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Original Article

The Effects of Floor-seated Exercise Program on Physical Fitness, Depression, and Sleep in Older Adults: A Cluster Randomized Controlled Trial

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SUMMARY

Background: Older adults with deteriorating health and limited activity levels spend most of their leisure time sitting on the floor; this indicates the need for preventive programs to increase the accessibility of exercise. We developed a floor-seated exercise program (FSEP) for them and examined its effect.

Methods: A randomized comparison of pre-and post-test design was used with 77 participants assigned to either an exercise group (n = 39 in three clusters) or control group (n = 38 in three clusters) in six senior community centers. The final sample included 33 participants who completed the FSEP for 12 weeks, and 30 control participants. The exercise group participated in the FSEP four days a week; they were provided direct and videotaped instruction respectively for two days each by a peer volunteer at the senior community center to which the participants' belonged.

Results: Adjusted analysis revealed that the 12-week FSEP was significantly effective in enhancing muscle strength ($p < 0.005$) and shoulder flexibility ($p = 0.001$), except in the non-dominant side wrist muscle strength and shoulder flexibility. Further, it reduced depression ($p = 0.001$), but had no significant effect on sleep quality ($p = 0.087$).

Conclusion: FSEP should be adopted as a health promotion program at senior community centers for South Korean older adults.

1. Introduction

Owing to decreases in physical and cognitive functions caused by chronic diseases and aging, the proportion of the elderly population having difficulties in performing daily activities of living (ADL) independently is also increasing. Sleep disturbances and depression are major public health problems in older adults[1]. Their sleep disturbances are attributed to sedentary lifestyles and lack of physical activities that could result in fatigue, depression, greater anxiety, and irritability[2,3]. Older adults tend to use pharmacological treatments to relieve common symptoms such as sleep disturbance and depression. However, pharmacological treatments of sleep disturbance and depression in older adults are related to hazardous side effects[2,4].

A current systematic review synthesized the evidence that meditative movement interventions, such as Tai-chi, Yoga, and Qigong, may benefit older adults with sleep problems[5]. Meditative movement interventions take advantage of the interactions among the body, mind, and behavior to maintain and improve physical function and health. Exercise is commonly considered a planned and recurring subset of physical activity that results in physical fitness[6].

Senior community centers comprise 95.1% of leisure and welfare facilities for older adults in South Korea[7]. They are mostly used by older adults with deteriorating health and limited activity levels, and provide spaces for leisure where 10–20 older adults can spend their time on the floor. These spaces are, however, not suitable for older adults to stand up and exercise. Considering that one of key cultural habits of Korean elderly, is to spend most of their time sitting on the floor rather than on chairs, the accessibility of exercise can be increased if a floor-seated exercise program (FSEP), in which an exercise is done sitting on the floor, that fits their life style

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is developed and utilized. Older adults with weak lower limb strength have to push the floor or wall with their palms to get up from the floor, so the exercise program should include movements that strengthen not only the lower limb but also the upper limb muscles. In addition, it is necessary to distribute the FSEP as a group exercise by making FSEP videos and train peer volunteers to increase adherence to the exercise.

This study developed a FSEP suited for older adults with reduced physical strength, within the spatial constraints of senior community centers, and trained them for 12 weeks. Further, we aimed to determine its effect on improvements in physical strength and quality of sleep and reduction in depression.

2. Materials and methods

2.1. Sample and recruitment

This study adopted a cluster randomized controlled trial and a pre-posttest design to test the effectiveness of a FSEP for older adults, which was conducted between July and October 2016. Six senior community centers in the city of Siheung in South Korea, with sufficient floor space for 10 or more people to exercise and participate in the FSEP, were selected. Six senior community centers were randomly assigned to either the exercise or control group using RANDBETWEEN statement of Microsoft Excel 2010. Participants' eligibility criteria were as follows: a) aged ≥65 years, b) able to sit for 40 min independently without an assistive device, c) scored 19 or higher on the Mini-Mental State Examination-Korean version (MMSE-K)[8], d) absence of any unstable physical condition, evidence of terminal illness, or history of abusive behavior, e) completion of the consent form, and f) did not have a regular exercise routine.

The sample size of the two groups was calculated based on sleep quality data from a previous study[9,10]. For a sufficient statistical power of 0.80, an effect size of 0.80, with a significance level of 0.05, a minimum 52 participants were required for a two-sided two-sample *t*-test, as per Cohen's power analysis[11]. Assuming an intra-cluster correlation coefficient (ICC) of 0.049 (derived from a community-based intervention study[12]), 6 clusters with an average cluster size of 12, and we estimated a design effect of 1.539[13]. Thus, the sample size was required 47. Allowing for up to 30% loss to follow-up, 39 and 38 participants were recruited for the exercise and control group respectively from the six randomly selected senior community centers. The final sample included 33 (84.6%) and 30 (78.9%) participants in the exercise and control group respectively (Fig. 1). This study was approved by the institutional review board (IRB approval number: MC16QISI0072). Written informed consent was obtained from each participant.

2.2. Measurements

To ensure the accuracy and consistency of measurements, two nurses with at least three years of experience were appointed as research assistants; they were trained in how to measure the variables and take precautions prior to the study. Demographic information was collected using a self-report questionnaire. Dependent variables were evaluated at baseline and after 12-week intervention after blinding the information of both the groups.

The primary outcome measure was sleep quality that was evaluated using the Korean version of the Pittsburgh sleep quality index (PSQI-K)[14]. The total PSQI-K scores range from 0 to 21 points, with a “good” or “poor” sleeper determined with reference to 8.5 points, and higher scores representing poor quality of sleep. Cronbach's alpha was 0.70 in the present study.

The secondary outcome included physical fitness and depression. The percentage of muscle to body weight was calculated by bioelectrical impedance analysis (Inbody H20, Biospace, Seoul, South Korea). Shoulder flexibility, grip strength, elbow, and wrist joint muscle strength were assessed to measure physical fitness. The back scratch test measured the distance between the middle fingers of both hands, while the dominant arm was lowered from the front to back of the shoulder and the non-dominant arm was raised from the waist to shoulder as far as possible. The shoulder flexibility of the non-dominant arm was measured using the same method. The back scratch test was conducted twice and the mean value was recorded. Grip strength was measured twice for each hand with an electronic hand dynamometer EH101 (Camry, Guangdong, China), and the mean value was recorded[15]. A Nicholas manual muscle tester (Model No. 01163, Lafayette instrument company, IN, USA) was used to measure muscle strength of both shoulders, elbows, and wrists based on the developer's guideline. Each participant performed lying supine with the elbow at 90° of flexion and the forearm in neutral supination. The participants were to exert maximal force and continue exerting during a four-to 5-s period[16]. The examiner held the hand-held dynamometer stationary while the subject exerted maximal force against it[17]. Two measurements were taken at one to 2 min intervals, and the average value was recorded in kilograms[13]. The interrater coefficient of the pre-test for five subjects was r = 0.90–0.96.

Depression level evaluated using the Geriatric Depression Scale Short Form-Korean version (GDSSF-K)[18]. The GDSSF-K is composed of 15 items with the score ranging from 0 to 15 and a cut-off score of 5; higher scores indicate a greater the degree of depression. Cronbach's alpha was 0.83 in the present study.

2.3. Intervention

The FSEP is based on the “sitting yoga program” for wheelchair-seated nursing home residents[19]. The program was modified to fit older adults in senior community centers based on consultation with one exercise specialist, yoga instructor, and nursing professor experienced in developing an exercise program for older adults. In addition, a video of the FSEP was produced so that older adults could gather at the senior community center at a time convenient to them and easily follow the exercise.

Peer volunteers were trained for 50 min on the method for checking the health status of the participants before and after the program, the coping method when a side effect occurs, and how to play the video; their understanding was verified after the training. The exercise group participated in the FSEP twice a week by direct instruction and twice a week by a peer-volunteer-led videotaped program. When the peer volunteer was leading the FSEP using the videotape, the investigator also participated in the program for the first eight sessions (four weeks) to ensure that the participants were familiar with the exercise method using the videotape for their safety.

The exercise group attended 30–40 min sessions of the FSEP four times weekly for 12 weeks, according to the ACSM guidelines[20], while the control group received the usual care without any knowledge of the exercise. The FSEP consisted of warm-up and cool-down routines rated 8–9 on the Rated Perceived Exertion (RPE) scale[21] assessing exercise intensity, conducted 5 min before and after the main exercise. The goals of the main exercise were to improve grip strength, upper limb muscle strength, and shoulder flexibility through gradual, repetitive movements, and to increase the exercise intensity to 10–14 on the RPE. The main exercise focused on stretching, strengthening, coordination, breathing, and relaxation techniques for 20–30 min (Fig. 2). After the completion

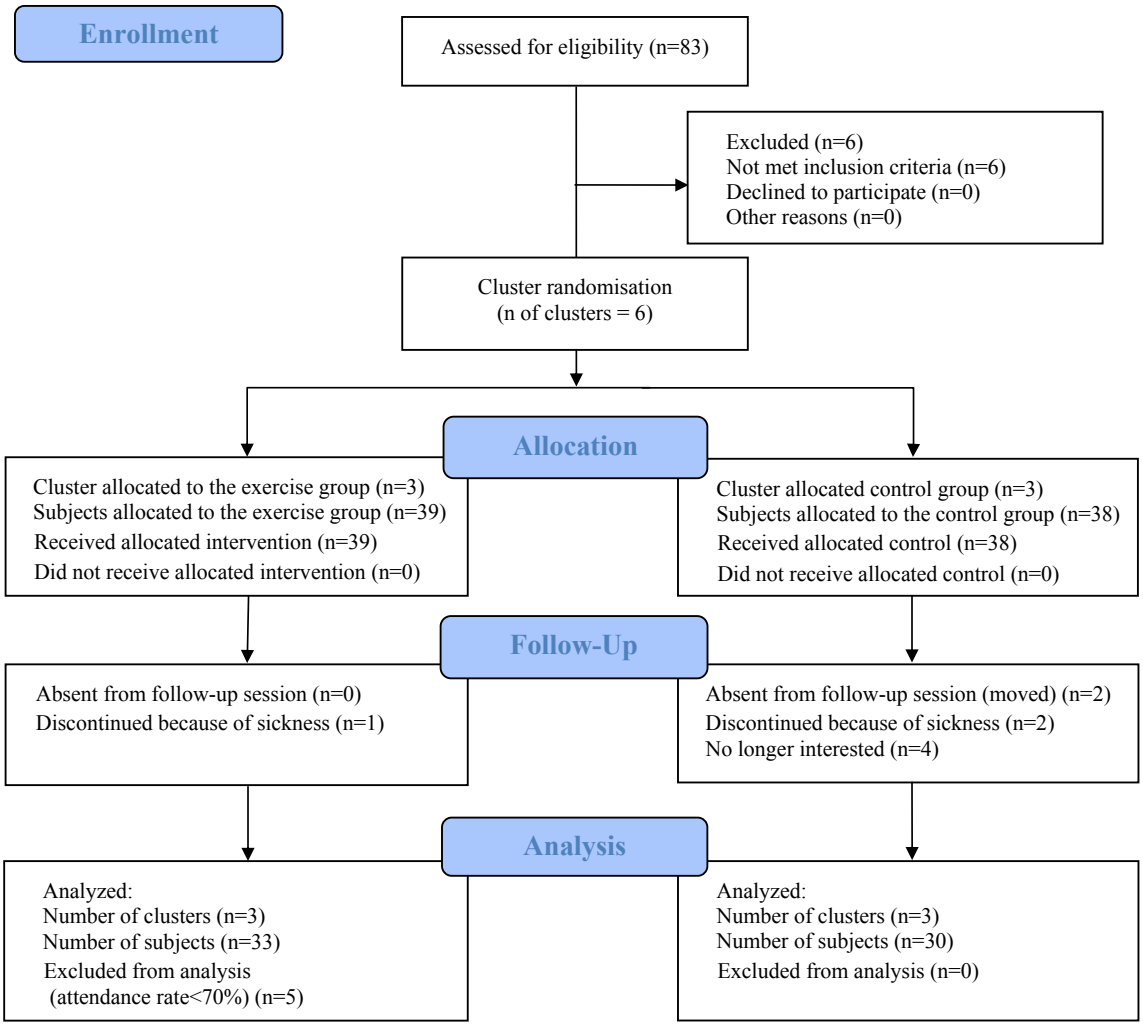

Fig. 1. Flowchart showing recruitment and follow-up of clusters and participants.

Phase	Week	RPE	Exercise contents	Duration (min)
Warm-up	1~12	8-9	·Deep breathing with arm raise & down · neck, shoulder, joint ROM	5
Main exercise	1-4	10-11	·**Stretching** -ROM exercise from head to toe ·**Strengthening** -hand grip, wrist press, knee-up holding, quadriceps setting exercise	20
	5-8	12-13		25
	9-12	14		30
Cool- down	1~12	8-9	.Deep breathing ·Relaxation & meditation	5

RPE = Rating of perceived exertion; ROM = Range of motion

Fig. 2. Protocol of the floor-seated exercise program.

of data collection, the control group participated in a 30-min FSEP demonstration session by the investigators and received a videotape.

2.4. Statistical analyses

Data were analyzed using SPSS version 21 (SPSS Inc., Chicago, IL, USA). Homogeneity between the two groups was examined using two sample *t*-test, chi-square test, and Fisher's exact test. The normality distributions were tested with the Shapiro-Wilks test. We used analysis of covariance (ANCOVA) to adjust for covariates and detect significant differences between the exercise and control group. Analysis was performed at the individual level.

3. Results

The exercise and control groups exhibited similar general characteristics, except for the presence of spouse (Table 1). Non-significant differences were found in the baseline dependent variables between the two groups (all $p > 0.05$).

Using ANCOVA, we found significant differences between the groups regarding the scores for both sides in grip strength, elbow, dominant side wrist muscle strength and shoulder flexibility, and the mean depression score. However, there was no significant difference regarding sleep quality (Table 2).

4. Discussion

In the meditative movement interventions, such as chair Yoga, seated Tai-chi, and Qigong using wheelchairs, considering the older adults was reported to improve upper body strength and quality of life and decrease sleep disturbances and depressive symptoms[22–24]. The FSEP improved muscle strength, shoulder flexibility, while reducing the level of depression of older adults in the senior community centers. Positive opinions of the participants on the FSEP were obtained, such as "It was nice to be able to exercise at a convenient time since we had the video" or "It was great to be able to continue the exercise without pain in the knee or ankle since we do the exercise in a seated position." These opinions could be because of the increased interest and ADL of the participants because the FSEP is a group exercise program[25] with increased accessibility and sustainability by utilizing local senior community centers and peer volunteers.

Improved shoulder flexibility was reported not only in this study, but also in most previous studies related to yoga and exercise interventions among older adults[26]. The improvement in dominant shoulder flexibility of the exercise group appears to be the effect of steadily performing exercise, such as back scratch, shoulder rotation, and pulling the arms toward the body at the shoulder height, for 12 weeks. Conversely, the flexibility of the non-dominant shoulder was not improved, and this appears to be because many

Table 1
Homogeneity test of the general characteristics.

Characteristics	Categories	Exer (n = 33)	Cont (n = 30)	*t or* χ^2	p
		Mean ± SD or n (%)	Mean ± SD or n (%)		
Age (years)		77.6 ± 5.69	78.8 ± 5.83	−0.82	0.415
Sex	Male/Female	3 (9.1)/30 (90.9)	1 (3.3)/29 (96.7)		0.614[a]
Educational level	Illiterate	11 (33.3)	11 (36.7)		0.888[a]
	Elementary school	16 (48.5)	15 (50.0)		
	Above middle school	6 (18.2)	4 (13.3)		
Spouse	Yes/No	15 (45.5)/18 (54.5)	5 (16.7)/25 (83.3)	6.01	0.014
Religion	Yes/No	20 (60.6)/13 (39.4)	18 (60.0)/12 (40.0)	0.00	0.961
Public assistance	Yes/No	1 (3.0)/32 (97.0)	2 (6.7)/28 (93.3)		0.601[a]
Perceived health	Healthy	3 (9.1)	4 (13.3)		0.360[a]
	Moderate	9 (27.3)	12 (40.0)		
	Not healthy	21 (63.6)	14 (46.7)		
Muscle mass (%)		33.66 ± 3.90	34.36 ± 3.24	−0.77	0.445

Exer = exercise group; Cont = control group; SD = standard deviation.
[a] Fisher's exact test.

Table 2
Differences between the groups regarding before and after outcome measures, adjusted for spouse, baseline values.

Variables			Exercise group		Control group		Mean difference between groups[a] (95% CI)	P
			Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD		
			Before	After	Before	After		
SF (cm)	DT		16.35 ± 12.11	13.06 ± 10.90	16.19 ± 10.93	17.75 ± 11.57	−4.94 (−7.73 to −2.14)	0.001
	NDT		17.97 ± 12.14	15.97 ± 11.33	21.44 ± 10.79	21.79 ± 11.69	−3.52 (−7.10 to 0.07)	0.054
GS (kg)	DT		20.96 ± 6.64	22.29 ± 6.30	19.33 ± 3.72	18.97 ± 3.92	1.83 (0.29–3.36)	0.020
	NDT		19.92 ± 6.08	21.13 ± 5.49	18.54 ± 4.17	17.81 ± 3.01	1.76 (0.17–3.35)	0.031
MS (kg)	DT	EF	6.80 ± 2.07	8.98 ± 4.02	7.62 ± 1.95	6.86 ± 1.36	2.09 (0.49–3.69)	0.011
		EE	6.60 ± 1.87	7.66 ± 3.62	6.40 ± 1.57	5.32 ± 1.42	2.30 (0.84–3.75)	0.003
		WE	4.57 ± 1.50	7.23 ± 3.60	4.35 ± 1.06	4.93 ± 1.53	2.30 (0.81–3.79)	0.003
	NDT	EF	6.27 ± 1.88	7.89 ± 2.89	7.16 ± 1.88	6.35 ± 1.30	1.79 (0.56–3.02)	0.005
		EE	5.99 ± 1.73	7.52 ± 2.12	6.27 ± 1.32	4.60 ± 0.92	3.07 (2.26–3.88)	<0.001
		WE	4.42 ± 1.17	5.57 ± 2.36	4.33 ± 1.56	4.73 ± 1.03	0.86 (−0.12 to 1.84)	0.085
Depression level			5.88 ± 2.97	3.82 ± 2.82	4.57 ± 3.33	4.63 ± 3.14	−1.40 (−2.53 to −0.26)	0.017
Sleep quality			6.12 ± 2.72	4.97 ± 2.27	5.83 ± 2.64	5.97 ± 2.71	−1.00 (−2.15 to 0.15)	0.087

SD = standard deviation; SF = shoulder flexibility; GS = grip strength; MS = muscle strength; DT = dominant; NDT = non-dominant; EF = elbow flexion; EE = elbow extension; WE = wrist extension.
[a] Adjusted mean difference, calcuated using ANCOVA. Positive values indicate an increase in the exercise group compared to control group. Negative values indicate higher reductions in the exercise group compared to control group.

participants complained of stiffness of pain in the shoulder and were not forced to perform the exercise. Therefore, it is necessary to develop movements that can gradually improve the flexibility of the non-dominant shoulder and take sufficient time to exercise them.

There were differences in grip strength in the right and left sides between the two groups, which support the results of previous studies[27]. It is necessary to improve the function and strength of the upper limbs[28], which have a lower muscle reduction rate than the lower limbs, to improve the daily life performance of older adults, since the ability to perform in daily life is mainly related to upper limb function. The FSEP appeared to strengthen the upper limbs, with repetitive nonresistance and resistance muscle exercises. This study supports previous studies that reported improvements in the upper limb strength, closely related in ADL of older adults in an eight-week yoga exercise program[29]. There seems to be no difference in the muscle strength of the non-dominant wrist between the two groups; however, exercises for the non-dominant wrist were not pushed because most participants complained of stiffness. In the future, it would be worth considering movements and weight load to prevent the sarcopenia common to older adults[30] and to improve the strength of the non-dominant wrist.

The mean score for depression was reduced in the exercise group, which is similar to the finding of a previous study[31] that stated physical exercises including yoga reduce the depression level of older adults. This may be not only because of the FSEP's inclusion of emotional elements, such as yoga breathing, relaxation, and meditation, but also the fact that the exercise was performed in groups. Group activity provides social interactions and fun time to the participants; further, the participants performed the exercise program autonomously by selecting volunteers among the peers who had a deep understanding of them.

Most people with depressive disorders report sleep disturbances, and regulation of sleep is an important aspect of treatment of depression[32,33]. Generally, exercise and meditative movement interventions have a positive impact on sleep outcomes[5,34]. Yet, in line with a few previous researches[2,35], this study found that, although the exercise group showed a decrease in their sleep quality scores, there were no intergroup differences in sleep quality when adjusted for the presence of a spouse. There is a possibility that a sound relationship with spouse boosted the sense of safety and security[36], promoting healthy sleep among the exercise group, who had the higher ratio of living with spouse. In addition, considering that the previous month, which served as a reference for the measurement of sleep quality, was part of the hottest summer ever with 22 tropical nights, it might have been difficult for the FSEP to fully affect the participants' sleep quality scores.

This study had some limitations. First, the flexibility of the non-dominant shoulder and wrist muscle strength could not be improved, and movements for this should be developed. Second, the present study was not able to control for confounding factors of the participants' conditions, such as diet, pain, and level of participation in housework. Third, more than 90% of the participants were women and generalizing this effect to men is difficult. Fourth, future research should attempt a large sample and longer follow-up to reduce seasonal effects. However, we believe that the FSEP can be continuously used as a safe and economical local health improvement program for older adults, if the participants know the FSEP movements thoroughly and the peer volunteers leading the FSEP are well trained.

Conflicts of interests

None.

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