The Effects of a Home-Based Exercise Program on Physical Function in Frail Older Adults

Patricia Noritake Matsuda, PT, DPT; Anne Shumway-Cook, PT, PhD, FAPTA; Marcia A. Ciol, PhD

ABSTRACT

Background and Purpose: Exercise has been shown to improve physical function in frail older adults; however, the effects of exercise may vary with degree of frailty, the format and intensity of the exercise intervention, and level of supervision. This cohort study describes the effects of participation in a 6-week home-based exercise program on measures of physical function as well as exercise-related beliefs, including exercise self-efficacy and outcomes expectation, in frail older adults.

Methods: Participants were 72 frail older adults who participated in a 6-week home-based exercise program supervised by graduate physical therapy students. Individualized home-based exercises targeted strength, flexibility, balance, gait, and cardiovascular fitness. Physical function was measured at baseline and after completion of the 6-week exercise program using the Functional Fitness Test (Biceps Curl, Chair Stand, 8-Foot Up and Go) and velocity on a 4-m walk. Measures of exercise-related beliefs included the Self-Rated Abilities for Health Practices Scale and Exercise Outcome Expectations.

Outcomes: Participation in the 6-week home-based exercise program was associated with improvements in measures of physical function, including an average increase of 3 repetitions (35%) on the biceps curl, 2.4 repetitions (59%) on the chair stand, and an average increase of 0.17 m/s (33%) in gait velocity. Average decrease in Timed Up and Go test scores was 5.7 seconds (26%). Scores for exercise-related beliefs also improved (self-efficacy average increase was 7 points [40%], and average increase in outcome expectations was 3 [47%]).

Discussion: A supervised 6-week, multidimensional home-based exercise program was safe and associated with improvements in physical and exercise-related belief outcome measures in this cohort study of frail older adults.

Key Words: frailty, home-based exercise, physical function, psychological function

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Department of Rehabilitation Medicine, University of Washington, Seattle.

Address correspondence to: Patricia Noritake Matsuda, PT, DPT, Department of Rehabilitation Medicine, Division of Physical Therapy, University of Washington, 1959 NE Pacific St, Box 356490, Seattle, WA 98195 (pmatsuda@u.washington.edu).

INTRODUCTION

Frailty has been described as a state of increased risk or vulnerability, which is most often attributed to reduced physiologic reserve and a decrease in homeostatic capability for withstanding stressors.[1,2] Researchers have estimated that 40% of adults 80 years and older may be classified as frail.[3] Among older adults, frailty is associated with adverse health outcomes, including mortality, disability, falls, and the need for long-term care.[1] Although there is no universal agreement about the critical dimensions of frailty, core features include weight loss and sarcopenia, muscle weakness, reduced endurance and energy, slow movement, and low physical activity level.[2] These core features have been used to establish a continuum of frailty; with older adults exhibiting 3 or more core features categorized as fully frail, while those with 1 to 2 features classified as prefrail or intermediate frailty.[2] Frailty appears to be a dynamic process, rather than a static state, with transitions occurring between nonfrail, prefrail, and frail states.[2,4,5]

Exercise has been shown to improve physical function in frail older adults; however, the effects of exercise may depend on a number of factors, including the degree of frailty, the format and intensity of the exercise intervention, and level of supervision. Several studies have reported that exercise was more effective in improving physical function in adults classified as being intermediately frail compared with those who were frail,[6,7] whereas others have reported positive effects of exercise among frail older adults.[8-10] Among relatively healthy older adults, home-based exercise programs have greater adherence rates than group-based community programs[11,12] and are effective in improving functional performance and balance in functionally impaired elders.[11] Studies by King and colleagues[12,13] have shown that low-intensity home-based exercise programs were as effective as higher intensity programs in improving fitness among sedentary but healthy adults 50 to 65 years of age. Professional supervision also appears to play an important role in exercise programs as well. Supervision by a healthcare professional in both home-based[11] and class-based programs[14] demonstrated more positive health outcomes than in a comparable nonsupervised program.[11,14] Finally, it has also been shown that perceptions regarding the benefit of exercise and perceived ability to perform exercise can influence the outcome from training.[15] Few studies have systematically examined the effects of a supervised home-based, individualized exercise program on physical function in frail elders. In addition, the effect of outcomes expectation and exercise self-efficacy on posttraining physical function measures has not been examined in frail elders.

Given the current prevalence of frailty among the older adult population, and the paucity of research on the efficacy of home-based programs in this population, understanding the effect of a supervised home-based exercise program on physical function in frail elders is critical. The purpose of this cohort study is to describe the effects of participation in a 6-week home-based exercise program on physical function in frail older adults on measures of physical function as well as exercise-related beliefs, including exercise, self-efficacy, and outcomes expectation.

METHODS

Participants

Participants included 72 older adults, case-managed by Aging and Disability Services of Seattle-King County, who participated in the Project HomeStretch from 2002 to 2007. Potential participants were recommended to the program by their case managers; a telephone interview determined eligibility using the following criteria: age 55 years and older, English speaking, having 2 or more chronic conditions including but not limited to diabetes, the ability to ambulate independently with or without an assistive device (eg, walker or cane), functional vision (limited vision accepted), managed mental health conditions, not currently receiving physical or occupational therapy, ability to be contacted via telephone, living within 45 minutes of the University of Washington, and willingness to participate in a no-cost 6-week exercise program. Participants were excluded if they did not have a primary medical provider. Eligible participants who agreed to participate were sent a consent form. Upon receipt of the completed consent form, medical clearance was obtained from each participant's primary care physician. A certificate of exemption to use the data from these clients for this cohort study was approved by the Human Subjects Division of the University of Washington.

Physical Therapy Evaluation

All outcome measures were collected by the graduate physical therapy students at baseline (initial evaluation) and at 6 weeks (the end of the supervised home visits).

A health intake questionnaire was completed by interview at the initial session. Information gathered included age, ethnicity, body mass index, number and type of comorbidities, number and type of medications, and number of falls in the previous 6 months. Participants' self-reported independence in 7 activities of daily living (eg, bathing, dressing, transferring) and 8 instrumental activities of daily living (eg, preparing own meals, shopping for groceries) using a 0 to 3 scale (0 = *no help or independent* to 3 = *require assistance/unable to do alone*) using questions from the National Disability Followback Survey.[16] Higher scores on both tests indicate loss of independence (assistance required to complete activities). Readiness to exercise was assessed using the PACE (a part of the Physician-based Assessment and Counseling for Exercise program).[17] The PACE scale consists of 10 statements; the client chooses the statement that is closest to his or her current exercise or readiness state.[18]

Underlying physical impairments were tested and performance was used to determine intensity of exercise prescribed, rather than as primary outcome measures. Testing included upper and lower extremity strength assessed using the manual muscle test, joint range of motion (classified as either within normal limits or within functional limits), and pain reported using a Visual Analogue Scale of 0 (*no pain*) to 10 (*severe pain*). Monofilament testing was used to assess distal lower extremity sensation. Visual impairment was screened by participant self-report.

The sociodemographic, health, and functional characteristics of participants included in this cohort study are outlined in Table 1. The mean age of the participants was 71.0 years (9.0 years) and the majority of them were women (76%, n = 55). The participants were primarily African American and white. The majority of these participants lived alone and received chore service assistance. More than 94% of the sample were diagnosed with type 2 diabetes and classified as obese on the basis of body mass index. The mean number of comorbidities in the group was 5.5 (2.6) and the mean number of medications was 8.0 (5.0). Activities of daily living and instrumental activities of daily living scores were 9.1 (6.4) out of 21 maximum score and 11.0 (5.6) out of 24 maximum score, respectively. Fifty participants (69%) reported falling in the past 6 months; of these, 13 (18%) reported 2 or more falls during that time period. Only 36% of the participants walked without assistive devices.

Physical Function Outcome Measures

Three items from the Functional Fitness Test [19] were used to evaluate physical function: (1) Arm (Biceps) Curl, a measure of upper extremity strength that assesses the number of times in which a weight can be lifted (on their dominant side) in a 30-second time period, with women using a 5-pound and men using an 8-pound weight; (2) 30-second Chair Stand, a measure of lower extremity strength, in which participants are asked to stand up and sit down without using their arms from a 17-in high chair as many times as they can in a 30-second period; and (3) the 8-foot Timed Up and Go (TUG) test, a measure of balance and mobility in which participants are asked to stand up from a 17-inch chair, walk as quickly as they safely can for a distance of 8 ft, turn, walk back, and sit down in the chair. For the 8-foot TUG test, 2 trials were given, and the fastest time was recorded. The Functional Fitness Test includes age and gender norms for adults from 60 to 94 years of age. Gait velocity (in meters per second) was calculated from the time taken to complete a 4-m walking course. Two trials were given, and the participant's fastest time was recorded.

Table 1. Sociodemographic, Health, and Function of Participants (N = 72)

Characteristics	Mean (SD)	N (%)
Demographics		
Age, y (range, 54–97)	71.0 (9.0)	
Sex, females		55 (76.4)
Ethnicity		
African American		39 (54.2)
White		28 (38.9)
Asian		2 (2.8)
Latino		2 (2.8)
Native American		1 (1.4)
Social support		
Living alone		53(73.6)
Health and function		
Diagnosis of diabetes		67 (94.4)
BMI	34.0 (8.0)	
Normal (BMI ≤ 25)		8 (11.1)
Overweight (25 < BMI < 30)		13 (18.1)
Obese (BMI ≥ 30)		51 (70.8)
Number of comorbidities (range, 0–11)	5.5 (2.6)	
Number of medication (range, 0–23)	8.5 (5.2)	
ADL disability score (range, 0–21)	9.1 (6.4)	
IADL disability score (range, 0–24)	11.0 (5.6)	
Falls in previous 6 months		
0		22 (30.6)
1		37 (51.4)
2 or more		13 (18.0)
Assistive device use		
None		26 (36.1)
Cane		29 (40.3)
Walker		15 (20.8)
Crutches		0 (0.0)
No response		2 (2.8)

Abbreviations: ADL, activities of daily living; BMI, body mass index; IADL, instrumental activities of daily living.

Exercise-Related Belief Measures

Exercise outcomes expectation was measured using a single question from the Outcomes Expectation for Exercise scale.[20] Participants rated their level of agreement (0 *strongly disagree* to 10 *strongly agree*) to the question "Do you believe that exercising regularly is beneficial to your health?" Exercise self-efficacy was measured using a modified version of the Self-Rated Abilities for Health Practices questionnaire.[21] The exercise scale consists of 7 questions in which subjects score their level of confidence in exercise-related behaviors from 0 (*not at all confident*) to 4 (*completely confident*). Total scores range from 0 to 28 (higher score reflects a greater level of exercise-related self-efficacy). The Cronbach alpha coefficient for the exercise subscale was .87 in a previous study.[22]

Table 2 summarizes participant performance on outcome tests and measures before beginning the 6-week exercise program.

Physical Therapy Diagnosis and Plan of Care

Three indicators were used to determine a diagnosis of frailty[2] including (1) reduced strength (defined as scoring below normal limits on the Chair Stand portion of the Functional Fitness Test), (2) reduced speed or slowness (defined as scoring below age and gender-based norms on gait velocity), and (3) low activity level (defined as a score < 4 on the PACE). On the basis of these criteria, all participants had a diagnosis of frailty, with 85% (61/72) of participants classified as fully frail (eg, having all 3 indicators), and 15% (11/72) as having intermediate frailty (eg, having 1 or 2 indicators).

The goals for physical therapy for all participants included (1) to be independent and safe in the performance of a home exercise program, (2) to improve the quality and safety of ambulation as indicated by an improvement in gait velocity and the time to complete the TUG test, and (3) to improve lower extremity strength in order to increase independence and safety with transfers, indicated by an improvement in the repeated Chair Stand test. Additional individualized goals were determined by each participant working in collaboration with the student physical therapists.

Intervention

Project HomeStretch is a multidimensional 6-week home-based exercise program that includes progressive strength training, balance, and gait activities, flexibility, exercises, and cardiovascular/aerobic exercises. The program is professionally supervised by graduate students in physical therapy, as part of a service learning project in a graduate course in geriatrics. Behavioral support is an integral part of the Project HomeStretch and includes written and verbal information regarding the importance and benefits of exercise, participant goal-setting and planning, identification of participant concerns and barriers, and active problem solving to overcome barriers. Exercise adherence is monitored via exercise logs completed by each participant and discussed with physical therapy on a weekly basis.

After receiving medical clearance to participate by their primary healthcare practitioner, participants were contacted by graduate physical therapy students to schedule the initial home visit. The students received a 4-hour orientation to Project HomeStretch including training in evaluation (physical performance testing and psychosocial questionnaires), intervention procedures including exercises, and

Table 2. Comparison of Baseline and Postprogram Measures of Function Following Participation in a 6-Week Home-Based Exercise Program

Outcome Measure	n[a]	Baseline	Posttest	Change	P[b]
Measures of physical function					
Number of biceps curl in 30s					
Mean (SD)	68	8.2 (4.0)	11.1 (4.4)	2.9 (3.1)	<.001
Median (range)		8.5 (0, 16)	10.0 (4, 30)	3.0 (−4, 17)	
Number of chair stands in 30s					
Mean (SD)	71	4.1 (3.8)	6.6 (4.4)	2.4 (2.9)	<.001
Median (range)		4.0 (0, 16)	7.0 (0, 20)	2.0 (−5, 10)	
Gait velocity, m/s					
Mean (SD)	62	.52 (.24)	.69 (.26)	.17 (.11)	<.001
Median (range)		(.10, 1.30)	(.20, 1.30)	(−.23,.58)	
Timed Up and Go, s					
Mean (SD)	48	22.1 (16.2)	16.3 (11.6)	−5.7 (7.6)	<.001
Median (range)		(3, 72)	(4, 81)	(−36, 1.3)	
Exercise-related beliefs					
Self-efficacy					
Mean (SD)	68	16.5 (5.3)	23.1 (4.5)	6.6 (4.3)	<.001
Median (range)		16.0 (3, 27)	24.0 (3, 28)	6.0 (−11, 16)	
Outcomes expectation					
Mean (SD)	67	6.2 (3.5)	9.2 (1.5)	2.9 (3.0)	<.001
Median (range)		6.0 (0, 10)	10.0 (2, 10)	3.0 (−1, 10)	

[a] Not all subjects were measured at baseline and postprogram.
[b] *P* for the paired *t* test between baseline and postprogram.

behavioral support materials. Following the initial evaluation, participants received a Project HomeStretch notebook, which contained information about the program, educational materials on the benefits of exercise, the importance of stretching, strengthening, and cardiovascular or aerobic activities, red flags to exercise (medical contraindications to exercise), an exercise log (to measure program adherence), and the exercises that would be included as part of their home program. On the basis of the results of their initial evaluation, each participant was instructed in an individualized home exercise program, including progressive resistive strength training (2 times per week for 15 to 20 minutes), balance and gait training (3 times per week for 15 to 20 minutes), and endurance activity (3 times per week for up to 30 minutes).

Project HomeStretch participants were seen once a week for 1-hour session over a 6-week period. The client's response to exercise (eg, blood pressure, heart rate, and respiratory rate) was monitored before and following each exercise session. The Borg scale was used to determine perceived level of exertion during the exercise sessions.[23] Weekly exercise sessions consisted of approximately 15 minutes of progressive strength training, 15 minutes of gait and balance training, and 20 minutes of cardiovascular exercise. Each session also included a review of the previous week's exercise logs, discussion of identified barriers to exercise, goal-setting, and a review and progression of their home exercise program based on continual reassessments.

After 6 weeks, participants were reevaluated and their discharge home program was reviewed.

PROGRAM OUTCOMES

Safety

The 6-week home-based exercise program was safe with only 1 adverse event reported. The adverse event was a significant (60 point) drop in blood glucose with associated symptoms of faintness and disorientation in a participant with type 2 diabetes. The session was discontinued, the participant was given food and juice, and the client's physician was notified. A number of participants reported transient postexercise symptoms including muscle soreness, joint pain, and fatigue.

Adherence

The mean number of sessions attended was 5 (range, 3–6); 59% of participants completed all sessions, 29% missed 1, and 12% missed 2 visits. Forty-three percent of participants in 2007, 54% in 2006, and 27% in 2005 were rated as being fully adherent to their prescribed home exercise program. Health reasons were given as the primary reason for both reduced adherence to exercise prescription (58%) and cancellation of visits (58%). Other reasons cited included falls, family issues, and scheduling conflicts.

Changes in Function Associated With Exercise

A number of participants were unable to perform the tests of physical function at baseline; however, following participation in the 6-week exercise program, they were able to complete testing. Twenty-one participants (29.2% of the total number of participants) were unable to complete the chair stand test at baseline; 13 of these (61.9%) were able to perform this test at discharge. Eleven participants (15.3% of the total number of participants) were initially unable to perform the TUG test, whereas 3 (27.2%) improved enough to be able to perform the test at discharge.

Among participants able to complete physical function measures at both baseline and posttesting, participation in a 6-week home-based exercise was associated with improvement in all measures of physical function. Table 2 shows the baseline and postprogram performance (mean, standard deviation, median, and range) and change for all outcome measures. On average, there was a 35% increase in the number of biceps curls and a 59% increase in the number of chair stands performed at discharge. Gait velocity improved on average by 33%, whereas TUG scores improved on average by 26%.

In addition, participation was associated with improvements in measures of exercise-related self-efficacy and outcomes expectation, with a 7-point (40.0%) improvement on average in the self-efficacy scale and a 3-point (46.7%) improvement on the outcomes expectation measure.

Association Between Changes in Psychological and Physical Function

To examine the association between change in exercise-related beliefs and physical function, we correlated change in performance on the 4 measures of physical function with baseline and absolute change in outcomes expectation and exercise self-efficacy. Table 3 presents the Pearson product-moment coefficient of correlation (r) between self-reported outcomes expectation and exercise self-efficacy (baseline and change) and change in the 4 measures of physical function. In general, there was little association between outcomes expectation or self-efficacy (baseline or change) and change in measures of physical function, with 3 exceptions. There was a significant association between change in self-efficacy and change in biceps curl and gait velocity, and baseline outcomes expectation was associated with change in performance on the TUG.

DISCUSSION

This study demonstrated that a professionally supervised 6-week, multidimensional home-based exercise program consisting of progressive strength training, balance and gait training, and cardiovascular or aerobic activities was safe and associated with an improvement in physical function, including upper and lower extremity strength and mobility, as indicated by improvements in both gait velocity and the TUG.

These results are consistent with findings from a recent systematic review of 20 randomized control exercise trials with frail older adults, which found that most exercise programs were effective in improving at least 1 outcome measure in frail elders.[24] However, the authors note that 6 of 20 studies reported no statistically significant improvement in physical function following exercise, and 5 of these studies were performed on highly frail groups. The authors concluded that the degree of frailty may moderate the effectiveness of exercise. For example, Gill et al[7] reported that following participation in a home-based exercise program, older adults with intermediate frailty improved physical function more than those classified as fully frail. Similarly, a randomized clinical trial by Faber and colleagues[6] found that a moderate-intensity group exercise program reduced fall risk in elders classified with intermediate frailty more than those classified as frail.

There are several possible explanations for varying results across studies related to exercise and frailty. Populations recruited may not be comparable across studies in part because of differences in the criteria used to classify elders as intermediate versus fully frail. For example, many studies use the 5 criteria developed by Fried et al,[2] which

Table 3. Pearson Correlation Between Changes in Physical Outcome Measures and Exercise-Related Belief Measures

	Postbaseline Change in			
	Number of Chair Stands	Number of Biceps Curl	Time for Timed Up and Go	Gait Velocity
Self-efficacy				
Baseline	0.06	−0.15	0.09	−0.05
Change (Postbaseline)	−0.07	0.24[a]	0.07	0.29[a]
Outcomes expectation				
Baseline	0.07	0.03	0.26[a]	0.06
Change (Postbaseline)	0.00	−0.06	−0.26	−0.01

[a] Correlation significant at .05 level (2-tailed).

include a significant weight loss to determine degree of frailty. However, a number of authors have suggested an association between frailty and obesity.[25,26] A high percentage of participants in our study were obese and thus did not completely fit Fried's definition.

Differences in age of study participants also make comparisons difficult. Many of the previous studies[11,26] were performed with people aged 70 years or older. Others looked at those who were aged 75 years or older, with an average age of 80 years.[6,7,27,28] The study by Fiatarone et al[10] focused on strength training in adults 85 years and older living in nursing homes. Although the mean age of participants in our study was 71 years, the range of ages was much broader than that in many of the studies (54 to 95 years).

Differences across studies may also be attributed to variations in the type, intensity, and duration of exercise, and the level of supervision provided. Our study used a moderate-intensity, multidimensional exercise program, carried out in the home, and supervised by professionals. The program intensity was individualized to the baseline function of each participant and was progressed weekly on the basis of changes in performance. This approach of matching the intensity of the program to the changing needs of the individual may have been a critical factor in improving function in both intermediate and fully frail participants. A randomized control trial by Binder et al[28] found that a center-based formal group exercise training sessions were more effective than a low-intensity home-based exercise program. The center-based, 9-month high-intensity program initially focused on 22 exercises that worked on flexibility, balance, coordination, and speed or reaction, with some strength components. Progressive resistance training was introduced in the second phase and cardiovascular activities, such as treadmills, stationary bicycles, rowing machines. Their home-based control group received 1 hour of training in a program focused primarily on flexibility incorporating 9 of the 22 exercises that the exercise-training group received.

Brown et al[8] examined the effects of low-intensity supervised community-based program with an unsupervised home-based flexibility exercises. Their low-intensity program was similar to ours: progressive, increasing the challenge of the 22 exercises as the participant improved. However, their supervised program was 3 times per week. Their home-based group differed from ours as the participants performed range-of-motion exercises only and had the opportunity to receive supervision 1 time per month but at the exercise site. In our study, we found that receiving exercise supervision in the home 1 time per week, 1 hour each session, was associated with functional improvements. Their findings were similar and support that those with some degree of frailty can demonstrate increases in strength, balance, and flexibility. It also suggested that improvements in these areas carry over into functional capabilities.

These studies suggest that multidimensional exercises are needed to improve function. In addition, supervised home-based exercise programs are safe and often preferred by older adults to the alternative of center-based exercise programs.[12] Finally, among frail elders, low-intensity exercise training is as effective as high-intensity training and has better adherence.[12] However, despite the growing research in this field, many questions about the relationship between frailty and exercise remain.

This cohort study demonstrated that participation in a supervised home-based exercise program was associated with significant improvements in exercise beliefs, including exercise self-efficacy and outcomes expectation. Participation in physical activity was found to improve satisfaction with physical function and self-efficacy for performing a 400-m walk in older adults.[29] Bean et al[30] found low self-efficacy and readiness to exercise among low-income community-dwelling elders with poor physical function; however, despite these barriers, interest in participating in a home-based or class-based exercise program remained high. Ewart et al[15] found that baseline self-efficacy was highly predictive of the ability to benefit from specific exercise behaviors in men with coronary artery disease. Our study found no correlation between baseline exercise self-efficacy and change in physical function following exercise. Thus, in contrast to Ewart's findings, baseline self-efficacy in this group of frail elders was not predictive of outcome. However, in our study, both self-efficacy and outcomes expectation were targeted through behavioral interventions and improved significantly following 6 weeks.

Future Directions

Future studies should include a randomized control trial to examine the effect and benefits of a multidimensional program on frail older adults, including a comparison of the benefits of exercise in intermediate versus fully frail elders. This may yield more information on the types, method, and dose of exercise that are most beneficial to each of these groups. Future studies should also follow the participants for a longer period of time to determine factors that influence adherence to this type of exercise program and how adherence impacts physical and psychological outcomes. Finally, as the older adult population continues to grow, future research should explore different models of care delivery, which may be most cost-effective as healthcare costs continue to increase.

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