SYSTEMATIC REVIEW

Effect of Exercise on Physical Function, Daily Living Activities, and Quality of Life in the Frail Older Adults: A Meta-Analysis

Chih-Hsuan Chou, BSc, Chueh-Lung Hwang, MS, Ying-Tai Wu, PhD


Objectives: To determine the effect of exercise on the physical function, activities of daily living (ADLs), and quality of life (QOL) of the frail older adults.

Data Sources: Relevant articles published between 2001 and June 2010 were searched in PubMed, MEDLINE, EMBASE, the Chinese Electronic Periodical Service, CINAHL, and the Cochrane Library databases.

Study Selection: The participants were selected based on the predefined frailty criteria and randomly assigned to either an exercise or control group. The intervention for the exercise group was a single- or comprehensive exercise training program, whereas usual care was provided to the control group.

Data Extraction: The characteristics and outcome measures of the included studies were identified independently by 2 investigators.

Data Synthesis: The effect sizes of physical function assessed by the timed up and go test, gait speed, the Berg Balance Scale (BBS), the ADL questionnaires, and QOL measured by the Medical Outcomes Study 36-Item Short-Form Health Survey were calculated, using a weighted mean difference (WMD) and a 95% confidence interval (CI) to represent the results. Compared with the control group, the exercise group increased their gait speed by 0.07m/s (95% CI 0.02–1.11), increased their BBS score (WMD=1.69; 95% CI 0.56–2.82), and improved their performance in ADLs (WMD=5.33; 95% CI 1.01–9.64). The exercise intervention had no significant effects on the Timed Up & Go test performance and the QOL between the groups.

Conclusions: Exercise is beneficial to increase gait speed, improve balance, and improve performance in ADLs in the frail older adults.

Key Words: Activities of daily living; Exercise; Frail older adults; Rehabilitation.

C⃝ 2012 by the American Congress of Rehabilitation Medicine

Health issues of older people have recently been emphasized owing to the rapid aging of society. Limited exercise capacity, reduced vital capacity, poor muscular strength, restricted flexibility, decreased bone mass, and glucose intolerance manifest during the aging process.1 These physiologic changes lead to loss of physical function and dependence on assistance in performing activities of daily living (ADLs), requiring hospitalization or extended hospital stays and reducing longevity.2,3 This transitional state is called frailty and may negatively impact physical, psychological, and social functions. The complex interactions between the dimensions of frailty cause poor quality of life (QOL). Fried et al.4 focusing on frailty phenotype, identified involuntary weight or muscle strength loss, weakness, decreased endurance, low physical activity, and reduced physical performance, such as a decrease in gait speed, as features of frailty. There are other assessment tools for frailty, such as the Edmonton Frail Scale (EFS) and the screening criteria developed by Speechley and Tinetti to classify frailty and vigorosity. The EFS uses 8 domains to evaluate frailty and is a short but feasible instrument that can be used by nongeriatric specialists,5 whereas Speechley and Tinetti’s screening criteria included physical and psychological functions and the use of medication.6

Exercise is a key intervention for improving physical function in older adults. The American College of Sports Medicine recommends aerobic, muscle strengthening, and flexibility exercises for older people.1 Moreover, additional exercises to improve, specifically, balance, agility, and proprioception were recommended to frequent fallers or those with mobility problems.7 Exercise slows down the physiologic changes associated with aging, promotes cognitive health, and complements the management of chronic disease in the older adults.1,8 Exercise is beneficial in improving physical functions, such as sit-to-stand performance, balance, agility, and ambulation in the older adults.9,10 Overall, exercise can not only reduce fall rate but also slow down deterioration in the ability to perform ADLs and maintain QOL. Exercise was once considered relatively dangerous for the frail older adults because it renders them vulnerable to injuries.11,12 However, the safety and positive effects of exercise that were observed turned the issue around. Functional capacity, cardiovascular fitness, and performance in ADLs were reported to improve as a result of regularly performing various types of exercise, for example, aerobic, resistance, endurance, balance, flexibility, task-oriented,
and/or goal-setting exercises with or without nutritional and/or pharmacologic intervention.\textsuperscript{9,13,14} Results of the Frailty and Injuries: Cooperative Studies of Intervention Techniques trials demonstrated the positive effects of exercise on fall prevention in older adults persons independently living in a community setting in the 1990s.\textsuperscript{15-18} Nevertheless, the effects of exercise on frail older adults persons were still inconsistent.\textsuperscript{11,19} The abovementioned studies were typically limited by a small sample size or heterogeneous subjects. A systematic search of literature published between January 1995 and August 2007 was undertaken, and a systematic review was conducted. It was found that the effects of exercise training programs on the frail older adults were quite diverse. In the recently published review of literature, the authors concluded that the frail older adults should exercise regularly to improve performance in physical functions.\textsuperscript{14} Thus, our study aimed to determine the effects of exercise training on frail older adults subjects, specifically on physical functions, performance in ADLs, and QOL, through a systematic review of literature and a meta-analysis.

METHODS

Search Strategy and Identification of Trials

The studies included in the literature review were identified from 6 electronic databases, namely, PubMed, MEDLINE, EMBASE, Chinese Electronic Periodical Service, CINAHL, and the Cochrane Library Register of Controlled Trials. Studies published between 2001 and June 2010 were included. We adopted in our search the operational definition of frailty by Fried,\textsuperscript{4} Rolfson,\textsuperscript{5} and Speechley\textsuperscript{6} and colleagues. The following keywords and Medical Subject Headings were used in the search: (frail older adults, frailty, or frail older adult) and (physical activity, exercise training, exercise therapy, or exercise). The search results were also limited to randomized controlled trials, human subjects, and either English or Chinese language. One author (C.H.C.) performed the search and forwarded the results from each electronic database to a centralized data bank to ensure no redundant trials. Two authors independently evaluated the title and the abstract of each trial in the databank and excluded irrelevant trials. Then, a full-text review and a methodologic appraisal were performed. In the event of disagreement, a discussion that involved the third reviewer (Y.T.W.) was conducted. The authors of the included studies were contacted via e-mail when there was a need to clarify information or request for missing data.

Study Selection

The studies included met the following criteria.

**Participants.** The frailty criteria used for participant selection were adapted from the Fried Frailty Index,\textsuperscript{4} Speechley and Tinetti’s criteria,\textsuperscript{8} and the EFS,\textsuperscript{7} including decreased strength, poor endurance, low physical activity level, weight loss, slow gait speed, depressed mood, sedentary lifestyle, dependence on assistance in performing physical activities or ADLs, fall rate, and poor nutritional status. The characteristics of the participant in the included trial matched with at least 1 of the abovementioned descriptions in the inclusion criteria for frailty.

**Intervention.** The intervention group participated in an exercise-training program with single or multiple components, whereas the control group received usual care with no intervention but with sham or light-intensity exercises. The intensity, duration, frequency, type, and length of exercise in each trial were recorded.

**Outcome measures.** We included studies reporting outcome measures including physical function assessed by the Timed Up & Go (TUG) test, gait speed, or Berg Balance Scale (BBS), performance in ADLs evaluated by the validated questionnaire or reliability inventory, and QOL evaluated by the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36). The TUG test and gait speed are commonly used to assess functional mobility in the frail older adults, and the BBS is used as an assessment tool for risk of falling in the frail older adults.\textsuperscript{20,22} The SF-36 is a widely used tool to evaluate QOL.\textsuperscript{22} The QOL scores are reported in 2 parts to represent the physical and mental health components of QOL.

**Methodologic quality assessment.** Each study was critically appraised by 2 reviewers (C.H.C. and C.L.C.) for methodologic quality by using the Physiotherapy Evidence Database (PEDro) scale (0–10).\textsuperscript{23-24} Higher PEDro scores indicated better quality, and trials with scores lower than 4 were excluded.

Data Extraction and Analysis

The meta-analysis was performed using the Review Manager software (version 5.0).\textsuperscript{6} For the postintervention sample size, the mean ± SD scores for each outcome measure in the exercise and control groups were calculated and analyzed. Differences of the mean ± SD scores between the baseline scores and after the intervention were calculated and analyzed by subgroups if postintervention data were inaccessible. The raw scores obtained from the different ADL questionnaires were converted to standard scores by using the equation: [real score/total score × 100%] and further converted using the equation [(1 – real score/total score) × 100%], while lower scores indicated better outcomes in the original scale. A higher score indicated a better performance in ADLs. If there were more than 1 intervention groups in a study, pooled mean ± SD scores were used. The effect sizes for each evidence database (PEDro) scale (0–10) were calculated based on between-group differences and expressed as a weighted mean difference (WMD) with a 95% confidence interval (CI). A chi-square test was performed, and a random effects model was adopted in case of significant heterogeneity; otherwise, the fixed effects model was applied.

RESULTS

The searches in the electronic databases were performed on June 1, 2010. We retrieved 146 trials, 15 of which were identified after evaluating titles, abstracts, and full texts. Two studies were excluded owing to overlapped participant groups.\textsuperscript{25,26} Moreover, 5 trials were excluded, 2 for having incomplete data (1 without raw mean and SD\textsuperscript{27} and the other without total score of assessment\textsuperscript{28}) and 3 for having PEDro scores lower than 4.\textsuperscript{29-31} A total of 8 trials were included in our meta-analysis (fig 1).\textsuperscript{9,11,26,32-36}

Characteristics of Included Studies

**Participants.** The trials involved 1068 participants with ages ranging from 75.3 to 86.8 years (table 1). Most of the participants were women; however, 1 trial did not report the sex distribution.\textsuperscript{36} The participants were recruited from hospitals,\textsuperscript{11,33,34} residential care facilities,\textsuperscript{35,37} day-care services,\textsuperscript{32} and communities.\textsuperscript{32} The identification of frail older adults persons in these trials was based on our predetermined inclusion criteria for frailty including dependence on assistance in performing ADLs or instrumental ADLs,\textsuperscript{9,11,32,35,36} difficulty in mobility,\textsuperscript{34} report of a recent fall,\textsuperscript{11,33} modified physical performance test score between 18 and 32, peak oxygen uptake between 10 and 18mL/kg per minute,\textsuperscript{32} reduced ambulation...
function, impaired balance, poor muscle strength, or disability in the lower extremities.  

**Interventions.** The various exercise programs identified include flexibility, low- or intensive-resistance, aerobic, coordination, balance, and Tai-Chi exercises; repetitive performance of ADLs; and task-oriented or gait training. Each exercise program generally involved 60- to 90-minute sessions, repeated daily or weekly for 3 to 12 months. The participants under supervision either exercised in facilities or in communities, or underwent home-based exercise training.  

**Methodologic quality.** The PEDro scale score of the included trials ranged from 4 to 8, with a mean of 6.1. None of the trials involved blinded participants or therapists, and the dropout rate in 3 of the 8 trials exceeded 15% (table 2).

### Effect of Exercise in Frailty

**Physical function.** Six trials were used and analyzed using the random model for TUG and the fixed model for gait speed and BBS.  

1. **TUG test:** 3 trials involving 400 participants provided the postintervention data for the TUG test.  

   There was no difference between the performance of the exercise and control groups in the TUG test (WMD = -1.11 s; 95% CI, -2.98 to 2.75; P = .94) (fig 2a).  

2. **Gait speed:** the effect of exercise on gait speed was evaluated with 4 trials involving 459 participants. The exercise group displayed a significant increase in gait speed of 0.07 m/s compared with the control group (95% CI, .02 - .11; P = .005) (fig 2b).  

3. **BBS:** BBS was used in 4 trials except in 1 that had incomplete postintervention data. A total of 3 trials involving 356 participants provided the postintervention data. The exercise group exhibited a significant improvement in a BBS score of 1.7 compared with the control group (95% CI, 0.6 - 2.8; P = .003) (fig 2c).

**Activities of daily living.** The effect of exercise on the performance in ADLs in the frail older adults was evaluated in 3 trials. Two sets of postintervention data with 2 exercise groups were combined. Three ADL questionnaires were used, the Barthel Index (BI), the FIM, and the physical function subscale of the Functional Status Questionnaire (FSQ). After the intervention, the exercise group exhibited significantly superior performance in ADLs compared with the control group (WMD = 5.33; 95% CI, 1.01 - 9.64; P = .02) (fig 3).

**Quality of life.** Two trials investigated on the effect of exercise on the physical and mental health component scales of QOL, whereas 1 trial focused solely on the physical component. One trial comprised 2 pairs of comparisons between the exercise and control groups, resulting in 1 additional set of data being added to the analysis. Insignificant effects of exercise training on the physical component scale were observed from the data of 409 participants (WMD = -.18; 95% CI, 1.46 - 1.11; P = .79) and a favorable trend in the mental health component score was observed based on data of 187 participants (WMD = 7.98; 95% CI, -8.53 to 24.49; P = .34).

### DISCUSSION

The meta-analysis performed provided evidence of the effects of exercise on the physical function, the performance in ADLs, and the QOL of the frail older adults. Exercise demon-
<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Interventions</th>
<th>Outcome Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peri et al&lt;sup&gt;9&lt;/sup&gt;</td>
<td>Ex, n=73 (11 men, aged 86.8y); Con, n=76 (12 men, aged 84.7y)</td>
<td>Exp = repetitive ADLs (include bed mobility, sit-to-stand, transfer to various surface and height, individual goal setting) and 14 PT visits in the first 2mo; Con = usual care (consult individual goal setting)</td>
<td>- Elderly Mobility Scale &lt;br&gt; - Observed function incorporating common activities &lt;br&gt; - TUG test &lt;br&gt; - SF-36 (physical component scale, mental health component scale)</td>
</tr>
<tr>
<td>Sato et al&lt;sup&gt;36&lt;/sup&gt;</td>
<td>Ex group A, n=10 (aged 79.2y); Ex group B, n=12 (aged 75.3y); Con, n=8 (aged 77.6y)</td>
<td>Exp = 10min flexibility exercise on land and 50min of exercise in water (walking, ADLs exercise, strengthening, stretching) 1d/wk (Exp group A) or 2d/wk (Exp group B) x 24wk; Con = usual care</td>
<td>- FIM &lt;br&gt; - SF-36 (physical component scale, mental health component scale)</td>
</tr>
<tr>
<td>Rosendahl et al&lt;sup&gt;35&lt;/sup&gt;</td>
<td>Ex, n=45 (14 men, aged 85.5y); Con n=50 (13 men, aged 85.6y)</td>
<td>Exp = individualized weight bearing strengthening 8–12RM, balance exercise, and task-oriented exercise daily for 3mo; Con = placebo exercise 6mo follow-up</td>
<td>- BBS &lt;br&gt; - Gait speed &lt;br&gt; - Strength (1RM, lower limb) &lt;br&gt; - Modified sit-to-stand</td>
</tr>
<tr>
<td>Wolf et al&lt;sup&gt;26&lt;/sup&gt;</td>
<td>Ex, n=158 (10 men, aged 81.0y); Con, n=153 (10 men, aged 80.8y)</td>
<td>Exp = Tai Chi (6 form) x 60min/d x 2 d/wk x 48wk; Con = controlled exercise, fall prevention exercise, and education 60min/wk x 48wk</td>
<td>- Gait speed &lt;br&gt; - Body mass index &lt;br&gt; - Blood pressure &lt;br&gt; - Heart rate &lt;br&gt; - Sit-to-stand &lt;br&gt; - Forward reaching</td>
</tr>
<tr>
<td>Hauer et al&lt;sup&gt;33&lt;/sup&gt;</td>
<td>Ex, n=31 (0 men, aged 83.3y); Con, n=26 (0 men, aged 80.3y)</td>
<td>Exp = ambulatory resistance, functional and balance training x 3d/wk x 12wk; Con = placebo exercise (flexibility exercise) x 3d/wk x 12wk</td>
<td>- BI &lt;br&gt; - TUG test &lt;br&gt; - Gait speed &lt;br&gt; - Instrumental ADLs &lt;br&gt; - Sit-to-stand &lt;br&gt; - Stair climb &lt;br&gt; - Performance Oriented Mobility Assessment-Geriatric Depression Scale &lt;br&gt; - Philadelphia Geriatric Center Morale Scale &lt;br&gt; - Falls Handicap Inventory</td>
</tr>
<tr>
<td>Latham et al&lt;sup&gt;11&lt;/sup&gt;</td>
<td>Ex, n=120 (54 men, aged 80.0y); Con, n=123 (80 men, aged 78.0y) (inpatient teaching and home visit)</td>
<td>Exp = resistance exercise, 60%–80% 1RM (knee extension) x 8 repetition/set x 2set/d x 3d/wk x 10wk; Con = exercise control with home visit (no exercise intervention)</td>
<td>- SF-36 (physical component scale) &lt;br&gt; - Health-related QOL &lt;br&gt; - TUG test &lt;br&gt; - BBS &lt;br&gt; - Fall rate</td>
</tr>
<tr>
<td>Binder et al&lt;sup&gt;32&lt;/sup&gt;</td>
<td>Ex, n=66 (25 men, aged 83.0y); Con, n=49 (23 men, aged 83.0y)</td>
<td>Exp = Phase 1: flexibility, balance, coordination, speed of reaction exercise; Phase 2: resistance exercise 65% 1 RM x 6–8repetition/set to 85%–100% 1RM x 12repetition; Phase 3: 65%–70% of VO&lt;sub&gt;2&lt;/sub&gt;peak x 15–20min, 85%–90% of VO&lt;sub&gt;2&lt;/sub&gt;peak x 3–5min, maximum of 30min for 3mo; Con = controlled home-based exercise, 3d/wk x 3mo</td>
<td>- Modified Physical Performance Test &lt;br&gt; - VO&lt;sub&gt;2&lt;/sub&gt;peak &lt;br&gt; - FSQ &lt;br&gt; - Strength &lt;br&gt; - BBS &lt;br&gt; - Older American resources and services</td>
</tr>
<tr>
<td>Timonen et al&lt;sup&gt;34&lt;/sup&gt;</td>
<td>Ex, n=34 (0 men, aged 76.1y); Con, n=34 (0 men, aged 78.7y)</td>
<td>Exp = low resistance training (20–30repetition), functional exercise, 90min/d x 2d/wk x 10wk; Con = usual care</td>
<td>- Gait speed &lt;br&gt; - Strength &lt;br&gt; - BBS</td>
</tr>
</tbody>
</table>

Abbreviations: Con, control group; Ex, exercise group; Exp, experimental group; MMSE, Mini-Mental Status Examination; PT, physical therapist; RM, repetition maximum; VO<sub>2</sub>peak, peak oxygen consumption.
It is of great importance that this study found that exercise positively influenced performance in ADLs in frail older adults. The improvement in ADLs might be associated with exercise type. Most of the included trials involving ADLs, either task-oriented or functional practice, were associated with findings that exercise is significantly beneficial. Researchers observed that the outcome of task-oriented ADLs training with repetitive practice could motivate subjects and recommended that it should be performed often. After frail older persons underwent individualized high-intensity training program under supervision, Binder et al observed an improvement in the baseline performance in ADLs within 6 to 9 months in the included trials. In the meta-analysis, 3 different tools (BI, FIM, and FSQ) were used in these trials, ambulation being the common feature. Previous studies are in concordance that because of the consistent increase in gait speed, improvements in performance in ADLs might be associated with increased physical function.

The present review found that exercise training did not have a statistically significant impact on QOL in frail older adults. However, previous studies reported that improvements in physical function and performance in ADLs resulting from exercise might stimulate individuals to engage in activity or social participation and improve mental health-related QOL. The reasons for the lack of improvement in the physical component scale of SF-36 are unclear, but the low level of frequency or intensity of the exercise performed may be 1 of the contributing factors.

No major exercise-related adverse events were reported in the included trials, and the exercise adherence rates ranged from 72% to 95%, with no difference among the home-based, day-care service, and residential care facility-based programs. The reasons some of the participants dropped out or discontinued the program included: being lost to follow-up, injury, hospitalization, and death, but none of which were reported as related to the exercise training. However, safety of exercise in the frail older adults should never be overlooked. Risks for adverse events may increase with high-intensity or home-based exercise. The findings of our meta-analysis, which involved various types of exercise interventions, demonstrated beneficial

<table>
<thead>
<tr>
<th>Study</th>
<th>Random Allocation</th>
<th>Concealed Allocation</th>
<th>Groups Similar at Baseline</th>
<th>Participants Blinding</th>
<th>Therapist Blinding</th>
<th>Assessor Blinding</th>
<th>Between-Group Difference</th>
<th>Intention-to-Treat Analysis</th>
<th>PEDro Score (0–10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peri et al</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>7</td>
</tr>
<tr>
<td>Sato et al</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>6</td>
</tr>
<tr>
<td>Rosendahl et al</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>8</td>
</tr>
<tr>
<td>Wolf et al</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>7</td>
</tr>
<tr>
<td>Hauer et al</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>5</td>
</tr>
<tr>
<td>Latham et al</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>5</td>
</tr>
<tr>
<td>Binder et al</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>4</td>
</tr>
<tr>
<td>Timonen et al</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>6</td>
</tr>
</tbody>
</table>

Abbreviations: N, no, do not meet the criteria; Y, yes, meet the criteria.
effects of exercise on the frail older adults. However, the most appropriate exercise program for this population is yet to be determined. Establishing the progression of exercise training and the long-term exercise behavior in the frail older adults is needed.

Study Limitations

There were several limitations in this meta-analysis. First, the descriptions of the subjects or the interventions in some of the trials were incomplete. Our meta-analysis was confined to

Arch Phys Med Rehabil Vol 93, February 2012
the physical component of frailty, with age as the common criterion in the included trials. However, frailty may result from chronic disease and can involve nonphysical dimensions. The findings of our meta-analysis might be limited in generalization because of the potential bias associated with various definitions of frailty. Gobbens et al. reviewed the literature and proposed that frailty should be defined based on multiple domains of functioning. Further work should include the identification of severity, adverse outcome predictions, and the exclusion of disease, comorbidities, or disabilities. Second, the included trials contained very limited information on the follow-up results. Because treatment may take longer to take effect in the frail older adults, the real benefits may not be demonstrated. The difficulty in blinding the participant and the therapist might lower the methodologic quality and lead to insignificant findings. The study design possibly succeeded in concealing the allocation of the intervention or blinding the outcome assessor and should be seriously considered. Third, these trials used had diverse outcome measures, which were individually analyzed based on a limited number of trials. Further prospective controlled trials are required and must be of a higher quality and larger scale.

CONCLUSIONS

To summarize, the exercise intervention only slightly affected physical function, mainly by increasing gait speed and BBS score and improving performance in ADLs. Notably, the participants in these trials may be unrepresentative of the total frail older adults population because of those who would have benefited from exercise but were excluded in the trial because of age or other comorbidities that prevented them from exercising. Furthermore, this review does not make clear recommendations regarding which type of exercise is most beneficial.

References


Arch Phys Med Rehabil Vol 93, February 2012


