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Physical activity combined with resistance training reduces symptoms of frailty in older adults: A randomized controlled trial

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A R T I C L E I N F O

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Frailty
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A B S T R A C T

Introduction: Increased physical activity (PA) is a crucial factor in the prevention of physical deterioration, and resistance training (RT) is also a common and effective intervention for older adults. However, the effects of PA as an adjunct to RT on frailty status remains unclear; therefore, we clarified the effect of a PA intervention with feedback, as an adjunct to resistance strength training, on the physical and mental outcomes of frail older adults.
Materials and methods: We employed a randomized controlled trial. Community-dwelling frail older adults in Japan were recruited to participate. Forty-one participants (mean age 81.5) were randomly assigned to engage in a resistance training with PA (RPA group) or RT group for six months. Frailty status and frailty scores, which were measured according to the Cardiovascular Health Study criteria—muscle strength, mobility, instrumental activities of daily living, and health-related quality of life—were assessed.
Results: Participants in the RPA group exhibited a significant increase in light-intensity PA, the number of steps taken daily ($p < 0.05$), and lower-limb muscle strength ($p < 0.05$) and a significant decrease in frailty scores. However, pre- and postintervention frailty status, instrumental activities of daily living, and health-related quality of life did not differ significantly.
Conclusions: Implementation of a PA intervention as an adjunct to RT is feasible, as it reduced frailty scores and increased lower-limb muscle strength and mobility in older adults with frailty symptoms.

1. Introduction

Physical frailty is a critical syndrome associated with health problems, such as falls, disability, and institutionalization, which lead to early mortality and increase medical costs. (Fried et al., 2001; Morley et al., 2013) Therefore, the prevention and treatment of frailty syndrome in older adults is important, and interventions to reduce the symptoms of frailty could benefit both patients and society. (Theou et al., 2011) Resistance training (RT) is a common and effective intervention for older adults. In addition, it is the primary therapeutic approach for the prevention and reversal of age-related deterioration in strength and function(Morley, Anker, & von Haehling, 2014) and it has been shown to reduce frailty in older adults. (Churchward-Venne et al., 2015; Gine-Garriga, Roque-Figuls, Coll-Planas, Sitja-Rabert, & Salva, 2014; Seynnes et al., 2004) Moreover, increased physical activity (PA) is a key factor in the prevention of physical deterioration including frailty. (Savela et al., 2013) Therefore, recent studies have focused on PA interventions for older adults and demonstrated positive effects on physical outcomes such as musculoskeletal mass(Yamada, Nishiguchi, Fukutani, Aoyama, & Arai, 2015) and mobility. (Snyder, Colvin, & Gammack, 2011) Further, Cesari and colleagues reported that PA interventions increased PA in frail older adults and aided in the treatment of frailty syndrome. (Cesari et al., 2015)

Previous research has shown that interventions involving combined RT and PA demonstrated encouraging outcomes. However, few studies have examined the effect of this type of intervention, (Rejeski et al., 2008) and the effects of PA as an adjunct to RT on frailty status remains unclear. One of the reasons for this lack of research could be that

Abbreviations: PA, physical activity; RPA, resistance training with physical activity; RT, resistance training; IADL, instrumental activities of daily living; HRQOL, health-related quality of life; SF-8, medical outcomes survey short form-8 questionnaire; MVPA, moderate to vigorous physical activity; RM, repetition maximum; ITT, intention to treat; TUG, timed up and go test

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practical feedback systems involving overall PA are scarce, even though wearable motion-sensing devices have recently allowed detailed assessment of PA levels. (Gierisch et al., 2015) If these systems were easily available, clinicians could prescribe PA interventions objectively and enhance adjunctive effects, even in frail older adults. Therefore, we developed a feedback system for PA interventions combined with RT and aimed to clarify the adjunctive effects of PA on health-related outcomes in frail older adults. We hypothesized that PA with feedback, as an adjunct to RT, would reduce frailty and increase lower-limb muscle strength and mobility in older adults.

2. Materials and methods

2.1. Participants

Community-dwelling older adults were recruited from a rehabilitation center. Participants received oral and written explanations concerning the study. The inclusion criteria were as follows: aged 65 years or older; presence of at least one symptom of frailty according to Fried's criteria (Fried et al., 2001); ability to walk independently (or using a cane); minimal or no auditory or visual impairment; and trainability, which required previous engagement in strength training using a training machine at the facility for 6 months.

The exclusion criteria were as follows: neurological impairment (e.g., stroke, Parkinson's disease, or paresis of the lower limbs), severe cardiovascular disease, severe cognitive impairment (Rapid Dementia Screening Test score of < 4 (Kalbe, Calabrese, Schwalen, & Kessler, 2003)), persistent joint pain, or severe musculoskeletal impairment (inability to participate in the training regimen). This study was approved by the ethics review board at Hyogo University of Health Sciences (No. 15005). The trial registration number is UMIN000017922. All participants provided written, informed consent.

2.2. Study design and randomization

Randomization was performed using computer-generated random numbers in blocks of four participants of each sex, stratified according to age by the research staffs. Of the 41 participants, 21 and 20 were randomly assigned to the RT with PA (RPA) and RT groups, respectively. The researchers who performed the measurements were not blinded to the group assignment.

2.3. Sample size

The required sample size was calculated according to predicted 6-month changes in frailty scores based on previous research indicating that a 26% score reduction could be predicted by the PA intervention. (Cesari et al., 2015) Using pilot data, the estimated effect size for the intervention was 0.71. Based on these assumptions, a sample size of 36 was required (with $\alpha = 0.05$, $\beta = 0.20$, and power of 0.80).

2.4. Outcomes

2.4.1. Frailty and physical function

Frailty was characterized by limitations in at least three of the following conditions, based on those described by Fried:(Fried et al., 2001) slow gait speed, weakness, exhaustion, low activity, and weight loss. The number of corresponding components was used as the frailty score. Participants who did not exhibit any components were considered nonfrail, and those who showed one or two components were considered prefrail. To calculate walking speed, which was used as the stratification variable, participants were asked to walk down a 12 m walkway at their preferred speed, and the time taken to reach 10 m was measured. (Lopopolo, Greco, Sullivan, Craik, & Mangione, 2006) Slow gait was established according to a cutoff point of < 1.0 m/s. (Fried et al., 2001) Weakness was assessed using maximum grip strength, which was measured in kilograms using a Smedley-type handheld dynamometer (GRIP-A; Takei Ltd, Niigata, Japan). Weakness was established according to sex-specific cutoff points (< 26 kg for men, < 18 kg for women). (Chen et al., 2014) Exhaustion was considered present if participants responded "*yes*" to the following question from the Kihon Checklist developed by the Japanese Ministry of Health, Labor, and Welfare:(Fukutomi et al., 2015) "In the last 2 weeks, have you felt tired without a reason?" The role of PA was assessed via the question, "Do you engage in physical exercise to improve your health?" If participants answered "*no*," we considered their PA level low. (Fried et al., 2001) Weight loss was assessed using the question, "Have you lost 2 kg or more in the past 6 months?"(Fukutomi et al., 2015). The timed up and go (TUG) test was used to assess balance and mobility. (Podsiadlo & Richardson, 1991)

2.4.2. Muscle strength

We measured isometric muscle strength in knee extensions and leg presses. Strength was measured using Weltonic Series equipment (Minato Medical Science Co., LTD, Kobe, Japan) connected to a personal computer, which included force sensor and recorded the results. Knee extension torque (kg/m) was measured in the dominant leg during isometric contraction of the knee extensor in a seated position, with the knee held at a 60° angle. Leg press strength (kg) was recorded during isometric contraction of the lower leg muscle in a reclining seated position, with the hip and knee held at 90° angles. Upon completion of premeasurement trials, each measurement was performed twice, and the larger value was recorded.

2.4.3. Instrumental activities of daily living (IADL)

IADL were measured using the Frenchay Activities Index (Holbrook & Skilbeck, 1983), which is a 15-item questionnaire that assesses recent participation in functional activity. For each item, participants are required to indicate the extent to which four statements reflect their recent participation in an activity. Although responses regarding the four statements varied between items, scores generally ranged from 0 ("*never*") to 3 ("*most days*" or "*at least once weekly*"). Total scores, calculated by summing the item scores, range from 0 to 45. The scale has demonstrated validity and reliability (Turnbull et al., 2000).

2.4.4. Health-related quality of life (HRQOL)

HRQOL was assessed using the Medical Outcomes Survey Short Form-8 questionnaire (SF-8) (Fukuhara & Suzukamo, 2004), which consists of eight items representing the following health profile dimensions: general health perception, physical functioning, role functioning-physical, bodily pain, vitality, social functioning, mental health, and role functioning-emotional. Responses are provided using a five- or six-point Likert scale, standardized according to the scoring system. Separate scores are provided for the physical and mental components of health.

2.4.5. Stages of change (transtheoretical model)

The transtheoretical model has been described as an integrative, comprehensive model of intentional behavior change that incorporates process-oriented variables to explain and predict how and when individuals change their health behavior including exercise adoption (Prochaska & DiClemente, 1983). Stages of change constitute the central organizational construct of the model and represent temporal and readiness dimensions (Sarkin, Johnson, Prochaska, & Prochaska, 2001). Participants were provided with a definition of regular exercise, which was described as engagement in exercise, such as walking, for 20–30 min at least twice per week, and answered the following question: "Do you currently engage in regular exercise?" They were instructed to select the item that reflected their current engagement in or readiness to initiate regular exercise, from the following items: (1) "No, I have no intention to begin in the next 6 months" (Precontemplation stage); (2) "No, but I intend to begin in the next 6 months"