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Comparative Study on the Effects of Proprioceptive Neuromuscular Facilitation and Elastic Band Exercise on the Physical Function and Blood Lipid Levels of Obese Elderly Women

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Abstract

The effects of Proprioceptive Neuromuscular Facilitation (PNF) and elastic band exercise on the physical functions and blood lipids of obese elderly women were investigated. The experimental group (n_1=16) patients underwent PNF for 12 weeks, and the control group (n_2=15) patients performed elastic band exercises. SPSS 21.0 was used to compute the means and standard deviations. After the 12-week PNF, both the experimental and control groups showed statistically significant differences in the physical functions (cardiovascular endurance, strength of the lower extremity, muscular endurance, flexibility, balance, and agility) ($p<.05$), but the difference in the experimental group was more significant than that in the control group ($p<.05$). In terms of the changes in the blood lipid levels (total cholesterol, triglycerides, high-density lipoprotein, and low-density lipoprotein), the experimental group showed significant changes ($p<.05$). In conclusion, PNF was confirmed as more effective than elastic band exercise in improving the physical functions and blood lipid levels of obese elderly women.

Key Words: Obese elderly women; Physical function; Proprioceptive neuromuscular facilitation.

Introduction

The average life expectancy of Koreans increased from 65.7 in 1980 to 81 in 2012. In 2011, the average life expectancy of Korean men was 77.7, 6.8 years lower than that of women, 84.5 (Statistics Korea, 2014). Thus, aged women have more health problems than aged men because the body functions deteriorate with the aging process (Sung et al, 2004). Moreover, women experience menstruation, pregnancy, and menopause due to hormonal changes, and have less muscles and a lower bone density, and perform less physical exercise, than men, so their risk of chronic degenerative diseases is higher than that of men (Choi et al, 2012).

The prevalence of obesity in Korean men in their 20s is 31%; in their 30s, 41.7%; in their 40s, 37.9%; and in their 50s, 41.7%, these figures show an increasing trend with age. But in Korean women in their 20s, it is 12.6%; and in their 30s, 12.8%. These figures show no significant difference from those of men. However, the prevalence of obesity in Korean women in their 40s is 26.6%, which is 13.8% higher than that in the Korean women in their 30s; and in Korean women in their 50s, it is 56.4%, which is 30% higher than that in the Korean women in their 40s (Korea Centers for Disease Control and Prevention, 2008). Obese individuals are known to show high levels of total cholesterol (TC), triglycerides (TG), low-density lipoprotein-cholesterol (LDL-C), and insulin resistance, and a low level of high-density lipoprotein-cholesterol (HDL-C). Hypercholesterinemia increases the prevalence of coronary artery diseases, so active preventive measures are required (Park et al, 1999).

Deterioration of the physical functions of the eld-

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erly is caused by the loss of skeletomuscular functions, joint movement, and sense of balance (Kim and Choi, 2004). Elderly obesity results in physical function disorders and metabolic disorders. Physical and physiological changes can cause fall accidents, fractures, and cardiovascular diseases. Nevertheless, not enough studies on these issues and exercise methods have been conducted (Hong and Oak, 2013).

Korean studies on the exercise programs for aged people include combination exercise (Moon, 2008), exercise program (Park, 2009), muscle power reinforcing exercise (Lee et al, 2010), and studies abroad include a combined program of exercise, education, environmental modification therapy, and an intake of nutritional supplements (Steinberg et al, 2000) and program (Robertson et al, 2001). Unlike drug therapy, exercise do not have side effects and are low-cost. In addition, exercises can increase muscular strength and reduce the body fat mass. Particularly, combined exercises can increase the effects of both aerobic exercises (American College of Sports Medicine, 2009). In a study of Park et al (2010), combined exercise was confirmed to have simultaneously shown the effects for anaerobic exercises.

Proprioceptive Neuromuscular Facilitation (PNF) is a method of stimulating the myoreceptors in the muscles and ligaments using a specific helical pattern to improve the physical functions, muscle power, flexibility, and balance (Klein et al, 2002). PNF is a treatment or training method that uses human movement patterns. Local studies on PNF targeted patients (Lee et al, 2009; Oh et al, 2011) and were focused on the physical functions of elderly women (Cho et al, 2007), preventing falling accidents (Kim and Kim, 2013), and training (Kim, 2008; Kim, 2009). The reports on PNF studies published abroad stated that the physical activities significantly improved. Addition of intensive repetition of facilitation exercise to multidisciplinary rehabilitation promotes motor functional recovery of the hemiplegic lower limb (Kawahira et al, 2004). PNF training and physical function in assisted-living older adults (Klein et al, 2002) and effects of two 4-week PNF programs on muscle endurance, flexibility and functional performance in women with chronic low back pain (Kofotolis and Kellis, 2006). Acute effects of static and PNF stretching on muscle strength and power output (Marek et al, 2005).

Elastic band exercise has been used for rehabilitation, but it recently started to be used as well to improve physical functions. Since it requires whole body resistance, the muscular strength increase and the correct posture is maintained. Elastic band exercise safe, low-cost, effective for increasing muscular strength, and highly accessible and mobile, thereby reducing the psycholocal burden of the user. Moreover, the elastic resistance exercise for the lumbar-pelvic and leg muscles has proven highly effective in improving elderly people's walking and balancing performance (Kim et al, 2006). Milkesky et al (1994), confirmed that elastic band exercise had helped increase elderly people's muscular strength. In this study of Krebs et al (1998), elderly people were asked to perform intermediate elastic band exercise for six months, after which their leg's muscular strength significantly improved.

Many studies on PNF and elastic band exercise have been conducted, but few comparative studies on these two methods that targeted obese elderly women have been reported. In this study, the effects of PNF, which is frequently used as a combined exercise methods, and elastic band exercise, which is often used as a resistance exercise, on obese elderly women's physical functions and blood lipid levels were compared for use as basic data for exercise prescription.

Methods

Subjects

The experimental group was asked to perform PNF exercise, and the control group, which consisted

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of 31 obese elderly women (aged 65~70) living in G city who did not have regular physical activities, was asked to perform elastic band exercise, for 12 weeks. The effective size calculation equation was used to determine the sample size. The determined size range was .6 to 1.0, and .8 was estimated as an effective size for the power analyses. When power=.83, alpha=.05, and d=.8, the sample size by group was 23, so considering possible dropouts, 52 participants were supposed to be selected. However, since the selection was challenging due to the requirement for inclusion of obese elderly women, only 35 subjects were selected through face-to-face interviews after they voluntarily signed the consent form. They were randomly assigned to the groups, but four of them voluntarily dropped out or were uncooperative, so eventually, 31 subjects were included (16 in the experimental group and 15 in the control group). The inclusion criteria were; no difficulty in managing daily life activities, capability to walk independently for at least 10 meters without a walker, no serious skeletomuscular problems in the last six months, and a body mass index of at least 28 ㎏/㎡. The general features of the subjects are shown in Table 1.

Measurement tools and methods

Body composition

The water and food intakes of the subjects were restricted from two hours before the measurements. Their body fat percentage was measured using a body composition analyzer (InBody 570, Biomedical, Seoul, Korea).

Table 1. General characteristics of subjects (N=31)

	Experimental group (n_1=16)	Control group (n_2=15)
Height (㎝)	158.0±2.2[a]	155.8±3.9
Weight (㎏)	67.1±2.1	68.2±3.2
Age (year)	66.7±2.9	65.9±3.1
BMI[b] (㎏/㎡)	32.5±1.5	32.7±2.1

[a]mean±standard deviation, [b]body mass index.

Physical functions

The Senior Fitness Test (SFT) was used to measure the physical functions in this study. Such test determines elderly people's physical strength to measure the parameters of their functional activities and their capability to manage their daily activities. SFT was designed to have such features as reliability, validity, and discrimination. It is easy and safe to use, and requires no permission from a doctor (Jang et al, 2006). It is used for healthy individuals in a community, and includes items that represent the muscle power and flexibility of the upper and lower extremities power, cardiorespiratory endurance, agility, and dynamic balance. The reference data of normal males and women aged 64~94 are included in SFT. The SFT references to cardiorespiratory endurance, the lower extremities, muscular endurance, flexibility, balance, and agility were used in this study (Rikli and Jones, 1999).

Cardiorespiratory endurance test: two-minute walking in place

In a straight standing position, the subjects raised their knee up to the middle of their patellar and iliac bones. The number of times they could do this in two minutes was recorded. A higher score meant higher aerobic endurance and physical strength. In both men and women, less than 65 steps is a risky level. In this study, the test was conducted twice with a one-minute interval, and the higher measurement result was recorded.

Lower-extremity test: sit-to-stand

It is used for healthy individuals in a community, and includes items that represent the muscle power and flexibility of the upper and lower extremities, cardiorespiratory endurance, agility, and dynamic balance. The reference data of normal males and women aged 64~94 are included in SFT. The SFT references to cardiorespiratory endurance, the lower extremities, muscular endurance, flexibility, balance, and agility were used in this study.

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Muscular endurance test: sit-up

In a supine position, the subjects were asked to flex their knees up to 90 degrees with their feet on the floor. Their hands had to be on their chest, with their arms folded. They elevated their upper body to touch their knees with their hands, and then they extended their back to touch the floor. The number of times they could do this in 30 seconds was recorded. The test was conducted twice with a one-minute interval, and the higher measurement result was recorded.

Flexibility test: standing and forward bending

The subjects stood on a 40 ㎝-high table, their hands were stretched upward to their head, and they bent forward. Rebound was prohibited when they bent forward slowly, and the tips of their hands slightly touched their legs and stretched downward. The maximum distance of their hand tips below the table was measured. The tips had to be horizontal and to remain still for at least three seconds. The test was conducted twice with a one-minute interval, and the higher measurement result was recorded.

Balance test: standing on one foot

For the balance test, the subjects were asked to stand on one foot. This test has a high correlation with the lower extremities. The subjects put one leg flat on the floor with their hands on the side of their waist. After the 'start' signal, they raised one leg with their eyes open, and the length of time in which they could maintain this position was measured (Casio HS-3, Casio, Hong Kong, China). The test was conducted twice with a one-minute interval, and the higher measurement result was recorded.

Agility test: time's up and go test

This test measures the functional mobility and ambulation functions. The intra-measurer reliability was .99, and the inter-measurer reliability was .98 (Podsiadlo and Richardson, 1991). A 46 ㎝-high chair was prepared on a flat floor, and the three-meter distance from the chair was marked. The subjects stood up from the chair to reach the mark with the 'start' signal, and go back to the chair. The duration between their standing up from the chair and their sitting on the chair after coming back was measured with a stopwatch to the second (Casio HS-3, Casio, Hong Kong, China). The test was conducted twice with a one-minute interval, and the higher measurement result was recorded.

Blood test

The subjects fasted overnight for at least eight hours to minimize the diet effects. Exercise was also prohibited 24 hours before the blood collection to minimize the exercise effects. The subjects arrived an hour before the blood collection and took a 30-minute rest, and then 10 ㎖ of blood was collected from their median cubital vein using a disposable syringe. The blood was collected before the exercise, and 6 weeks and 12 weeks later at 9:00 A.M. each time. The sample was centrifuged for five minutes at 3,000 rpm, and then frozen at -70～-80˚C for the analyses at N Center.

Blood lipid level analysis

The levels of TC, TG, HDL-C, and LDL-C were analyzed using a blood analyzer (AU 680 Clinical Chemistry System, Beckman Coulter, California, USA).

Proprioceptive neuromuscular facilitation

Based on the guidelines for exercise prescription for the aged provided by the American College of Sports Medicine (2009), the Sprint & Skate combined Exercise Program (Dietz, 2009) using PNF was applied to the experimental group thrice a week for 12 weeks. According to the American College of Sports Medicine guidelines, an exercise frequency of three to five times a week is recommended to enhance cardiorespiratory endurance, and two to three times a week to enhance muscle power and muscular endurance. Based on the recommendations, the PNF

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program was conducted with three categories thrice a week for 12 weeks at T Center in G city: a warm-up exercise, the main exercise, and a cooling-down exercise. The ratings of the perceived exertion (RPE 6~15) were used to determine the exercise level. The frequency was gradually increased to twice for weeks 1~4, thrice for weeks 5~8, and four times for weeks 9~12. The warming-up and cooling-down exercises were stretching and de-ambulation. The details of the program are shown in Table 2 and Table 3.

Table 2. Proprioceptive neuromuscular facilitation exercise program

Procedures	Sprint program		Period (week)		
			1~4	5~8	9~12
Warm up	• Stretching: gluteus maximus, hamstrings, gastrocnemius, trunk rotators, quadratus lumborum, quadriceps • Walking: 100 m		10 min		
Exercise	Head & neck	• Stance phase direction: flexion, rotation, lateral flexion	10 min (2 sets)	20 min (3 sets)	30 min (4 sets)
	Upper extremity	• Stance phase -Scapular anterior elevation -Shoulder joint flexion, adduction, external rotation -Elbow joint flexion, supination -Wrist joint extention, ulnar deviation/finger extension • Swing phase -Scapular posterior depression -Shoulder joint extension, abduction, internal rotation -Elbow joint extension, pronation -Wrist joint flexion, radial deviation/finger extension			
	Lower extremity	• Stance phase -Hip joint extension, abduction, internal rotation -Knee joint extension -Ankle joint plantar flexion, eversion -Pelvic posterior depression • Swing phase -Hip joint flexion, adduction, external rotation -Knee joint flexion -Ankle dorsiflexion, inversion -Pelvic anterior elevation			
Cool down	• Stretching: gluteus maximus, hamstrings, gastrocnemius, trunk rotators, quadratus lumborum, quadriceps • Walking: 100 m		10 min		

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Table 3. Proprioceptive neuromuscular facilitation exercise program

Procedures	Skate program		Period (week)		
			1~4	5~8	9~12
Warm up	• Stretching: gluteus maximus, hamstrings, gastrocnemius, trunk rotators, quadratus lumborum, quadriceps • Walking: 100 m		10 min		
Exercise	Head & neck	• Stance phase direction: extension, lateral flexion • Swing phase direction: rotation	10 min (2 sets)	20 min (3 sets)	30 min (4 sets)
	Upper extremity	• Stance phase -Shoulder posterior elevation -Shoulder joint flexion, abduction, external rotation -Elbow joint extension, pronation -Wrist joint extension, radial deviation/finger extension • Swing phase -Scapular anterior depression -Shoulder joint extension, adduction, internal rotation -Elbow joint extension, supination -Wrist joint flexion, ulnar deviation/finger flexion			
	Lower extremity	• Stance phase -Pelvic posterior depression -Hip joint extension, adduction, external rotation -Knee joint extension -Ankle joint plantar flexion, inversion • Swing phase -Pelvic posterior elevation -Hip joint flexion, abduction, internal rotation -Knee joint flexion -Ankle joint dorsiflexion, eversion			
Cool down	• Stretching: gluteus maximus, hamstrings, gastrocnemius, trunk rotators, quadratus lumborum, quadriceps • Walking: 100 m		10 min		

Elastic band exercise

The elastic band exercise was conducted thrice a week for 12 weeks. It was composed of a 10-minute warming-up exercise, a 30-minute main exercise, and a 10-minute cooling-down exercise. The warming-up and cooling-down exercises were stretching and de-ambulation. Since the subjects were obese elderly women, the easiest yellow elastic band (Thera-band, Hygienic Corporation, Ohio, USA) was initially used, and after they completed 10 repetitions

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Table 4. Elastic band exercise program

Procedures		Elastic band exercise	Period (week) 1~4	Period (week) 5~8	Period (week) 9~12
			yellow band	blue band	blue band
Warm up		• Stretching: gluteus maximus, hamstrings, gastrocnemius, trunk rotators, quadratus lumborum, quadriceps • Walking: 100 m	10 min		
Exercise	Upper extremity	• Elbow flexion, extension • Reverse files • Upright row • Side bend • Bilateral shoulder flexion, extension	10 min (2 sets)	20 min (3 sets)	30 min (4 sets)
	Lower extremity	• Hip flexion, extension • Hip adduction, abduction • Mini squat knee extension • Leg press • Ankle dorsiflexion, plantarflexion			
Cool down		• Stretching: gluteus maximus, hamstrings, gastrocnemius, trunk rotators, quadratus lumborum, quadriceps • Walking: 100 m	10 min		

or two sets, a blue band was used to increase the exercise intensity. The details of the program are shown in Table 4.

Data processing

The SPSS ver. 21.0 program (SPSS Inc., Chicago, IL, USA) was used for data processing. The mean and the standard deviation were obtained from each item. Repeated-measurement two-way analysis of variance was used to investigate the difference in the items and the measurement time (at the baseline and on the 6th and 12th weeks) between the groups. When a significant difference was observed, the Duncan method was used. An independent t-test was used to verify the mean difference between the groups at each measurement time. Statistical significance was accepted when p<.05.

Results

Changes in the physical functions

The physical function changes after the PNF program application are shown in Table 5. The cardiorespiratory endurance level of the experimental group significantly increased from 139.19±7.67 to 164.20±7.35 (p<.001), as did that of the control group, from 140.24±6.69 to 153.19±7.42 (p<.01). The lower-extremity power of the experimental group significantly increased from 13.37±3.09 to 18.19±2.21 (p<.001), as did that of the control group, from 13.24±2.93 to 18.21±2.39 (p<.01). The muscular endurance of the experimental group significantly increased from 5.26±2.19 to 9.28±1.96 (p<.001), as did that of the control group, from 5.29±2.17 to 7.87±1.97 (p<.01). The flexibility level of the experimental group significantly increased from 2.32±2.09 to 4.51±1.93 (p<.01), as did that of the control group, from 2.24±1.83 to 3.52±1.79 (p<.01). The balance level of the experimental group significantly increased from 15.44±2.37 to 20.97±2.78 (p<.001), as did that of the control group, from 14.97±2.25 to 16.74±2.42 (p<.01). Finally, the agility level of the experimental group significantly decreased from 8.81±1.57 to 6.29±1.57 (p<.01), as did that of the control group, from 8.68±1.62 to 6.91±1.20.

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Table 5. Results of physical function

Item	Group	0 week (a)	6 weeks (b)	12 weeks (c)	F	Post-hoc
Cardiorespiratory endurance (count)	Experimental	139.19±7.67[a]	153.23±7.95	164.20±7.35	2.14***	a<b<c
	Control	140.24±6.69	146.29±6.12	153.19±7.42	1.34**	a<c
	t	-.98	.024	1.93*		
Lower extremity power (count)	Experimental	13.37±3.09	16.72±3.07	18.19±2.21	2.33***	a<c
	Control	13.24±2.93	15.21±2.66	18.21±2.39	1.85**	a<c
	t	-.15	.42	3.35**		
Muscular endurance (count)	Experimental	5.26±2.19	7.75±2.12	9.28±1.96	2.48***	a<c
	Control	5.29±2.17	6.83±1.89	7.87±1.97	1.49**	a<c
	t	-.79	.083	2.94		
Flexibility (㎝)	Experimental	2.32±2.09	3.39±2.10	4.51±1.93	1.89***	a<c
	Control	2.24±1.83	2.87±2.18	3.52±1.79	1.33**	a<c
	t	-.19	.15	1.38*		
Balance (sec)	Experimental	15.44±2.37	17.69±2.65	20.97±2.78	2.49***	a<c
	Control	14.97±2.25	15.76±2.87	16.74±2.42	1.78**	a<c
	t	-.19	.46	1.48*		
Agility (sec)	Experimental	8.81±1.57	7.23±1.39	6.29±1.57	1.69**	a<c
	Control	8.68±1.62	7.97±1.57	6.91±1.20	1.55**	a<c
	t	-.17	-.35	-.43		

[a]mean±standard deviation, *p<.05, **p<.01, ***p<.001.

Table 6. Results of blood lipid (Unit=㎎/dℓ)

Item	Group	0 week (a)	6 weeks (b)	12 weeks (c)	F	Post-hoc
Total cholesterol	Experimental	234.87±10.12[a]	218.35±19.59	201.79±19.52	17.90***	a<b<c
	Control	234.54±10.53	226.18±11.47	224.77±18.48	1.01	
	t	-.07	-.70	-2.92		
Triglyceride	Experimental	245.16±17.97	223.32±19.44	205.73±16.03	17.91***	a<b<c
	Control	249.19±14.61	248.96±21.05	245.17±21.18	.16	
	t	-.64	-2.66	-4.68		
High density lipoprotein	Experimental	37.39±1.27	42.14±2.75	46.25±1.99	7.27*	a<b<c
	Control	38.68±2.97	38.96±2.63	39.56±4.52	.24	
	t	-1.35	2.18	3.31		
Low density lipoprotein	Experimental	242.26±6.39	231.07±7.15	217.11±14.24	16.76***	a<c
	Control	237.40±38.17	234.67±12.15	231.27±15.98	.19	
	t	.48	-.75	-1.65		

[a]mean±standard deviation, *p<.05, **p<.01, ***p<.001.

Changes in the blood lipid level

The changes in the blood lipid level after the PNF program application are shown in Table 6. The TC level of the experimental group significantly increased from 234.87±10.12 to 201.79±19.52 (p<.001), unlike that of the control group (234.54±10.53 to 224.77±18.48, p>.05). The TG level of the experimental group significantly decreased from 245.16±17.97 to

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205.73±16.03 (p<.001), again unlike that of the control group (249.19±14.61 to 245.17±21.18, p>.05). The HDL-C level of the experimental group significantly increased from 37.39±1.27 to 46.25±1.99 (p<.01), still unlike that of the control group (36.68±2.97 to 39.56±4.52, p>.05). Finally, the LDL-C level of the experimental group significantly decreased from 242.26±6.39 to 217.11±14.24 (p<.001), unlike that of the control group (237.40±38.17 to 231.27±15.98, p>.05).

Discussion

In this study, the effects of PNF on the physical functions and the blood lipid levels of obese elderly women were investigated, and the following are discussed.

Physical function changes

Through regular exercise, elderly people's physical functions, which had deteriorated due to lack of endurance, muscular strength, walking, and exercise, can their physical response speed (Rubenstein et al, 2000). Physical functions are major factors that affect the daily activities of aged people, and include cardiorespiratory endurance, muscular endurance, muscle power, balance, flexibility, walking speed, and agility. In this study, cardiorespiratory endurance, lower-extremity power, muscular endurance, flexibility, balance, and agility were operationally defined.

Cardiorespiratory endurance was investigated using the 20-minute walking-in-place test. The test results showed a significant difference in both the experimental group and the control group, but a greater difference in the experimental group. These results corresponded to those of previous studies. The functional and structural changes in an aging heart could be prevented or increased through exercise. Functional changes increase the maximum oxygen consumption, maximal heart rate, cardiac output, and stroke volume (Oxenham and Sharpe, 2003). This means PNF can positively affect the cardiorespiratory endurance of obese elderly women who have regular physical activities.

The lower-extremity power was measured through the sit-to-stand method, which is most frequently used to estimate muscle power changes in the elderly. Significant changes in the lower-extremity power were observed in both the experimental and control groups, but the changes were greater in the experimental group than in the control group. Deterioration of muscle functions in the elderly can cause falling accidents and deterioration of physical functions such as lower-extremity power, walking balance, and range of motion of the lower extremities (Lord et al, 2002). Aged people have significantly reduced physical activities, which result in less use of their muscle fibers and a decrease in their muscle power, which aggravate the level of their daily activities and increase their risk of falling accidents (Yoon, 2006). A reduced muscle amount can cause chronic fatigue and deterioration in physical strength, physical response speed, and activities, which eventually result in bone density reduction, function deterioration, walking impairment, balance function deterioration, and stress (Faulkner et al, 2007). In this study, the lower-extremity power increased in both groups, and the subjects who did not exercise earlier benefited from their participation in the regular physical activities during the study period. The subjects in both groups performed resistance exercises, which contributed to the strengthening of their leg muscles.

The muscular endurance was measured using the sit-up test. Both the experimental and control groups showed differences after the experiments, but a more significant difference was seen in the experimental group than in the control group. These results corresponded to those of the 10-week resistance exercise study of Jung and Lee (2004) and the effects of the exercise program for the elderly study of Kim (2007).

Flexibility was measured using the standing and forward bending test. During the aging process, the range of motion decreases, and independent daily ac-

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tivities deteriorate. The flexibility levels in this study significantly differed in both the experimental and control groups, but the difference was greater in the experimental group than in the control group. These results corresponded to those of the study of Barbosa et al (2002) on a 10-week resistance exercise program and the study of Fatouros et al (2002) on the effects of strength training, cardio vascular training and there combination on flexibility of in active older adults.

The balance was measured using the single-leg-balance test. In the aging process, the lower-extremity power deteriorates, as do coordination, flexibility, and proprioceptive functions, which cause problems in the neural and skeletomuscular systems (Edelberg, 2001). Regular and intermediate-level exercises are useful for preventing fall accidents and improving the sense of balance (Lin et al, 2004). Balance is highly associated with falling accidents in obese elderly women. In this study, changes in balance were significant both in the experimental and control groups, but the changes were greater in the experimental group. These results of the single-leg-balance test, which were highly associated with ambulation functions such as walking and with balance control, corresponded to those of the study of Persad et al (2010). The PNF in this study was composed of the coordination motions of the closed kinetic chain and the open kinetic chain, which contributed to the enhancement of the single-leg-balance test results.

The agility was tested using time's up and go test, which is often used to test the dynamic balance ability level and rehabilitation in the elderly. The deterioration of the exercise control functions is caused by the delay in the sensory information processing and the reduction in the physical response speed (Barnett et al, 2003). In this study, the agility level significantly changed both in the experimental and control groups, but the change was greater in the experimental group. The PNF in this study included patterns in the body, upper extremities, legs, and head and neck, and programs for the four-step sprint and skating motions and the three-step motor learning, which were associated with all the motions and activities (Koo et al, 2010).

Blood lipid level changes

The PNF in this study was a combination of resistance exercise and aerobic exercise. During a combined exercise, fat metabolism is facilitated through aerobic exercise, and the body fat mass is maintained or increased through resistance exercise, which results in positive physical changes (Izquierdo et al, 2004). In the meantime, the blood lipid levels must be controlled through continuous exercise (Roussel et al, 2009). In this study, PNF was suggested as an exercise program that can be easily used in daily life to improve the blood lipid levels of obses elderly women.

TC and LDL-C are the major risk factors of coronary artery diseases, and the HDL-C level functions as a protective factor of coronary artery diseases (Moon, 2005). In this study, the TC level in the experimental group gradually decreased with statistical significance from the baseline 6 weeks and 12 weeks after the exercise, whereas in the control group, the TC level decreased, but the change was not statistically significant. These results corresponded with those of the previous study, in that the TC level in the combined middle-aged women training group decreased more significantly than that in the other exercise group (Yoon, 2008). Accordingly, in this study, the TC level in the experimental group was more significantly affected than that in the control group. The TG level in the experimental group gradually decreased with statistical significance from the baseline 6 weeks and 12 weeks after the exercise, whereas in the control group, the TG level decreased, but the change was not statistically significant. These results corresponded with those of the previous study, in that after the long-term exercise, the TG, TC and LDL-C levels decreased, and the HDL-C level increased (Taylor et al, 2004). The

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HDL-C level in the experimental group gradually increased with statistical significance from the baseline 6 weeks and 12 weeks after the exercise, whereas in the control group, the change was not statistically significant. These results corresponded with those of the previous study, which showed that through regular aerobic exercise or aerobic resistance exercise, the HDL-C level can be enhanced (Kim et al, 2004). The LDL-C level in the experimental group gradually decreased with statistical significance from the baseline six weeks and 12 weeks after the exercise, whereas in the control group, the change was not statistically significant. These results corresponded with those of the previous study, in which long-term aerobic physical activities or reduced the TC and LDL-C levels and increased the HDL-C level (Katzmarzyk et al, 2003). Accordingly, in this study, PNF was considered to have affected the blood lipid levels of obese elderly women.

In summary, after the PNF program was applied, the TC, TG, and LDL-C levels of the experimental group significantly decreased, and the HDL-C level significantly increased. The TG level change was the most significant, as in previous studies. This showed that regular aerobic and resistance exercise facilitated the activities of the lipoprotein lipase to dissolve TG in the blood and tissues (Sgouraki et al, 2001). As a combination of aerobic and resistance exercise, PNF was confirmed to have positively affected the blood lipid levels of the obese elderly women who did not have regular physical activities. The limitations of this study include its limited sample size, and the imperfect control over the subjects, such as over their diet and drug intake. Accordingly, generalization of the results from the obese elderly subjects to the general population may be inappropriate. Further comparative studies with a large sample size and with diet and medical conrtrols may be needed in the future.

Conclusion

In this study, the effects of PNF and elastic band exercise on the physical functions and blood lipid levels of obese elderly women were compared. The changes in the physical functions of the obese elderly subjects were significant both in the experimental and control groups, but the experimental group showed more improvements. Therefore, PNF was considered to have more significantly affected the physical functions than elastic band exercise. In terms of the blood lipid levels, the experimental group showed significant changes, but the control group did not. The means that PNF, a combined exercise, more significantly afferted the blood lipid levels than did elastic band exercise, a resistance exercise. In conclusion, PNF more effectively changed the physical functions and blood lipid levels of obese elderly women than did elastic band exercise.

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