in the 60s and 70s and by approximately 30% per decade thereafter(4). These declines in muscle strength and the skeleton cause diseases such as low back pain. The recommendation revised by American College of Sports Medicine in 2010 encourages elderly persons to perform active medium intensity aerobic exercise for five days per week or perform medium or high intensity physical activities for 3~5 days per week to maintain health and improve functional abilities(5).

Among low back pain related exercise programs, pilates exercise is body stabilization exercise that not only develops muscles in the abdomen, the thoracolumbar region, the buttocks, and the inner side of the thigh to straighten the vertebrae and the pelvis which are the center of the body but also prevents coronary artery diseases and reduces the risk of respiratory diseases(6). Pilates largely comprises mat

exercises and equipment exercises. Since equipment cannot be easily moved and involves large economic burdens, mat exercises that can be easily performed anywhere without being restricted by places or costs and thus suitable for elderly persons are recommended(7). Mat exercises are low/medium intensity exercises that can be easily performed by even elderly persons which include both muscle strengthening exercises and aerobic exercises to develop muscle strength and flexibility(8) and can be performed easily if there is a mat or blanket without the necessity of any particular equipment or tool.

As interest in pilates exercises increased recently, studies have been conducted with diverse groups and many studies reported that pilates exercises are effective for improvements of scoliosis(9), body balance(10), and blood lipid(11). However, studies that quantitatively evaluated the strength of the lumbar muscles on the center of the body are not sufficient.

Therefore, the purpose of this study is to examine the effects of pilates mat exercises on elderly women's lumbar muscle strength through a pilates mat exercise program for 12 weeks and provide basic data for later pilates exercise programs so that pilates exercise programs can be utilized for the prevention of elderly women's low back pain and as elderly women's rehabilitation exercises.

METHODS

Subjects

The subjects of this study were 40 elderly women who showed good health conditions, had no particular disease, and had no experience of systematic exercises for the last six months selected from among those who were residing in N-gu of K Metropolitan City and the subjects were randomly assigned to an exercise group of 20 subjects or a control group of 20 subjects. During experiments, three subjects in the exercise group and six in the control group dropped out. Therefore, a total of 31 subjects except for those who dropped out were final

subjects of this study. All the study subjects sufficiently understood of the purpose of the study and agreed to voluntarily participate in the study in writing before the experiment. The study subjects' physical characteristics are as shown in (Table 1).

Pilates Mat Exercise Program

In this study, observing the amount of exercises recommended for promotion of elderly persons' health presented in ACSM(5), a pilates mat exercise program for a total of 60 minutes consisting of 10 minutes of warming-up exercises, 40 minutes of main exercises, and 10 minutes of cooling-down exercises was composed and applied three times per week for 12 weeks.

The pilates mat exercise items applied to the study subjects in the exercise group were composed of movements suitable for performance by elderly persons selected from the book written by Murakami(12) that appropriately applied the basic movements of Joseph pilates(Table 2).

During the experimental period, the principle of incremental exercise loads to increase exercise intensity by increasing the range and number of times of pilates movements while changing the kinds of movements and the movements were composed so that the set maximum exercise intensity would not be exceeded. In addition, safety was emphasized rather than accuracy in the performance of each movement and movements that could not be easily made by elderly persons were modified.

Experimental Procedure

Lumbar muscle strength was measured using isokinetic equipment(Biodex Pro 4, Biodex Inc., USA). Isokinetic muscle strength was measured two times each at angular speeds $90^\circ/s$ and $120^\circ/s$. Peak Torque and Agonist To Antagonist Ratios were measured at $90^\circ/s$ and Total Work was measured at $120^\circ/sec$. In all tests, main tests were conducted immediately after a rest following two times of practice implemented with below maximum muscle strength

Table 1. Characteristics of the subjects

Group	Age(yrs)	Height(cm)	Weight(kg)	Bodyfat(%)
Exercise group(n=17)	67.88±3.88	155.57±5.13	59.31±4.47	32.04±4.42
Control group(n=14)	67.64± 2.95	153.50±4.76	62.79±8.70	36.25±5.96

Mean±SD

in a range from 20° flexion to 40° extension.
 Since the experimental subjects were elderly persons, their blood pressure was measured using a blood pressure gauge before the test to prevent dan-

gers due to the test in advance and the subjects were acoustically encouraged during measurement so that they could exert their maximum muscle strength.

Table 2. Pilates mat exercise program

Program stage		Movement items
Warm-up (10 minutes)		1. Breathing : 2reps 2. Imprint & releas : 4reps×2sets 3. Supine spinal : 2reps×2sets 4. Arm circles : 8reps×2sets 5. Knee over knee twist stretch : 4reps×2sets 6. Pelvic peel and hinge : 4reps×2sets 7. Spine spinal with arms crossed : 4reps×2sets 8. Seated hip stretch : 4reps
Main exercise 40 minutes	1~4 week	1. Hundred : 10reps×1sets 2. Roll up & roll down : 3reps×2sets 3. Single leg circle : 5reps×2sets 4. Rolling like a ball : 4reps×3sets 5. Single leg stretch : 10reps×2sets 6. Double leg stretch : 5reps×2sets 7. Spine stretch forward : 2reps×2sets 8. The side Kick series(front and back) : 10reps×1sets 9. Should bridge hold : 4reps×2sets 10. Double leg kick : 6reps×3sets 11. Saw : 4reps×3sets
	5~8 week	1. Hundred : 10reps×2sets 2. Roll up & roll down : 4reps×3sets 3. Cork screw : 5reps×2sets 4. Half open leg rocker : 8reps 5. Single leg stretch : 10reps×3sets 6. Double leg stretch : 5reps×3sets 7. Spine stretch forward : 3reps×2sets 8. The side Kick series(front and back) : 10reps×2sets 9. Should bridge hold : 5reps×3sets 10. Double leg kick : 8reps×4sets 11. Saw : 4reps×3sets
	9~12 week	1. Hundred(Intermediate) : 10reps×2sets 2. Roll up & roll down(intermediate) : 3reps×2sets 3. Cork screw : 5reps×3sets 4. Teaser : 6reps×2sets 5. Double leg stretch : 5reps×3sets 6. Double straight leg stretch : 5reps×3sets 7. Roll over : 3reps×3sets 8. The side Kick series(small circle) : 10reps×3sets 9. Should bridge hold : 5reps×3sets 10. Double leg kick : 10reps×4sets 11. Saw : 6reps×3sets
Cool-down (10 minutes)		1. Head stretch : 3reps 2. Elevation & depression of scapula : 6reps×3sets 3. Supine spinal : 2reps×2sets 4. Figure stretch : 4reps×2sets 5. Knee over knee twist stretch : 4reps×2sets 6. Cat stretch : 4reps×3sets 7. Child pose : 1rep

Data Analysis

In this study, data were processed using SAS Version 9.2 to produce means and standard deviations by measurement item. Paired sample t-tests were conducted to compare the data of each group before and after the exercises for 12 weeks and independent sample t-tests were conducted to compare differences in changes between before and after the exercises between the two groups. The statistical significance level α was set to .05.

RESULTS

None of the exercise group and the control group showed any significant difference in maximum extensor muscle strength at 90°/sec ($p > .05$) and comparisons of changes between before and after exercises between the two groups showed no significant difference in changes in maximum extensor muscle strength at 90°/sec after 12 weeks of exercises ($p > .05$).

The exercise group's maximum flexor muscle

strength at 90°/sec significantly increased from 61.41 ± 13.05Nm before exercises to 75.91 ± 16.41Nm after exercises ($p < .01$) and the control group did not show any significant difference. In comparisons of changes between before and after exercises between the two groups, the exercise group showed a significant increase in maximum flexor muscle strength at 90°/sec after 12 weeks of exercises compared to the control group ($p < .01$).

The exercise group's agonist to antagonist ratio at 90°/sec significantly decreased by $-46.17 \pm 3.68\%$ from 119.98 ± 17.05% before exercises to 73.81 ± 9.46% after exercises ($p < .001$) and the control group's agonist to antagonist ratio at 90°/sec significantly decreased by $-3.88 \pm 1.06\%$ from 120.71 ± 14.34% before exercises to 116.82 ± 16.12% after exercises ($p < .01$). In comparisons of changes between before and after exercises between the two groups, the exercise group showed a significant decrease in agonist to antagonist ratios at 90°/sec after 12 weeks of exercises compared to the control group ($p < .001$).

The exercise group's extensor's total work at 120°/sec significantly increased by 187.53 ± 15.91J from 222.29 ± 23.09J before exercises to 409.82 ± 65.17J after exercises ($p < .001$) and the control group

Table 3. The changes of lumbar muscle strength

	Variable	Group	Before	After	t	Δ 차이	F
	Extensor's maximum muscle strength(Nm)	Exercise group	91.32±14.31	110.61±40.06	1.96	19.28±9.84	-1.97
		Control group	109.01±15.26	108.87±15.13	-.53	-.14±.26	
		t	3.32**	-.15			
	90°/sec	Flexor's maximum muscle strength(Nm)	Exercise group	61.41± 13.05	75.91±16.41	3.04**	14.49± 4.76
Control group			76.37±18.44	75.92±18.47	-2.08	-.44± .21	
		t	2.64*	.00			
Agonist to antagonist ratio(%)		Exercise group	119.98±17.05	73.81±9.46	-12.53***	-46.17± 3.68	11.02***
	Control group	120.71±14.34	116.82±16.12	-3.64**	-3.88± 1.06		
	t	.13	9.25***				
120°/sec	Extensor's total work(Joule)	Exercise group	222.29±23.09	409.82±65.17	11.78***	187.53± 15.91	-11.65***
		Control group	219.66±16.33	220.38±18.31	.36	.72± 1.98	
		t	-.36	-10.51***			
	Flexor's total work(Joule)	Exercise group	126.42±19.61	321.05±89.65	9.13***	194.62± 21.31	-8.99***
Control group		122.38±18.18	124.94±19.53	2.05	2.55± 1.24		
	t	-.59	-8.01***				

** $p < .01$ *** $p < .001$

did not show any significant difference. In comparisons of changes between before and after exercises between the two groups, the exercise group showed a significant increase in extensor's total work at 120°/sec after 12 weeks of exercises compared to the control group ($p < .001$).

The exercise group's flexor's total work at 120°/sec significantly increased by $194.62 \pm 21.31\text{J}$ from $126.42 \pm 19.61\text{J}$ before exercises to $321.05 \pm 9.65\text{J}$ after exercises ($p < .001$) and the control group did not show any significant difference. In comparisons of changes between before and after exercises between the two groups, the exercise group showed a significant increase in flexor's total work at 120°/sec after 12 weeks of exercises compared to the control group ($p < .001$) (Table 3).

DISCUSSION

The purpose of this study was to examine the effects of pilates mat exercises for 12 weeks on elderly women's lumbar muscle strength. Low back pain occurs due to diverse complicated causes and regardless of causes, all low back pain patients show declines in muscle strength, reduction in endurance, declines in flexibility, and restriction of the range of motion of lumbar and lower extremity joints. The muscles around the spine serve important roles in maintaining the stability of physical activities. Since the lumbar muscles can be easily damaged by external force when they are weak, exercise prescriptions focused on the improvement of the lumbar muscle strength and the surrounding muscles' strength are necessary.

To review previous studies related to the effects of pilates exercises on lumbar muscle strength or spinal stability, Lee(9) reported that when elementary school students performed pilates exercises, the strength of their muscles around the spine increased along with the improvement of their physical strength so that their scoliosis was improved, Yang (13) reported that pilates mat exercises performed by university students for 16 weeks improved not only muscle strength, explosive muscular strength, flexibility, static balance ability, dynamic balance ability, and paraspinal muscle strength but also scoliosis, and Kim(14) reported that lumbar extensor muscle strength and right lateral flexor muscle strength were significantly improved through a pilates program for 8 weeks.

In this study, the effects of pilates exercises for 12

weeks on elderly women's flexor muscle strength and extensor muscle strength were examined by analyzing Peak torque and agonist to antagonist ratios at an angular speed of 90°/sec and the total work of the flexor and the extensor an angular speed of 120°/sec. According to the results, out of lumbar muscle strength, maximum extensor muscle strength at an angular speed of 90°/sec showed a certain increase after exercises but the difference was not significant. This was consistent with the results of a study conducted by Choi(15) in which elderly women with low back pain conducted pilates mat exercises and it was reported that maximum extensor muscle strength at angular speeds 60°/sec, 90°/sec, and 120°/sec showed certain increases after exercises but the differences were not statistically significant. The reason for this is thought to be the fact that the subjects of this study were elderly women who could not show great improvement in muscle strength. However, whereas the control group showed slight decreases in muscle strength, the exercise group showed increasing tendencies. Therefore, pilates mat exercises are considered effective in maintaining elderly women's muscle strength.

On the other hand, after the exercises, maximum flexor muscle strength significantly increased, agonist to antagonist ratios significantly decreased, and the total work of both the extensor and the flexor significantly increased at an angular speed of 120°/sec. To review previous studies related to the foregoing, Hwang(16) reported that when elderly women performed lumbar stabilization exercises in water for 8 weeks for examination of differences in the lumbar muscles' isokinetic exercise ability, the maximum ratio of couple of forces expressed according to flexor muscle strength and extensor muscle strength increased at angular speeds of 30°/sec, 60°/sec, and 120°/sec and Han et al.(17) reported that after aerobic exercises, elderly women's maximum lumbar flexor muscle strength and extensor muscle strength increased at an angular speed of 60°/sec. These results indicated that even small exercise loads positively affected the enhancement of elderly persons' lumbar muscle strength and the improvement of their imbalance. However, additional studies on the effects exercises on elderly persons' lumbar muscle strength are considered necessary.

As an experimental study, this study has a limitation that social/psychological factors were not considered except for physical characteristics. However, this study is meaningful in that it composed a program with only mat exercises out of pilates exercises without any special tool and that it quantitatively

evaluated elderly women's lumbar muscle strength using isokinetic muscle strength measuring equipment and presented basic data on lumbar muscle strength. Studies that would select more subjects and analyze diverse indicators to prove the effects of mat exercise programs are considered necessary.

CONCLUSION

In this study, the effects of pilates mat exercises on elderly women's lumbar muscle strength were analyzed and the following conclusions were obtained.

In changes in lumbar muscle strength, increases in maximum flexor muscle strength ($p < .01$) and differences in agonist to antagonist ratios ($p < .001$) appeared at $90^\circ/\text{sec}$ while maximum extensor muscle strength did not show any statistically significant difference. At $120^\circ/\text{sec}$, the total work of the extensor and the flexor showed significant increases ($p < .001$).

When considering the aforementioned results altogether, pilates mat exercises for 12 weeks are considered to have shown positive effects on basic physical strength (muscle strength, muscle endurance, flexibility, balance) and lumbar muscle strength (Maximum flexor and extensor muscle strength, total work, lumbar agonist to antagonist ratio) and a conclusion was obtained that these positive effects will relieve musculoskeletal system diseases that may characteristically appear in elderly women, delay the progress of diseases, and help body functions.

REFERENCES

1. Korean National Statistical Office. The Results Statistical Death and Cause of Death, 2010.
2. Ministry of health and welfare. Plan for aging society and population, 2009.
3. Spirduso WW, Francis K, Eakin T, Stanford C. Quantification of manual for cecontrol and tremor. *J Mot Behav* 2005; 37(3): 197-210.
4. American College of Sports Medicine. Current Comment from the ACSM. American college of sports medicine, 2000.
5. American College of Sports Medicine. ACSM's guidelines for exercise testing and prescription (8thed) Lippincott, MD: Lippincott Williams & Wilkins, 2010.
6. Lange C, Unnithan V, Larkam E, Latta PM. Maximizing the benefits of Pilates-inspired exercise for learning functional motor skills. *Journal of Body work and Movement Therapies* 2000; 4(2): 99-108.
7. Lee JS. The comparison between exercise intensity and quantity according to the diverse forms of pilates. Kyunghee University. Master's Thesis; 2011
8. Kim SY. The effect of phylates mat exercise of middle-aged womens' physical strength and composition. Daejeon University. Master's Thesis; 2005.
9. Lee SH. The effect of pilates on scoliosis and physical fitness inelementary school students. Donga University. Master's Thesis; 2007.
10. Lee SH. Effects of pilates exercise on body composition, health related physical fitness and blood lipid factors in adult women. Daegu Catholic University. Master's Thesis; 2011.
11. Shim SY. The effects of pilates on cholesterol, CRP and leptin in obese adults men. Daegu University. Master's Thesis; 2010.
12. Cathleen Murakami. Morning Pilates workouts: Enhance Your Morning Mat Work with Programs for Every Schedule. HUMAN KINETICS, 2006.
13. Yang HJ. The effect of pilates mat exercise on scoliosis and physical fitness in university student's. Cheongju University. Master's Thesis; 2010.
14. Kim SH. Effect on muscular strength of the ballet dancer's waist through application of pilates method. Suwon University. Master's Thesis; 2007.
15. Chae BH. Effect of pilates mat exercise in old aged women with low back pain on lumbar muscular strength, pain scale and body composition. Daejeon University. Master's Thesis; 2007.
16. Hwang JS. The effect of core stability exercise in the water on vertebra posture and lumbar strength in the female elderly. Korea National Sport University. Master's Thesis; 2007.
17. Han JW, Lee SS, Jee YS, Seo KH, Kim NS, Song BD. The effects of aerobic exercise on body composition, isokinetic knee and trunk muscular strength of elders. *Journal of sport and leisure studies* 2000; 13(1): 411-423.