J Korean Soc Phys Med, 2022; 17(4): 27-35
https://doi.org/10.13066/kspm.2022.17.4.27

Online ISSN: 2287-7215
Print ISSN: 1975-311X

Research Article

Open Access

Effects of Mat Pilates on the Autonomic Nervous System in the Elderly Women

Kyung-Tae Yoo, PT, PhD†

Department of Physical Therapy, Namseoul University, Chunan-si, Korea

Received: October 20 2022 / Revised: October 20 2022 / Accepted: November 14 2022
ⓒ 2022 J Korean Soc Phys Med

| Abstract |

PURPOSE: A Mat Pilates exercise program and a stretching program were conducted for elderly women to determine how the two interventions affect their autonomic nervous system.

METHODS: The subjects of this study were 20 elderly women over 65 who regularly used a welfare center located in C city of Chungnam. The subjects were assigned randomly to the following two groups: 10 people in the breathing and mat Pilates exercise program group (PG) and 10 people in the breathing and stretching program group (SG).

RESULTS: The present study design is randomized controlled trial. Vascular age was decreased significantly in the PG ($p < .05$). The mean stress index was reduced significantly in the PG ($p < .05$), and the amount of change was significantly larger in the PG than in the SG ($p < .05$). The health index was significantly lower in the PG than the SG ($p < .05$), and the amount of change in the PG was significantly more prominent than in the SG ($p < .05$).

CONCLUSION: The Mat Pilates program was effective in improving the vascular age, average stress index, and health index of elderly women. In particular, it was significantly more effective than the stretching exercise program in improving the average stress and health indices.

Key Words: Autonomic nervous system, Elderly women, Mat pilates, Stretching

Ⅰ. Introduction

The elderly population in Korea has been increasing, and as of 2021, the elderly population aged 65 years or older accounted for 16.5% of the total population. This increase is expected to continue and reach 20.3% in 2025, making Korea a super-aged society [1]. Among the problems of the elderly, continuous stress in old age can affect mental and physical health, such as a decrease in the autonomic nervous system function, a decrease in immune function, and depression, which can directly affect the lack of activity and lack of exercise [2-4]. As aging progresses, structural changes in blood vessels cause functional changes, causing an increase in arterial stiffness and dilatation and increasing systolic blood pressure, pulse pressure, and pulse wave transmission rate [5]. In particular, stress accelerates the functional changes in blood vessels,

†Corresponding Author : Kyung-Tae Yoo
taeyoo88@nsu.ac.kr, https://orcid.org/0000-0001-7956-819X
This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/3.0) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

and the greater the severity, the greater the incidence of cardiovascular disease [6]. In the case of women, the level of estrogen in the blood decreases rapidly during menopause, which causes hot flashes, genital changes, urinary incontinence, and osteoporosis, as well as increases the prevalence of various chronic diseases [7, 8]. Older people are more vulnerable to stress [9]. From the point of view of mental health, old age stress induces physical and psychological reactions in the elderly and is an important factor influencing physical illness [10]. Stress-related diseases are related to the autonomic nervous system (ANS). Chronic stress activates the sympathetic nerve to cause cardiovascular diseases, which can lead to various adverse effects on the human body, such as decreased immune function [11]. The autonomic nervous system maintains the physiological function of homeostasis by responding appropriately to various stresses occurring inside and outside the body. The heart responds dynamically to environmental changes under the control of the autonomic nervous system [12]. The state of the autonomic nervous system needs to be evaluated to determine the effect of stress on the human body. On the other hand, few test methods can be used clinically. Therefore, the Heart Rate Variability (HRV) signal evaluation is a method that is easy to measure and evaluates the activity of sympathetic and parasympathetic nerves quantitatively. Common HRV signal analysis includes time domain analysis, frequency domain analysis, and nonlinear dynamic analysis, but time domain Using analysis and frequency domain analysis are usually performed to interpret the activity of the autonomic nervous system [13,14]. During physical exercise, the sympathetic and parasympathetic nerves of the autonomic nervous system change, and the activity of the parasympathetic nervous system is inactivated. In addition, the sympathetic nervous system is activated, which increases the heart rate, preload, and systemic vascular resistance, thereby increasing the cardiac output and blood flow to activate the metabolic cells. During the recovery period after exercise, the parasympathetic nervous system is activated again, and the sympathetic nervous system function is weakened. The decrease in heart rate immediately after exercise is closely related to this [15].

The most commonly applied intervention in clinical practice is stretching, which can maintain the joint position before the pain occurs. Maintaining the tension caused by appropriate muscle elongation for a certain time induces muscle relaxation to improve the range of motion (ROM). In addition, stretching can help prevent injury, improve athletic performance, increase blood circulation, and improve breathing, circulation ability, and the ability to adapt to the environment. [16]. In particular, static stretching is the most common type of stretching and has been recognized as a relatively safe and effective way to improve flexibility, and results suggest static stretching and rest for the elderly to maintain a sense of balance and safe walking [17,18]. Dynamic stretching effectively activates active and natural muscles as an integrated movement [19]. In addition, by-products (H^+) removal and nerve stimulation conductivity can be improved by increasing the blood flow supplied to the muscles and facilitating the oxygen-carrying ability. Moreover, dynamic stretching has a more significant effect on improving most exercise performance than static stretching [20].

Another intervention method is the Pilates exercise, which was first developed by Joseph H. Pilates in the early 1900s and has been developed continuously. It is easy for anyone to follow and is an exercise that accompanies physical rehabilitation that can increase the correct alignment of the body and lower extremity muscle strength, flexibility, balance, and balance based on deep breathing exercises [21-23]. Pilates has the characteristics of both static and dynamic exercise that dynamically connects breathing and body movement to hold the body in an aligned position and has been reported to be effective for elderly women [24-25]. Pilates is an exercise that has been

proven to be physiologically, psychologically, and physically effective for the elderly. Previous studies confirmed it to be a sufficiently suitable exercise for the elderly because it positively affects stress reduction and tension relief through breathing control [26,27].

Therefore, mat Pilates has been established as a major exercise program for rehabilitation and is reported to have a positive effect on daily life because it consists of various types of strength and flexibility exercises. On the other hand, studies on the difference in autonomic nervous system changes are insufficient compared to conventional stretching exercises. Therefore, in this study, a mat Pilates exercise program and a stretching program were conducted for elderly women to determine how the two interventions affect their vascular age, stress, and health index and to suggest a better intervention.

Ⅱ. Materials and Methods

1. Subject

In this study, 20 elderly women aged 65 years or older, who used a welfare center located in C city of Chungnam regularly, could walk normally, and were not currently participating in other exercise programs, were selected as subjects. All subjects voluntarily participated after being fully explained the purpose and method of the study before participating and after signing the consent form for the study. Ten people in the mat Pilates exercise program group (PG) and 10 people in the breathing and stretching program group (SG) were randomized. In this study, an auxiliary therapist was also assigned to ensure safety as a group exercise.

2. Measurement Apparatus

The height, weight, and body mass index (BMI) were measured using a body composition analyzer (Inbody 720, BioSpace, Korea). Canopy9 Perfect (IEMBIO, Korea) was used to evaluate the visceral fat, vascular age, average stress index, and health index. As a device to perform the measurement, the heart rate variability was analyzed using a computer connected to a USB cable. The heart rate variability refers to the periodic change in heart rate that occurs when the autonomic nervous system, which changes according to the internal and external environment, affects the intrinsic spontaneity of the pacemaker cells in the sinus node [28]. Through this, the vascular age, average stress index, and health index are displayed. For the output range and decision, the vascular age was compared with the actual age. The stress index was assessed in a range from 1 to 10. A score closer to 10 indicated higher stress. The health index is a composite score from 40 to 100 according to the autonomic nerve test, and a score closer to 100 indicated good physical health.

3. Experimental Method

1) Mat Pilates exercise program group (PG)

The exercise program applied to the PG in this study is a modification of the interventions conducted in a previous study [29] according to the purpose of this study. Table 1 lists the program implemented in this study. The exercise program was applied twice a week for 50 minutes a day for eight weeks.

2) Stretching program group (SG)

The exercise program applied to SG in this study is a modification of the interventions conducted in the previous study [30] according to the study purpose. Table 2 summarizes the program implemented in this study. The exercise program was applied twice a week for 50 minutes a day for eight weeks (Ed note: Numerals 1 to 9 are written in words.).

4. Data Analysis

This study used the statistical analysis program SPSS 23.0 for Windows for data analysis. The Shapiro-Wilk test was performed for normality verification, and the independent sample t-test was performed for subject homogeneity verification before the experiment. An independent t-test

Table 1. Mat pilates exercise program

Stage	Movement	Duration	Intensity
Warm-up	Stretching the whole body Standing extension exercise Breathing in the prone position	10 min	
Main exercise	The Bridge The Hundred The Hip joint circle The Single leg stretch The Side Lying The Quadruped The Bridge The Hundred The one-leg circle The crisscross The side kick The Quadruped	30 min	10 rep, 2 set (rest between exercise: 30 sec)
Cool-down	Cross your legs and twist your back Leg twist Neck strengthening exercise	10 min	

Table 2. Stretching exercise program

Stage	Movement	Duration	Intensity
Warm-up	Stretching the whole body Standing extension exercise Breathing in the prone position	10 min	
Main exercise	The Bridge The Hundred The Hip joint circle The Single leg stretch The Side Lying The Quadruped The Bridge The Hundred The one-leg circle The crisscross The side kick The Quadruped	30 min	10 rep, 2 set (rest between exercise: 30 sec)
Cool-down	Cross your legs and twist your back Leg twist Neck strengthening exercise	10 min	

was conducted to compare the changes in vascular age, average stress index, and health index according to intergroup intervention. A paired sample t-test was performed to examine the changes in vascular age, average stress index, and health index before and after the intervention within the group. The statistical significance was set to $p < .05$.

Ⅲ. Results

1. General Characteristics of the Participants

Table 3 lists the general characteristics of the subjects. The homogeneity test showed no significant difference in age, height, weight, BMI, and visceral fat between the two groups, and both groups satisfied the normality test ($p > .05$).

2. Changes in vascular age, average stress index, and health index

Table 4 presents the changes in vascular age, mean stress index, and health index after the intervention. The vessel age was significantly decreased in the PG ($p < .05$) and did not change significantly in the SG ($p > .05$). The difference in the amount of change in each group was not significant ($p > .05$). The mean stress index was significantly decreased in PG ($p < .05$), and there was no significant change in the SG. ($P > .05$). The amount of change in the PG was significantly larger than that of the SG ($p < .05$). The health index was increased significantly in the PG ($p < .05$), and there was no significant change in the SG ($p > .05$). The amount of change in PG was significantly larger than the amount of change in SG. ($p < .05$).

Table 3. General characteristics

	PG (n = 10)	SG (n = 10)	t	p
	Mean ± SD	Mean ± SD		
Age	78.10 ± 8.89	82.64 ± 3.59	1.572	.132
Height (cm)	153.00 ± 6.03	148.27 ± 4.41	- 2.099	.051
Weight (kg)	61.51 ± 12.09	58.13 ± 9.46	- .731	.473
BMI (kg/m)	26.33 ± 5.27	26.39 ± 3.60	.033	.974
Visceral Fat (cm^2)	216.20 ± 281.41	164.19 ± 106.39	- .573	.573

*p < .05, PG: Mat Pilates Group, SG: Stretching group, BMI: Body mass index.

Table 4. Changes in vascular age, average stress, and health index

		Pre	Post	t	p
		Mean ± SD	Mean ± SD		
Vascular age	PG	75.09 ± 2.47	74.09 ± 2.88*	.247	.807
	SG	72.73 ± 8.00	71.91 ± 7.61		
Average stress index	PG	9.46 ± .69	6.73 ± 3.20*	2.280	.034†
	SG	8.18 ± 1.99	8.09 ± 2.30		
Health index	PG	56.00 ± 12.36	63.91 ± 14.34*	- 2.328	.033†
	SG	62.64 ± 12.44	61.55 ± 11.00		

*There was a significant difference between before and after intervention ($p < .05$), †: This means that the difference in the amount of change between the two groups is significant ($p < .05$), PG: Mat Pilates Group, SG: Stretching group.

Ⅳ. Discussion

The vascular age was decreased significantly after the intervention in the PG ($p < .05$), but there was no significant change in the SG ($p > .05$). The difference in the amount of change in each group was not significant ($p > .05$). These results were consistent with the results of a previous study [31] in which the vascular age of adult women was reduced by the application of the diet program, and another study [32] in which the triglyceride level of the experimental group was reduced significantly by the eight-week weight control education program compared to the control group. Kim [33] analyzed the effects of tai chi exercise on the shoulder joint, cardiovascular function, and immunity improvement in breast cancer surgery patients. After tai chi exercise, the heart rate, circulatory resistance, and cortisol significantly decreased. Hence, tai chi exercise positively affected stress management and cardiovascular function. The mat Pilates exercise program conducted in this study also positively affected the cardiovascular function of elderly women.

Mean stress index significantly decreased after intervention in the PG ($p < .05$), and there was no significant change in the SG after the intervention ($p > .05$). Regarding the difference in the amount of change in each group, the amount of change in the PG was significantly larger than that of the SG ($p < .05$). These results were consistent with the results of the reduction in the stress index of adult women by the application of the diet program in the previous study [31], and were similar to the results of a previous study [34] in which the stress score was reduced significantly by nutrition education and exercise intervention for 12 weeks. This is because the decrease in the parasympathetic activity of the autonomic nervous system is closely related to psychogenic mortality by lowering the ventricular fibrillation threshold [35, 36]. Based on these mechanisms, the mat Pilates exercise program conducted in this study helped relieve stress.

The health index increased significantly after the intervention in the PG ($p < .05$), but there was no significant change in the SG ($p > .05$). The amount of change in the PG was significantly larger than that of the SG ($p < .05$). In Yang's study [37], the Pilates exercise produced similar increases in cardiorespiratory endurance in health-related fitness items of adult women in their 30s and 40s. Chae et al. [38] reported that Pilates exercise produced a significant increase in flexibility in the healthy physical strength of the elderly. Currently, for the healthy life of the elderly, a training program including 150 minutes of activity per week and various components (balance, strength, flexibility) is recommended [39]. The effect of the PG was superior to the SG because Pilates had a greater effect on the improvement of activity volume, balance, muscle strength, and flexibility compared to stretching. In a previous study [40] that measured the changes in physical fitness of the elderly by applying the Pilates program for 12 weeks to elderly women, there was a significant improvement in lower extremity strength, lower extremity flexibility, whole body endurance, agility, and dynamic balance. In another previous study [41], the effectiveness of Pilates exercise was assessed by the improvements in postural control, sensory interaction, total fatigue, and cognitive scores after 10 weeks of Pilates exercise for multiple sclerosis patients. Based on several previous studies on the effects of Pilates, Mat Pilates exercise program conducted in this study also helped improve the cardiovascular function and autonomic nervous system, and physical ability of the subjects participating in this study.

On the other hand, the individual's privacy after the program was not controlled, the number of subjects was small to generalize the results of this study, and it was somewhat difficult to compare the results of the two interventions with the eight-week intervention period. Future studies will require a study with a wider range of age groups and men. Such a program will be more effective than the results shown in this study if the number of times

per week is increased and a program that includes a more diverse range of exercise is developed.

Ⅴ. Conclusion

This study investigated the effects of mat Pilates exercise and stretching program on the vascular age, stress, and health index of elderly women. The mat Pilates program was effective in improving the vascular age, average stress index, and health index of elderly women. In particular, it was significantly more effective in improving the average stress index and health index than the stretching exercise program. The mat Pilates program was practical to implement, and it improved the vascular age, stress, and health index of elderly women. If the above limitations are overcome, it is expected that a more effective intervention will provide a good direction for the health management and rehabilitation of the elderly.

Acknowledgments

Funding for this paper was provided by Namseoul University year 2022.

References

[1] Statistics Korea. 2021 2021 Senior Statistics. Seoul: *Statistics Korea.* 1-81. https://kostat.go.kr/portal/korea/kor_nw/1/1/index.board?bmode=read&aSeq=403253

[2] Chang LC. The relationship between nature-based tourism and autonomic nervous system function among older adults. J Travel Med. 2014;21(3):159-62.

[3] Kwag KH, Martin P, Russell D, et al. The impact of perceived stress, social support, and home-based physical activity on mental health among older adults. Int J Aging Hum Dev. 2011;72(2):137-54.

[4] McNaughton ME, Smith LW, Patterson TL, et al. Stress, social support, coping resources, and immune status in elderly women. J Nerv Ment Dis. 1990;178(7):460-1.

[5] Meaume S, Benetos A, Henry OF, et al Aortic pulse wave velocity predicts cardiovascular mortality in subjects >70 years of age. Arterioscler Thromb Vasc Biol. 2001;21(12):2046-50.

[6] Hamer M, Molloy GJ, Stamatakis E. Psychological distress as a risk factor for cardiovascular events: pathophysiological and behavioral mechanisms. J Am Coll Cardiol. 2008; 52(25):2156-62.

[7] Currie LJ, Harrison MB, Trugman JM, Bennett JP, Wooten GF. Postmenopausal estrogen use affects risk for Parkinson disease. Arch Neurol. 2004 Jun;61(6):886-8. doi: 10.1001/archneur.61.6.886. PMID:15210525.

[8] Y. J. Hong. Effects on elderly women's aging hormone, immunity substance and the cognitive function by participating in Korean dance and administering melatonin for 12weeks. Master dissertation, National University of Changwon. 2008.

[9] Cairney J, Krause N. Negative life events and age-related decline in mastery: are older adults more vulnerable to the control-eroding effect of stress?. J Gerontol B Psychol Sci Soc Sci. 2008;63(3):S162-70.

[10] Wilson RS, Arnold SE, Schneider JA, Li Y, Bennett DA. Chronic distress, age-related neuropathology, and late-life dementia. Psychosom Med. 2007;69(1):47-53.

[11] Cacioppo JT, Tassinary LG, Berntson GG, eds. Handbook of Psychophysiology. 4th ed. Cambridge: Cambridge University Press; 2016.

[12] Lee TK, Chung WH. Vestibular influences on autonomic regulation. J. of the Korean Balance Society, 2006; 5(2):329-35.

[13] Woo JM. The Concept and Clinical Application for the Measurement of Heart Rate Variability. Korean J Psychosomatic Medicine. 2004;12(1)3-14.

[14] Heart rate variability: standards of measurement, physiological interpretation and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology.

Circulation. 1996;93(5):1043-65.

[15] Rosenwinkel ET, Bloomfield DM, Arwady MA, et al. Exercise and autonomic function in health and cardiovascular disease. Cardiol Clin. 2001;19(3):369-87.

[16] Perrier ET, Pavol MJ, Hoffman MA. The acute effects of a warm-up including static or dynamic stretching on countermovement jump height, reaction time, and flexibility. J Strength Cond Res. 2011;25(7):1925-31.

[17] Blahnik J. Full-body flexibility. Human Kinetics. 2011.

[18] Han MJ, Yuk GC, Gak H, et al. Acute effects of 5 min of plantar flexor static stretching on balance and gait in the elderly. J Phys Ther Sci. 2014;26(1):131-3.

[19] Mann DP, Jones MT. Cite Seer Guidelines to the implementation of a dynamic stretching program. National Strength & Conditioning Association. 1999;21(6):53-5.

[20] Curry BS, Chengkalath D, Crouch GJ, Romance M, Manns PJ. Acute effects of dynamic stretching, static stretching, and light aerobic activity on muscular performance in women. J Strength Cond Res. 2009;23(6):1811-19.

[21] Lee JS. The Comparison between exercise intensity and quantity according to the diverse forms of Pilates. [Master's thesis]. Kyunghee University. 2011.

[22] Cruz-Ferreira A, Fernandes J, Kuo YL, et al. Does pilates-based exercise improve postural alignment in adult women?. Women Health. 2013;53(6):597-611.

[23] Bullo V, Bergamin M, Gobbo S, et al. The effects of Pilates exercise training on physical fitness and wellbeing in the elderly: A systematic review for future exercise prescription. Prev Med. 2015;75:1-11.

[24] Choi PB. The effects of pilates mat gym program on blood pressure, heart rate and lipids profile in elderly women with hypertension. Korea J Sport Sci, 2012; 21(2):893-903.

[25] Hong SY. Silver pilates program development compliant with the health protection & promotion model. [Doctor's degree]. Ewha Womans University. 2016.

[26] Seo DI, Han YR, Kim IH, et al. The effect of 8 weeks of Pilates on physical fitness and fall efficacy in elderly women. Korean Society for Wellness, 2014;9(4):201-08.

[27] Lee CJ, Choi YH. The effects of a pilates exercise program using self-efficacy sources in elderly women. Journal of Environmental Science International, 2015; 24(1): 117-31.

[28] Lee YJ, Kim MS, Kim BT, et al. Heart rate variability in metabolic syndrome. J Korean Acad Fam Med, 2002;23(12):1432-39.

[29] Kim NJ. The effect of pilates mat exercise on fall-related fitness and aging-related hormone in sarcopenic obesity elderly. The Korean Journal of Physical Education. 2013;52(4); 449-59.

[30] Lim RH. The silver stretching program development and effectiveness analysis of the elderly's physical, psychological, social health change. [Doctor's thesis]. Myongji University. 2007.

[31] Park HJ, Cho SK, Koo JO. Effect of a diet program for adult women on body weight loss and health related indices. Korean J Community Nutr, 2013; 18(6):599-610.

[32] Jung YK. Effects and development of the body weight control education program of female college students. [Doctor's thesis]. Kosin University. 2006.

[33] Kim CW. The effect of Tai-Chiexercise on the function of shoulder joint, cardiovascular systems and immune system in breast cancer patients. [Doctor's thesis]. Dong Eui University. 2009.

[34] Lee HS, Lee JW, Chang N, et al. The effect of nutrition education and excercise program on body composition and dietary intakes, blood lipid and physical fitness in obese women. The Korean Journal of Nutrition. The Korean Nutrition Society. 2009.;42(8):759-69

[35] Thayer JF. Lane, RD. The role of vagal function in the risk for cardiovascular disease and mortality. Biol Psychol, 2007;74:224-42.

[36] Song RH, Kim DH. The effects of foot reflexion massage on sleep disturbance, depression disorder, and the physiological index of the elderly. J Korean Acad Nurs, 2006;36(1):15-24.

[37] Yang SY. The effects of the pilates work and the hatha yoga exercise on the health-related fitness and body composition of women in their 30s and 40s. [Master's degree]. Kyungsung University. 2012.

[38] Chae BW, Kim KS, Hwang PH, et al. Effects of pilates exercise on senior fitness test and reaction time of the elderly. Korean J Sport Sci. 2017;26(6):1169-79.

[39] Chodzko-Zajko WJ, Proctor DN, Singh MA, et al. Exercise and physical activity for older adults. Medicine & Science in Sports & Exercise, 2009;41(7):1510-30.

[40] Jung JY, Cha KS. The effects of prop pilates exercises on physical fitness and balance in elderly women. Korean Society for Wellness, 2019;14(2):431-40.

[41] Soysal Tomruk M, Uz MZ, Kara B, İdiman E. Effects of Pilates exercises on sensory interaction, postural control and fatigue in patients with multiple sclerosis. Mult Scler Relat Disord. 2016;7:70-3.