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Original Article

Report on Multicomponent Exercise Interventions for Community-Dwelling Prefail/Frail Elderly

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Purpose: Evidence has shown that exercise interventions can improve frailty status. However, the exercise capacity of the frail aged is reduced, and they fatigue easily. The aim of this study is to record our practical experience of exercise interventions for five community-dwelling prefrail/frail elderly.
Methods and Results: Participants included one frail elderly and four prefrail elderly (average age 85.7 years) who were excluded from a randomized control trial due to low cognitive status, leg length discrepancy after an accident, or low cardiac function. The interventions were conducted for one month, three times per week for 40 minutes each time, and included individually-tailored training for flexibility, muscle strength, cardiopulmonary fitness, and coordination and balance. The exercise program was based on the suggestions of the American College of Sports Medicine. Three participants attended all 13 exercise sessions, one missed seven sessions due to vertigo after catching a cold, and one missed two sessions due to physical discomfort. One participant (Participant 5) frequently had a blood oxygen concentration below 90% and cyanosis, but was determined to exercise. We did not observe any adverse effects attributable to the exercises. No participant fulfilled the exercise prescriptions for muscle strengthening or cardiopulmonary training. After exercise, the Rating of Perceived Exertion Scale increased to 13-17, which was higher than the target value. However, the heart rate reserve percentage did not reach the target value, probably due to the use of anti-hypertensive medications. After exercise interventions, the number of frailty indicators decreased in three participants, especially in Participant 5 who showed two fewer frailty indicators.
Conclusion: After only one month of exercise intervention, there was a trend toward improvement in frailty status. However, exercise programs prescribed for prefrail/frail elderly require flexibility and individualized modification.

Keywords: exercise prescriptions, frailty, heart rate reserve, intervention effects, Rating of Perceived Exertion

Introduction

The prevalence of frailty in the older population ranges from 7.0% to 16.3%[1]. Recent research has shown the impact of frailty on older individuals, their families, and society, bringing increased attention to this issue. Frailty is distinct from disability and comorbidity. It manifests as dysregulation of multiple physiological systems,

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decreased biological reserve capacity, and a state of vulnerability to minor stressors resulting in disability or even death[2].

Relative to disability and comorbidity, frailty is a reversible state[1-3]. There have been numerous studies investigating ways to eliminate frailty, including nutritional supplementation/consultations, psychosocial programs, and exercise[4, 5]. Nutritional supplementation alone has been proven ineffective in reducing physical frailty[6]. In a review article, Landi et al. found that exercise intervention is the only effective way to consistently improve physical function, cognitive performance, and mood of the frail aged[7]. Similarly, the American College of Sports Medicine (ACSM) proposed that exercise intervention is more effective for the frail aged than any other form of intervention[8]. Previous research has demonstrated the effects of exercise on functional outcomes[9, 10]. Exercise prevents, delays, or reverses the frailty process[11] and minimizes the impact of disability[12].

Although exercise intervention benefits frail elderly[13] and the contraindications to exercise for this population are the same as those for healthier populations[14], the frail population has reduced exercise capacity, is more easily fatigued, and is less capable of handling minor stressors[15]. Whether these characteristics of frail elderly lead to the need for flexible adjustments to exercise prescriptions remains an open question. Previous research has documented the compliance rates and rates of adverse effects of exercise interventions for the frail aged[4-6, 13, 16-18]. However, from a literature review, we failed to find any study in which the goal achievement rate of exercise prescriptions were reported, with the exception of one that focused on resistance training only[5]. Furthermore, the average age of participants in previous relevant research was 71 to 83 years[13], with the exclusion criteria of low cognitive function and insufficient cardiac function[5, 6, 18]. However, aging is associated with lowered cognitive and cardiac functions and the risk of frailty in community-dwelling elderly people. This is exactly the group in need of exercise interventions.

The aim of this study is to report on our practical experience of exercise interventions for community-dwelling prefrail/frail elderly in a relatively low socioeconomic suburban area of Taichung, Taiwan. Our participants were five elderly people who were excluded from a randomized control trial, but expressed strong motivation to exercise. As the syndromes of frailty include impaired muscle strength, flexibility, balance, neuromuscular coordination, and cardiovascular fitness[19, 20], our one-month exercise interventions were multicomponent, based on the suggestions of the ACSM and relevant literature[5, 17, 18, 21]. In addition to the effects of exercise, we focused on the difficulties encountered and the goal achievement rate of the exercise program.

Materials and Methods

Participants

There were five participants, four males and one female, from a community center in a relatively low socioeconomic suburban area of Taichung City, Taiwan. They were excluded from a randomized control trial due to low cognitive function, leg length discrepancy as the result of a car accident, and low cardiac function. They expressed strong motivation to exercise and a one-month exercise program was designed for them. Their average age was 85.7 years (range 76.3–91.1 years, see Table 1). The inclusion criteria were (1) living in the community, (2) aged above 60, (3) independent in daily activities and functions, and (4) able to commute to the community center on their own. The exclusion criteria were (1) moderate or severe arthritis, (2) unstable medical status, (3) usual physical activity over 30 minutes per day, 6 to 7 days per week. All participants signed the informed consent form that was approved by the institutional review board..

Assessment

Participants were interviewed in person to obtain demographic and health status information including age, sex, education, and number of comorbidities. The comorbidities considered in this study were hypertension, diabetes mellitus, neurological disease, cardiopulmonary disease, back problems, and arthritis. Mental status was

Table 1. Basic characteristics of the participants (N=5)

	Age (years)	Sex	Comorbidity	Education (year)	Mini-Mental State Examination	Frailty status at baseline
Participant 1	88.0	Male	Hypertension	1	6	prefrail
Participant 2	82.2	Male	Hypertension Leg length discrepancy	3	20	prefrail
Participant 3	90.9	Male	Mild arthritis of bilateral knee	0	9	prefrail
Participant 4	76.3	Female	Hypertension Parkinson's disease	1	11	prefrail
Participant 5	91.1	Male	Hypertension Mild arthritis of bilateral knee Pleural effusion Low cardiac function	2	23	frail

assessed by the Mini-Mental State Examination (MMSE)[22]. In the week before and the week after exercise intervention, frailty status, balance, sensory organization ability, functional mobility, dual-tasking efficiency, and falls efficacy of all participants were assessed.

The five frailty indicators were operationalized as closely as possible to the phenotypic definition of Fried et al.[23]. First, self-reported unintentional weight loss was indicated by more than 3 kilograms or greater than 5% of body weight loss in the previous year[24]. Second, exhaustion was indicated by a self-reported "more than 3 days a week" to either of the following statements: "I felt everything I did was an effort" and "I could not get going" on the Center for Epidemiological Studies-Depression Scale[23, 25]. Third, physical inactivity was measured by the Taiwan International Physical Activity Questionnaire-Short Form[26]. Criteria for minimum weekly energy expenditures were 383 Kcal for men and 270 Kcal for women[23]. Fourth, slow walking speed was indicated by a usual walking speed below that of the sex- and height-adjusted criterion-specific thresholds[23]. To measure walking speed, participants performed two walks at their usual pace along a 7.56-meter walkway that extended for one meter at both ends to allow for acceleration and deceleration. Fifth, weakness was indicated by

Table 2. Frailty status pre- and post-exercise intervention

	Unintentional weight loss		Exhaustion		Physical inactivity		Slow walking speed		Weakness		Number of positive indicators	
	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
Participant 1	+	+							+	+	2	2
Participant 2	+						+	+			2	1
Participant 3	+	+	Missing	Missing	+						2	1
Participant 4				+					+	+	1	2
Participant 5	+		+	+	+	+	+		+	+	5	3

+*: positive indicator*

grip strength below criterion-specific thresholds adjusted for sex and body mass index[23]. Two peak grip measures of the dominant hand were taken using a hydraulic hand-held dynamometer (North Coast Medical, Inc). Each of the above frailty indicators, if present, contributed 1 point to the overall frailty score, which was based on the sum of all five indicators. Participants with a score of 0 were classified as nonfrail, 1–2 as prefrail, and 3–5 as frail[23]. Before exercise intervention, four of the participants were classified as prefrail with one to two positive indicators, and one was classified as frail with five positive indicators (Table 2). Participants 3 and 5 used a single cane as their usual assistive device.

Balance was assessed by the Functional Reach test[27], which evaluates the limit of stability in a comfortable stance while reaching forward. The peak value of two trials was taken. Sensory organization ability was assessed by the Modified Clinical Test of Sensory Interaction on Balance[28], which measures the duration of balance maintenance under the following four conditions: while standing, eyes open on a firm surface (Condition 1), eyes closed on a firm surface (Condition 2), eyes open on a soft surface (Condition 4), and eyes closed on a soft surface (Condition 5). Each condition was assessed once in that order. Functional mobility was assessed by the Timed Up and Go test[29], which asks participants to stand up from a seated position, walk forward three meters at their usual pace, turn around, walk back to the chair, and sit down. The smallest value of two trials was taken. Dual-tasking efficiency was assessed by the Dual-Task Timed Up and Go test[30], which asks participants to complete the Timed Up and Go test while counting backward by threes from a randomly selected number between 80 and 99. The smallest value of two trials was taken. Falls efficacy was assessed by the Modified Falls Efficacy Scale[31], which interviews participants about their confidence level in maintaining their balance during 14 activities. A higher score indicated a higher confidence level.

Multicomponent Exercise

Circuit training with a one-to-five therapist-participant ratio was conducted for 40 minutes per session, three sessions per week. We adopted eight functional pieces of training equipment designed for the elderly (SMARC, Preventive Medical Health Care Co., Ltd.) and tailored the parameters to individual exercise prescriptions. Each participant performed the following types of exercises (in order) for 10 minutes each: flexibility training, muscle strengthening, aerobic training, and balance and coordination training. Exercise prescriptions were based on the suggestions of the ACSM and relevant literature[5, 17, 18, 21] and adjusted for the initial phase of exercise or for unconditioned elderly.

Flexibility training involved movements on four pieces of equipment, including stretching of the anterior chest, scapula, shoulder, elbow, back, hip, and knee. Each static stretch was maintained for 10 seconds at terminal range, with five to six repetitions. Muscle strengthening involved movements on four pieces of equipment, including strengthening of the back muscles, core muscles, gluteus muscles, and extensors of the upper and lower extremities. Movements were performed at low speed with resistance set at the highest point at which the individual could perform 10 repetitions twice with an intermediate 10-second rest. This was approximately equal to 60% 1-RM (one-repetition maximum)[21]. Aerobic training involved only one piece of equipment, which was changed every week. It included alternate movements of the upper extremities, lower extremities, or trunk. The movement range was set at the middle range of the joint's range of motion, and the resistance and speed of movement were set at the point at which the individual could reach 12 to 13 RPE (Rating of Perceived Exertion) or 40-50% HRR (heart rate reserve). Balance and coordination training involved four pieces of equipment, including static balance on a single leg, dynamic sitting balance, dynamic balance in the kneeling position, coordination of the lower extremities, and coordination between the upper and lower extremities. The movements were performed at low speed, and the participants were encouraged to adjust their movements to keep pace with the auditory tones and visual feedback on the equipment screen.

For safety reasons, a physical therapist stood beside the frail participant during equipment changes and monitored blood oxygen of all participants using oximeters. Exercise was stopped if a participant's heart rate exceeded the set goal, the blood oxygen level was lower than 80%[21], the resting blood pressure was over 260/115, or there was complaint of vertigo, headache, or pain in the muscles or joints.

Results

Effects of Exercise

After one month, the number of frailty indicators decreased in three participants, especially in Participant 5 who showed a decrease of two indicators. One participant showed no change in the number of frailty indicators and one showed an increase of one frailty indicator. Improvements in frailty status were demonstrated by the indicators of unintentional weight loss, physical inactivity, and slow walking speed.

In addition to the trend in frailty status improvement, after the one-month exercise program there was a trend toward improvement in the outcome measures of Functional Reach, Condition 4 of Modified Clinical Test of Sensory Interaction on Balance, Timed Up and Go test, and Dual-Task Timed Up and Go test. However, due to the small sample size, no inferential statistics were derived (Fig. 1). Participant 5 showed the greatest improvement in all four variables.

Goal Achievement Rate and Practical Difficulties

Participants 1, 2, and 4 attended all 13 exercise sessions, Participant 5 missed two sessions due to physical discomfort, and Participant 3 attended only six sessions because he experienced frequent vertigo after coming down with a cold (Table 3). Participant 5 frequently had a blood oxygen level between 85% and 90% and showed cyanosis of the lips before exercise. Despite this, he was willing to continue exercising and only paused for five to 10 minutes in three sessions due to continued lowering of his blood oxygen level. No other participants needed to stop exercising. No adverse effects attributable to exercise were observed, and no falls or near falls occurred during exercise.

Resistance exercises for strengthening muscles included two sets of 10 repetitions, 60% 1-RM. However, all participants complained that the load was too heavy, and they adjusted by slowing down their movement or narrowing their movement

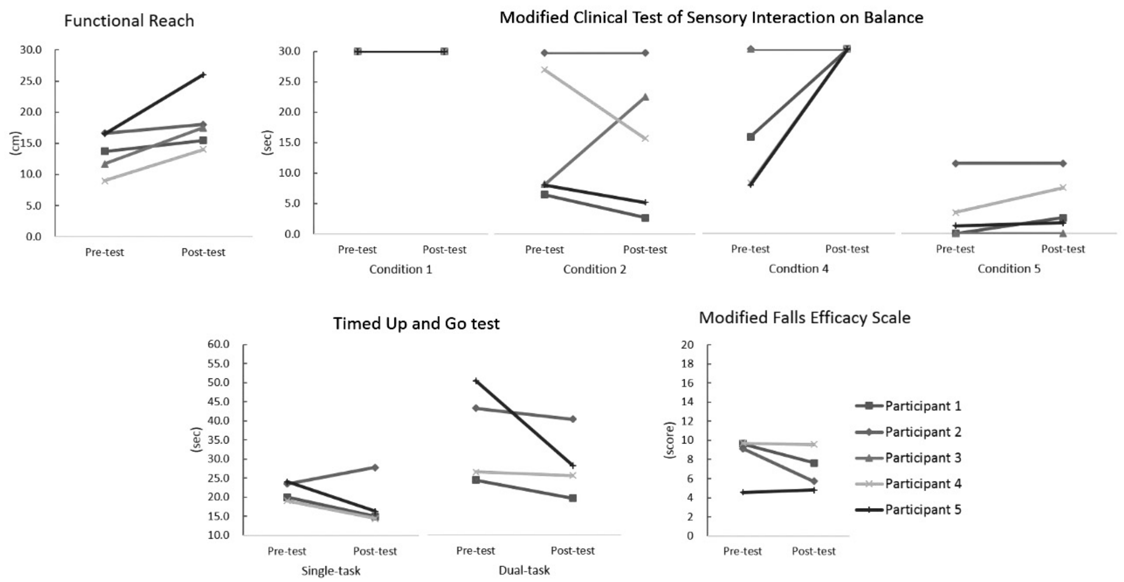

Fig. 1 Changes of performance in pre- and post-exercise intervention of balance (Functional Reach), sensory organization ability (Modified Clinical Test of Sensory Interaction on Balance), functional mobility (Timed Up and Go), dual-tasking efficiency (Dual-Task Timed Up and Go), and falls efficacy (Modified Falls Efficacy Scale)

Table 3. Compliance and response to exercise of each participant

	Attended exercise sessions /13 (%)	Rating of Perceived Exertion (range)		Average percentage increase in Heart Rate Reserve (%)
		pre	post	
Participant 1	13 (100%)	11-13	13-17	4.0%
Participant 2	13 (100%)	10-13	13-17	-8.0%
Participant 3	6 (46%)	11-13	15	15.0%
Participant 4	13 (100%)	11-13	13-15	9.8%
Participant 5	11 (85%)	11-17	15-17	9.6%

range. Despite this, participants did not complain of any muscle soreness or limb heaviness, probably due to our instruction on how to avoid delayed muscle soreness. The resistance and speed of movement for aerobic training was set at 12 to 13 RPE or 40%–50% HRR. However, no participants reached the target movement speed. After 30 minutes of exercise (flexibility training, muscle strengthening, and aerobic training), RPE increased to 13–17, which was higher than the target goal. All participants had an increased RPE after exercise, except Participant 5 who sometimes had an RPE of 17 before exercise. After 30 minutes of exercise, the average percentage increases in HRR of the five participants were 4.0%, -8.0%, 15.0%, 9.8%, and 9.6%, respectively. None of the participants reached the target goal. Participant 3 had the highest percentage HRR increase, while the remaining participants, who took anti-hypertensive medications, had HRR percentage increases of less than 10%.

Discussion

The participants in this study had a relatively low socioeconomic status and met the exclusion criteria of most interventional studies. We observed that they were relatively quiet in the community center. However, they expressed strong motivation to participate in an exercise program. During the one-month multicomponent intervention, we observed that (1) there were practical difficulties in executing an exercise program based on ACSM recommendations and the relevant literature and (2) there was a trend toward improved frailty status and other measures.

Although there was only one frail participant in this study, two participants used a single cane as their walking assistive device and the average age was higher than that of similar studies in community settings (71 to 83 years)[13]. The average age of participants in the present study was closer to that of studies in chronic institutional settings (77 to 90 years)[13]. Furthermore, the participants in our study all met the exclusion criteria of most interventional studies, that is, low cognitive function or insufficient cardiac function[5, 6, 18]. Hence, we expected a certain amount of difficulty in implementing exercise intervention. However, by adopting eight pieces of functional training equipment and finger oximeters, we were able to conduct a program for five elderly people with only one therapist and no adverse effects.

We chose the lower band of suggestions from the ACSM and relevant literature[5, 17, 18, 21] for our exercise program, as our participants were in their initial phase of exercise after a long period of sedentary life. ACSM guidelines include the use of more than one set of 10-15 repetitions of 60-70% 1-RM for muscle strengthening in older adults and very deconditioned individuals[21]. Latham el al.[5] and Binder et al.[17] chose 60-80% and 65% 1-RM, respectively, for frail elderly. Hence, we chose two sets of 10 repetitions, which is approximately equal to 60% 1-RM[21]. ACSM guidelines also include 30-60% HRR for aerobic training for deconditioned individuals[21]. Tarazona-Santabalbina et al. suggested 40-60% HRR for frail elderly[18]. Hence, we elected to use 40-50% HRR. However, our participants were unable to reach the set parameters of their individually-tailored exercise prescriptions. After 30 minutes of exercise, nearly all participants had increased RPE, higher than the set target of 12-13. Hence, our findings suggested that downward adjustments are necessary for the prefrail/frail aged who are relatively disadvantaged physically, especially in their initial phase of exercise. A similar finding was reported by Latham el al.[5], who adjusted resistance from 60-80% 1-RM to 51 ± 13% 1-RM. Tarazona-Santabalbina et al. used 25% 1-RM for the initial phase of exercise, which was very different from other studies[18]. Further research is needed to determine the optimum parameters for prescribed exercises.

Most likely due to the use of anti-hypertensive medications, the average percentage HRR increases were less than 10%, which was far from the set goal. This contrasted strongly with the increases in RPE. Hence, our findings suggest that relative to the measure of HRR, RPE is a better indicator of the progress of exercise intervention for prefrail/frail elderly.

Despite the limitations of the study design and sample size, we observed improved frailty status, primarily in the indicators of unintentional weight loss, physical inactivity, and slow walking speed. Body weight gain, increase in physical activity, and increase in the usual walking pace were all noted after only one month. Participant 5, who had five positive indicators before exercise intervention, showed the most improvement. Only one participant showed an increase of one frailty indicator, which was exhaustion after exercise. However, her Mini-Mental State Examination score was 11, which may make the assessment of exhaustion less valid. We also observed trends in improved balance, sensory organization ability (Condition 4 representing participant's use of visual ability in maintaining balance), functional mobility, and dual-tasking efficiency. Again, Participant 5 showed the greatest improvement in all four variables.

The average compliance in this study was 77.1%, ranging from 46.1% to 100%, which was within the range reported in other studies[4-6, 13, 16-18]. Participant 3 had the lowest rate of compliance as, after catching a cold, he experienced vertigo and frequently had to stop exercising. However, he still showed improved frailty status, balance, and sensory organization ability. According to the ACSM guidelines, exercise should be stopped if the blood oxygen level falls below 80%[21]. Participant 5's blood oxygen level was frequently between 85% and 90% before exercise. However, he only paused for 5 to 10 minutes in three sessions due to continued lowering of his blood oxygen level. No other participants needed to stop exercising. Latham el al.[5] and Binder et al.[17] both reported muscular-skeletal pain attributed to exercise intervention. In our study, functional training equipment designed for the elderly was used, and no adverse effects attributable to exercise were observed. This may support the recommendation of machines over free weights for older individuals due to skill-related and safety factors[21].

This study focused on participants of low socioeconomic status and high average age. We found practical difficulties with individually-tailored exercise programs based on the suggestions of the ACSM and relevant literature[5, 17, 18, 21]. The exact exercise programs to be prescribed need further research and should be very flexible. Our findings also suggested that RPE is a better indicator than HRR for monitoring the progress of exercise interventions in prefrail/frail elderly. Even with the difficulties noted above, our study showed that multicomponent exercise program for prefrail/frail elderly with low cognitive or cardiac function results in improved frailty status, balance, sensory organization ability, functional mobility, and dual-tasking efficiency.

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