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Effects of 12-week resistance exercise and interval training on the skeletal muscle area, physical fitness, and mental health in old women

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This study aimed to determine the effects of resistance exercise and interval training on the visceral fat to skeletal muscle area, physical fitness, cognitive functions, and mental health in old women. The study was conducted among 30 older women enrolled in the National Fitness Center in Seoul. They were randomly sampled into the resistance exercise and interval training group (RI group: n = 10, aged 64.10 ± 3.35), the resistance and aerobic exercise group (RA group: n = 10, aged 65.20 ± 5.10), and the control group (n = 10, aged 63.20 ± 2.62). Twelve weeks of exercise involving 30-min resistance exercise followed by 30-min interval training or aerobic exercise, 3 times a week, were performed by each group. A computed topography was used to the measure visceral fat area and the thigh skeletal muscle area. For physical fitness, maximum oxygen uptake, knee isokinetics muscle functions, ankle range of motion, and functional fitness of the elderly (muscle strength, cardiorespiratory endurance, flexibility, balance, and agility) were measured. For blood test, the metabolic syndrome risk factors, growth hormone, testosterone, and insulin-like growth factor-1 (IGF-1) were measured. A self-administered questionnaire was used to measure cognitive functions and quality of sleep. The 12-week RA and RI groups were effective in changing the thigh skeletal muscle area, IGF-1, knee joint extension and flexion, ankle range of motion, functional fitness, and quality of sleep. In conclusion, resistance exercise, followed by interval training or aerobic exercise, was effective in improving the skeletal muscle function indexes, physical fitness, and quality of sleep for the elderly. However, no difference was found between the two types of exercise.

Keywords: Elderly women, Resistance exercise and interval training, Visceral fat/skeletal muscle area, Physical fitness, Cognitive function, Quality of sleep

INTRODUCTION

The recent socio-demographic characteristics have included life expectancy adjusted to aging and disability on the basis of the extended average life expectancy. In an aging society, importance is attached to disability-adjusted life expectancy without chronic disease or dysfunction (Rowe and Kahn, 1997). However, sarcopenia, caused by a decrease in skeletal muscle mass and muscle strength, plays a central role in shortening disability-adjusted life expectancy in old age (Nair, 2005) due to aging reducing growth hormone and insulin-like growth factor 1 (IGF-1), both of which affect the anabolism of muscle protein metabolism (Møller et al., 2007). Moreover, old age is characterized by the decrease in functional fitness, which makes it hard for one to independently perform physical activity, tending to cause physical disorder (Enoki et al., 2007; Janssen et al., 2002).

Old age can also involve cognitive impairment directly associated with the quality of life. Cognitive impairment was associated with the activities of daily living in the elderly population (Haimov et al., 2008; Luck et al., 2010). Another mental health problem in old age is sleep disturbance. While sleep disturbance can occur in every age group, it is more common in the elderly group.

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Some epidemiological studies found that in the United States, ≥50% of the elderly complained of sleep disturbance (Foley et al., 1995) and that the sleep problems led to a decline in the ability to maintain sleep rather than changes in the absolute sleep demand (Crowley et al., 2011). It is therefore necessary to develop intervention strategies for the diverse physical and mental health problems transpiring in old age.

Exercise is effective in improving physical and cognitive functions, as well as quality of sleep (Cassilhas et al., 2007; Misic et al., 2007). Many researchers found that resistance exercise was effective in increasing skeletal muscle mass, in synthesizing muscle protein, and in improving the muscle functions in the elderly population (Koopman et al., 2009; Rolland et al., 2008; Strasser et al., 2009). The muscle function increase caused by resistance exercise improved functional fitness (Liu and Latham, 2009; Ramírez-Campillo et al., 2014). Aerobic exercise is effective in improving the cardiopulmonary functions and in increasing skeletal muscle oxidation capacity (Hagberg et al., 1989; Short et al., 2004). Recent research has reported that interval training, which involves repeated performance of high- and low-intensity exercise helpful for the cardiopulmonary functions, was also applied to cardiac rehabilitation programs and was effective in recovering the motor skills and the cardiovascular functions (Milanović et al., 2015; Rognmo et al., 2004; Weston et al., 2014). Many researchers found that in old age, interval training was also effective in protein synthesis, which is considered important in developing the muscle functions (Bell et al., 2015; Gibala et al., 2013; Robinson et al., 2017).

However, almost no comparative analysis has been performed on physical and mental health between conventional types of resistance interval training (RIT) and resistance aerobic exercise (RAE), in pursuit of health promotion for the elderly. This study intended to allow old women to perform RIT and RAE for 12 weeks and to determine which combination was more effective in improving the visceral fat to skeletal muscle area ratio, physical fitness, cognitive functions, and quality of sleep.

MATERIALS AND METHODS

Subjects

This study was conducted among 30 physically healthy old women enrolled in the National Fitness Center in Seoul. They were divided into the resistance exercise and interval training group (RI group, n=10), the resistance exercise and aerobic exercise group (RA group, n=10), and the control group (n=10). Before the experiment, the subjects were given explanation about the purpose and methods of this study and were asked to give consent. The exclusion criteria for sampling included surgical history and medication due to cancer diagnosis, cardiovascular disease, pulmonary disease, and musculoskeletal disorder. This study was reviewed by Korea National Sport University's Institutional Review Board (1263-201809-BR-007-02). The participants' physical characteristics are presented in Table 1.

Measurement items and methods

The subjects' height and weight were measured using an automatic body meter (Jenix, Seoul, Korea). The body mass index (BMI) was calculated by dividing the measured body weight (kg) by the square (m^2) of the height (cm). The body fat percentage was estimated using bioelectrical impedance analysis (InBody 3.0, InBody, Seoul, Korea). Computed topography (CT; Siemens, Somato Emotion, Oberasbach, Germany) was employed to determine the total abdominal fat area, the visceral fat area, the subcutaneous fat area, and the thigh skeletal muscle area. The visceral to subcutaneous fat ratio and the visceral fat to skeletal muscle area ratio were also estimated.

An automatic blood pressure monitor (FT500R, Jawon Medical, Seoul, Korea) was utilized to measure blood pressure. The subjects took a 5-min rest in a chair and, subsequently placing their right forearm into the instrument to register two measurements, the mean of which was used. Approximately 100-mL blood collected from a brachial vein 10 hr after a meal was tested using a biochemical analyzer (Selecta XL, Vital Scientific, Newton, MA, USA). The

Table 1. Physical characteristics of subjects

Group	Age (yr)	Height (cm)	Weight (kg)	BMI (kg/m²)	Body fat (%)
RI (n=10)	64.10±3.35	159.11±5.08	58.66±6.90	23.11±1.69	31.87±3.73
RA (n=10)	65.20±5.10	154.26±4.18	53.13±3.85	22.34±1.67	30.49±2.73
Control (n=10)	63.20±2.62	159.01±4.39	56.56±7.81	22.32±2.41	30.43±4.23
P-value	0.513	0.038	0.170	0.593	0.608

Values are presented as mean±standard deviation.
RI, resistance and interval training; RA, resistance and aerobic exercise; BMI, body mass index.

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blood test covered total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triglyceride, fasting blood glucose, growth hormone, testosterone, and IGF-1.

Exercise stress test was performed by means of an automatic breathing gas analyzer (Q4500, Quinton, Bothell, WA, UAS) with an altered Balke protocol on a treadmill. The test was discontinued when the rating of perceived exertion is ≥17, the respiratory exchange ratio ≥1.15, the maximum heart rate ≥90% (220-age), and when the subject demands for discontinuation. The knee isokinetics muscle function test was performed using an isokinetic equipment, Biodex system-3 (Biodex Co., New York, NY, USA). For load velocity, right and left power measurements per weight were repeated 3 times, with angular velocity set at 60°/sec. For the ankle range of motion, a goniometer (Goniometers, Sammons Preston, Bolingbrook, IL, USA) was used, with the anatomical posture of 0° as a starting posture. Dorsal and plantar flexions of the ankle joints were performed, with the knee joints flexed.

For functional fitness related to daily life for the elderly, muscle strength (grip strength, arm curl, chair stand), cardiorespiratory endurance (2-min step), flexibility (chair & sit reach, back scratch), balance (functional reach, one-leg stance), and agility (2.45-m up-and-go) were tested. Grip strength was tested twice with both hands alternatively using a grip dynamometer (GRIP-D 5101, TAKEI, Tokyo, Japan). For arm strength test (arm curl), a set of lifting and lowering a 2-kg dumbbell in a sitting position was counted for 30 sec. For leg strength test (chair stand), the subjects were asked to repeatedly sit down on and stand up from a chair for 30 sec. For cardiorespiratory endurance test, the subjects were asked to do a 2-min step. While doing a 2-min step, they were asked to lift each of the legs to the marked height and to lower it so that it could land completely on the ground. For lower limb flexibility test (chair & sit reach), the subjects were asked to have a leg stretched and both hands reached out toward the tip of the foot on a chair with the aim of measuring the gap between the hands and the tip of the foot. For upper limb flexibility test (back scratch), they were asked to lift the targeted hand above the shoulder and the other hand above the middle of the back so that the hands reached for each other with the aim of measuring the gap between the middle fingers. For balance test, functional reach and one-leg stance with eyes closed were tested. For functional reach test, subjects were asked to stand straight and reach the arms parallel to each other with the shoulder joints flexed to 90°, with the aim of measuring the distance between the tip of the third phalanges distalum in the starting position and in the greatest reach. For one-leg stance with eyes closed, people were asked to stand on a single leg akimbo. For agility test was 2.45-m up-and-go measured. With a starting signal, they were asked to stand up from a chair and walk at a rapid pace around a cone at 2.45-m distance and return to sit down on the chair with the aim of measuring the length of time between the signal and the return on the chair.

For cognitive dysfunction test, the Korean Dementia Screening Questionnaire-Cognition (KDSQ-C) developed by Yang et al. (2002) was tapped. This tool is composed of three areas: memory, linguistic competence, and activities of daily living. The score for each area ranges from 0 to 2, with the total score being 30 and with ≥6 suspected as cognitive dysfunction. For reliability based on internal consistency, Cronbach α was estimated at 0.78 at the time of its development and at 0.65 in this study.

The Korean translation by Sohn et al. (2012) of the Pittsburgh Sleep Quality Index (PSQI) developed by Buysse et al. (1989) was used to measure the quality of sleep. PSQI is composed of seven areas: perceived quality of sleep, sleep latency, sleep duration, usual sleep efficiency, sleep disturbance, sleeping medication use, and daytime dysfunction. The score for each area ranges from 0 to 3 and the total score was 0–21 for the sum of the seven items, with the higher total score meaning a lower quality of sleep. For reliability based on internal consistency, Cronbach α was estimated at 0.83 at the time of its development and at 0.67 in this study.

Exercise program

The exercise program was run 3 times a week for 12 weeks after a week of exercise intensity setting, education about how to do resistance exercise and aerobic exercise, and exercise adjustment. Resistance exercise intensity was determined using one-repetition maximum (1-RM) indirect measurement [1-RM = Wo + W1, (Wo = weight permitting 7–8 sets of shrinking), W1 = Wo × 0.025 × R (number of repeats)] developed by Fleck et al. (1988). For aerobic exercise intensity, Karvonen's (1957) formula [target heart beat = exercise intensity × (maximum heart beat - heart beat at rest) + heart beat at rest] was used to set a target heartbeat.

The RA group was asked to ride a bicycle (for 30 min) after a 30-min resistance exercise. The RI group was asked to do interval training for 30 min after a 30-min resistance exercise. Every group was asked to do warming-up before exercise and to execute 5-min walking and 5-min stretching for cooling-down. The details of resistance exercise, aerobic exercise, and interval training are as follows.

For resistance exercise, the subjects were asked to use weights to perform a total of nine events (five for the upper part of the body [chest press, lateral pull down, arm curl, back extension, and

Table 2. Change in body composition and computed tomography scan measurement

Variable	RI group		RA group		Control group		*P*-value		
	Pre	Post	Pre	Post	Pre	Post	Group	Time	Interaction
Body composition									
Weight (kg)	58.66±6.90	58.70±7.65	53.13±3.85	53.79 ±3.78	56.56±7.81	57.44±7.95	0.209	0.038	0.353
BMI (kg/m²)	23.11±1.69	23.07±2.08	22.34±1.67	22.64±1.53	22.32±2.41	22.60±2.38	0.725	0.105	0.362
Body fat (%)	31.87±3.73	31.88±3.69	30.49±2.73	30.82±3.04	30.43±4.23	30.96±4.21	0.695	0.128	0.519
CT scan measurement									
TFA (cm²)	434.16±64.93	434.76±89.58	422.60±50.14	420.94±47.96	414.96±67.83	418.77±66.77	0.811	0.907	0.960
Subcutaneous (cm²)	246.99±57.09	245.22±62.61	217.29±27.64	210.34±28.77	228.03±49.02	221.57±48.31	0.274	0.403	0.926
Visceral (cm²)	187.17±22.48	189.54±33.75	205.31±39.01	206.81±35.59	186.93±34.78	193.14±31.84	0.400	0.373	0.859
VSR	0.43±0.58	0.44±0.41	0.47±0.60	0.48±0.51	0.45±0.71	0.46±0.52	0.197	0.115	0.780
Skeletal muscle area (cm²)	106.47±16.65	117.38±18.36	106.24±14.54	113.43±15.21	106.30±14.42	107.29±14.83	0.751	0.000	0.002
VMR	1.79±0.27	1.64±0.37	1.94±0.27	1.85±0.38	1.76±0.24	1.81±0.26	0.402	0.123	0.114

Values are presented as mean±standard deviation.
RI, resistance and interval; RA, resistance and aerobic; BMI, body mass index; TFA, total fat area; VSR, visceral to subcutaneous ratio; VMR, visceral fat to skeletal muscle area ratio.

crunch] and four for the lower part of the body [leg press, leg extension, leg curl, and heel raise]) for 30 min. It was repeated 8–15 times at the intensity of 1-RM, 60%–80%, in 3 sets. For aerobic exercise, they were asked to do stationary bicycle exercise for 30 mi at the target heartbeat of 50%–60%. For interval training, they were asked to do stationary bicycle exercise for 5 min at the target heartbeat of 40%, followed by 10 sets of a 30-sec bicycle ride at the target heartbeat of 80%–90% and a 90-sec bicycle ride at the target heartbeat of 50%–60% for 20 min. After interval training, they were asked to ride a bike for 5 min at the target heartbeat of 40%. They wore a Polar Heart Rate Analyzer (Polar Electro OY, Kempele, Finland) to maintain the exercise intensity, with the aim of confirming that they did aerobic exercise within the scope of the established target heartbeat.

Data analysis

The data were processed using IBM SPSS ver. 18.0 (IBM Co., Armonk, NY, USA) to estimate and diagram the mean and standard deviation for each area. Repeated-measure two-way analysis of variance was carried out for intergroup differences in the mean. The significance level (α) was set at 0.05.

RESULTS

Changes in body composition and CT findings

The changes of body composition and the CT findings by exercise type are presented in Table 2. The RI group, the RA group, and the control group all had their weight significantly increased in the posttest ($P<0.05$) but no interaction effect was found. No significant intergroup difference was found in BMI or the body fat percentage at each point of time. No interaction effect was found as well. The visceral fat area, the subcutaneous fat area, or the visceral to subcutaneous fat area ratio differed insignificantly among the groups at each point of time. All groups had their skeletal muscle area increased in the posttest ($P<0.001$) and interaction effects were found ($P<0.01$). The visceral fat to skeletal muscle area ratio differed insignificantly.

Changes in metabolic syndrome risk factors and hormone

The changes in the metabolic syndrome risk factors and hormone by exercise type are presented in Table 3. Systolic blood pressure, diastolic blood pressures, triglyceride, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, or fasting blood glucose are among the metabolic syndrome risk factors differing insignificantly among the groups at each point of time where no interaction effect was found. The growth hormone or testosterone differed insignificantly among the groups at each point of time. No interaction effect was found. All three groups had their IGF-1 increased in the posttest ($P<0.05$) and no interaction effect was found.

Changes in VO_{2max}, knee isokinetic muscle function, and ankle range of motion

The changes in maximum oxygen uptake (VO_{2max}) and the knee isokinetic muscle functions by exercise type are presented in Table 4. VO_{2max} differed insignificantly among the groups at each point of

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Table 3. Change in metabolic syndrome risk factors and hormone

Variable	RI group		RA group		Control group		*P*-value		
	Pre	Post	Pre	Post	Pre	Post	Group	Time	Interaction
SBP (mmHg)	122.90±16.60	119.70±13.64	123.60±14.13	118.10±14.73	125.90±15.24	126.90±16.22	0.641	0.113	0.247
DBP (mmHg)	75.10±12.97	74.20±12.79	74.70±10.95	72.00±9.73	76.70±9.68	77.80±10.67	0.697	0.596	0.613
TG (mg/dL)	93.60±29.02	91.30±27.13	102.30±65.02	102.50±56.20	72.00±27.93	68.90±32.89	0.195	0.773	0.972
HDL-C (mg/dL)	61.10±12.37	54.40±11.72	60.80±10.40	61.60±14.84	65.60±11.43	61.00±10.72	0.515	0.084	0.286
LDL-C (mg/dL)	132.30±44.91	116.90±25.63	104.10±24.11	104.50±28.95	111.90±26.73	115.50±17.28	0.196	0.520	0.376
FBG (mg/dL)	93.70±6.68	91.90±8.60	94.40±5.62	92.40±16.59	97.70±13.94	97.50±7.20	0.265	0.649	0.962
GH (ng/mL)	1.54±1.38	1.44±1.94	1.34±0.57	1.15±0.93	1.46±1.15	1.16±0.78	0.869	0.334	0.917
IGF-1 (ng/mL)	132.40±28.43	157.28±40.81	127.71±25.54	136.60±20.19	130.27±20.79	135.00±30.50	0.454	0.014	0.226
Testosterone (ng/dL)	0.08±0.07	0.14±0.16	0.17±0.28	0.17±0.06	0.10±0.09	0.10±0.07	0.345	0.497	0.762

Values are presented as mean±standard deviation.
RI, resistance and interval; RA, resistance and aerobic; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglyceride; FBG, fasting blood glucose; GH, growth hormone; IGF-1, insulin-like growth factor-1.

Table 4. Change in cardiorespiratory fitness, knee isokinetic function, and range of motion in foot joint

Variable	RI group		RA group		Control group		*P*-value		
	Pre	Post	Pre	Post	Pre	Post	group	time	Interaction
VO_{2max} (mL/kg/min)	26.10±8.59	27.09±7.02	27.95±4.91	27.43±6.90	27.09±6.41	27.38±5.53	0.917	0.824	0.862
Rt Knee EX TQ/BW (Nm)	154.59±46.98	182.85±48.29	156.78±33.71	181.93±32.80	166.27±47.57	163.64±47.45	0.969	0.000	0.000
Lt Knee EX TQ/BW (Nm)	150.74±49.38	180.40±45.99	161.51±30.40	179.20±35.16	162.20±44.55	162.70±41.91	0.911	0.000	0.000
Rt Knee FX TQ/BW (Nm)	69.15±21.25	84.31±21.19	69.24±15.65	79.39±12.55	67.91±11.86	64.20±18.68	0.309	0.006	0.010
Lt Knee FX TQ/BW (Nm)	68.31±21.38	83.31±21.38	69.32±14.32	78.51±15.13	70.35±16.23	70.76±26.02	0.802	0.000	0.000
Lt. ankle PF (°)	51.26±3.87	53.30±3.80	51.34±4.16	52.20±4.13	51.19±5.46	51.10±4.95	0.848	0.000	0.000
Lt. ankle DF (°)	19.40±1.50	20.66±1.50	19.96±1.62	20.33±1.63	19.91±2.12	19.85±1.98	0.862	0.000	0.000
Rt. ankle PF (°)	51.26±3.86	53.14±3.87	51.34±5.32	52.13±5.25	51.19±5.96	51.48±5.29	0.927	0.000	0.012
Rt. ankle DF (°)	19.94±1.50	20.70±1.70	19.96±2.07	20.20±2.04	19.91±2.32	19.90±2.33	0.899	0.000	0.002

Values are presented as mean±standard deviation.
RI, resistance and interval; RA, resistance and aerobic; Rt Knee EX TQ/BW, right knee-extensor peak torque/body weight; Lt knee EX TQ/BW, left knee-extensor peak torque/body weight; Rt Knee FX TQ/BW, right knee-flexion peak torque/body weight; Lt Knee FX TQ/BW, Left knee-flexion peak torque/body weight; Lt, left; Rt, right; PF, plantar flexion; DF, dorsal flexion.

time and no interaction effect was found. For the knee isokinetic muscle functions, the RI and RA groups had their right and left extensor strength increased in the posttest ($P<0.001$ each), and interaction effects were found ($P<0.001$ each).

Right and left hamstring strengths increased in the posttest ($P<0.001$ each) and interaction effects were found ($P<0.001$ each). For the ankle range of motion, both the RI and RA groups had their right and left dorsal flexion increased in the posttest ($P<0.001$ each) and interaction effects were found ($P<0.001$ each). Both the RI and RA groups had their right and left plantar flexion increased in the posttest ($P<0.001$ each), with interaction effects being found ($P<0.001$ each).

Changes in functional fitness

The changes in functional fitness by exercise type are presented in Table 5. Grip differed insignificantly among the groups at each point of time and no interaction effect was found. Both the RI and RA groups had their arm strength increased in the posttest ($P<0.001$) and interaction effects were found ($P<0.05$). Both the RI and RA groups had their leg strength increased in the posttest ($P<0.001$) and interaction effects were found ($P<0.05$). Both the RI and RA groups had their 2-min step increased in the posttest ($P<0.001$) and no interaction effect was found.

Both the RI and RA groups had their upper limb flexibility improved in the posttest ($P<0.05$) and interaction effects were found ($P<0.05$). Lower limb flexibility differed insignificantly among the groups at each point of time and no interaction effect was found.

Functional reach or single-leg stance with eyes closed differed insignificantly among the groups at each point of time and no in-

Table 5. Change in functional fitness

Variable	RI group		RA group		Control group		*P*-value		
	Pre	Post	Pre	Post	Pre	Post	group	time	Interaction
Grip strength (kg)	24.39±4.63	24.76±4.36	24.66±4.19	24.84±4.79	24.26±3.09	24.69±2.39	0.987	0.324	0.948
Arm curl (reps/30 sec)	21.90±3.60	27.80±3.58	22.10±5.34	26.10±3.81	22.40±3.60	23.10±1.45	0.315	0.000	0.036
Chair stand (reps/30 sec)	22.30±3.80	27.10±3.38	21.90±3.75	25.30±3.53	22.30±5.68	23.80±4.47	0.643	0.000	0.029
2-Min step (reps)	123.40±11.41	134.90±10.19	122.8±17.57	133.00±7.86	123.00±11.56	126.30±13.50	0.650	0.000	0.219
Chair sit & reach (cm)	20.67±8.21	26.48±7.45	21.38±5.65	25.50±5.42	21.33±7.63	21.26±6.40	0.688	0.000	0.010
Back scratch (cm)	6.10±9.01	5.05±9.00	5.70±7.03	4.35±6.52	5.30±8.00	5.65±8.65	0.987	0.023	0.048
Functional reach (cm)	22.50±3.09	24.54±1.99	21.50±4.22	22.29±3.80	23.93±4.17	24.49±4.02	0.225	0.146	0.693
One-leg stance (sec)	11.23±10.59	11.49±6.55	11.04±11.31	11.30±2.70	10.61±3.16	10.78±2.51	0.966	0.880	1.000
2.45-m up-and-go (sec)	3.99±0.73	3.09±0.60	3.97±0.56	3.47±0.35	3.83±0.28	3.91±0.37	0.270	0.000	0.000

Values are presented as mean±standard deviation.
RI, resistance and interval; RA, resistance and aerobic.

Table 6. Change in cognitive function

Variable	RI group		RA group		Control group		*P*-value		
	Pre	Post	Pre	Post	Pre	Post	Group	Time	Interaction
Memory ability (score)	2.40±1.96	2.80±1.69	2.50±1.27	2.60±1.17	2.90±1.10	2.70±1.34	0.907	0.634	0.507
Language ability (score)	2.20±1.03	1.60±1.08	2.00±1.49	1.50±0.97	1.50±1.72	1.80±0.92	0.832	0.382	0.418
Daily living ability (score)	0.30±0.48	0.30±0.48	0.00±0.00	0.10±0.32	0.20±0.42	0.30±0.68	0.220	0.550	0.913
Total (score)	4.90±2.51	4.70±2.35	4.50±2.59	4.20±1.62	4.60±2.46	4.80±2.04	0.867	0.815	0.879

Values are presented as mean±standard deviation.
RI, resistance and interval; RA, resistance and aerobic.

Table 7. Change in sleep quality

Variable	RI group		RA group		Control group		*P*-value		
	Pre	Post	Pre	Post	Pre	Post	Group	Time	Interaction
Subjective sleep quality (score)	1.80±0.42	1.80±0.42	2.00±0.47	1.90±0.57	2.30±0.95	2.30±0.95	0.229	0.582	0.736
Sleep latency (score)	2.10±0.57	1.80±0.63	1.70±0.95	1.30±0.67	1.70±0.82	1.70±0.82	0.371	0.031	0.270
Sleep duration (score)	1.00±0.94	0.80±0.79	0.70±1.16	0.70±1.16	0.90±0.74	0.90±0.74	0.858	0.145	0.125
Habitual sleep efficiency (score)	0.70±0.67	0.50±0.71	0.40±0.97	0.40±0.97	0.40±0.97	0.40±0.97	0.841	0.145	0.125
Sleep disturbances (score)	2.10±0.74	2.00±0.82	2.10±0.32	1.90±0.57	2.20±0.63	2.20±0.63	0.707	0.388	0.775
Use of sleeping medication (score)	1.30±0.67	1.00±0.00	1.10±0.32	1.10±0.32	1.00±0.00	1.00±0.00	0.452	0.171	0.158
Day time dysfunction (score)	1.60±0.52	1.30±0.48	1.30±0.48	1.30±0.48	1.40±0.84	1.40±0.84	0.858	0.060	0.034
Total (score)	10.60±1.17	9.20±2.04	9.30±2.31	8.60±2.55	9.90±3.45	9.90±3.57	0.645	0.001	0.014

Values are presented as mean±standard deviation.
RI, resistance and interval; RA, resistance and aerobic.

teraction effect was found. Both the RI and RA groups had a 2.45 m decrease in the posttest ($P<0.001$), with interaction effects found ($P<0.001$).

Changes in cognitive functions

As for the changes in the cognitive function by exercise type, memory, linguistic competence, or activities of daily living differed insignificantly among the groups at each point of time, as presented in Table 6, and no interaction effect was found.

Changes in quality of sleep

The changes in the quality of sleep by exercise type are presented in Table 7. The quality of sleep, sleep duration, usual sleep efficiency, sleep disturbance, or sleeping medication use differed insignificantly among the groups at each point of time and no interaction effect was found. In contrast, sleep latency differed signifi-

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cantly at each point of time ($P < 0.05$) and no interaction effect was found. While daytime dysfunction differed insignificantly at each point of time, interaction effects were found ($P < 0.05$). Both the RI and RA groups scored higher for their quality of sleep in general in the posttest compared with the pretest ($P < 0.01$), with interaction effects found ($P < 0.05$).

DISCUSSION

Exercise program composition is essential for disability-adjusted life expectancy of the elderly. While aerobic exercise was primarily recommended in the past, importance is also attached to resistance exercise. Recently, the interval training of alternatively repeating low- and high-intensity exercise as a new paradigm to enhancing performance among athletes has been recommended for the health promotion in the elderly population. This study is composed of 12 weeks combined exercise for elderly women and is aimed to determine the effects of RIT and RAE on the visceral fat to skeletal muscle area ratio, physical fitness, cognitive functions, and quality of sleep. Both RIT and RAE were effective in changing the visceral fat to skeletal muscle area ratio, IGF-1, knee isokinetic muscle functions, ankle range of motion, functional fitness, and quality of sleep. However, no difference was found between the two types of exercise.

One of the main factors interfering with independent life in old age is sarcopenia. Sarcopenia means a decrease in skeletal muscle mass due to the decrease in the number of muscle fiber and the transversal area of muscle. This is caused by the decrease in hormone affecting muscle protein synthesis and body activity deficiency (Fielding et al., 2011; Møller et al., 2007). Exercise is key to sarcopenia prevention for the elderly (Visvanathan and Chapman, 2010). As results of this study, neither RIT nor RAE significantly changed the body fat percentage or the metabolic syndrome risk factors. The CT scan found no decrease in the visceral fat area but verified effectiveness in increasing the thigh skeletal muscle area. This result is similar to the finding that resistance exercise and interval training increased the transversal area of muscle and skeletal muscle mass (Bell et al., 2015; Roth et al., 2001). However, no significant difference was found in the growth hormone or testosterone, any of which decreases with aging. In contrast, IGF-1, which is a usual index of growth hormone excretion and causes protein synthesis and skeletal muscle hypertrophy, increased significantly. The literature review found contradicting results regarding skeletal muscle mass and aging-related hormone of the elderly by exercise type and intensity (Consitt et al., 2002). Therefore, further research should be conducted on exercise intensity and volume that are effective in promoting muscle protein synthesis between the two types of exercise.

Also, sarcopenia reduces the ability to perform physical activities that are important for the elderly in daily life. As results of this study, neither RIT nor RAE made significant differences in VO_{2max}, which is an index of cardiorespiratory fitness. However, these types of exercise were effective in improving knee joint muscle strength, which is used as a criterion for muscle strength measurement, and the ankle range of motion, which affects gait in the elderly population. This result is partially consistent with the finding that a mix of aerobic and resistance exercise as interval training improves oxygen uptake and knee joint muscle strength in the elderly population (Verney et al., 2006). They were also effective in improving arm and leg strength, 2-min step, upper limb flexibility, and 2.45-m up-and-go among the subareas of functional fitness considered important for daily living in the elderly population. Villanueva et al. (2015) also reported that high-intensity interval training increased arm and leg strength which is considered important among the elements of physical fitness for the elderly. Other researchers found that aerobic and resistance exercises were effective in improving functional fitness (Liu and Latham, 2009; Roma et al., 2013). Therefore, it can be said that a combined type of exercise, which is composed of resistance exercise, followed by aerobic exercise or interval training, is an effective intervention in improving the physical fitness necessary for the elderly to independently lead their daily lives.

Aging causes cognitive malfunction. These cognitive functions include memory and learning, concentration, perception, reasoning, and problem-solving. It is known that exercise increases the cerebral blood flow, brain-derived neurotrophic factor concentration and prevents cognitive malfunction (Cotman and Berchtold, 2002; Hall et al., 2001). As a result of this study, no significant difference was found in the changes of the cognitive functions between RAT and RAE. However, many researchers confirmed that aerobic and resistance exercises were effective in improving the cognitive functions (Cassilhas et al., 2007; Colcombe et al., 2006; Liu-Ambrose et al., 2010). The cognitive function test in this study is for screening. Therefore, research should be conducted to demonstrate the effectiveness of resistance exercise and interval training in objectively improving cognitive functions.

In old age, the disturbance of daily bio-rhythm affecting sleep and awakening can result in sleep disturbance. Sleep disturbance involves various symptoms, including troubled sleep maintenance, frequent awakening, frequent sleeping medication use, and excessive daytime drowsiness. Exercise and physical activity promotion are recommended for a higher quality of sleep (Shirota et al., 2000; Uezu et al., 2000). This study found that RAT and RAE were effective in changing the quality of sleep. De Jong et al. (2006) also found that sports activity improved the perceived quality of sleep for seniors with sedentary lifestyle. It can be said, therefore, that every type of exercise in this study is effective in improving the quality of sleep, which contributes to the recovery of physical and mental functions in the elderly population.

In conclusion, RAT and RAE were effective in improving the physical fitness and quality of sleep by increasing the skeletal muscle area and IGF-1 in old women. However, no difference was found between interval training and aerobic exercise, which followed resistance exercise. Further research should be conducted, taking into account intergroup variation in exercise intensity, exercise volume, and dietary intake influencing muscle protein synthesis, in a larger population.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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