Efficacy of Resistance and Task-Specific Exercise in Older Adults Who Modify Tasks of Everyday Life

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Background. The purpose of this study was to determine the efficacy of 10 weeks of resistance (RT), functional (FT), or functional plus resistance (FRT) training in older adults who modify tasks of everyday life and are at risk for subsequent disability.

Methods. Thirty-two older adults (75.8 ± 6.7 years) were tested following a control period and training. The primary outcome of the study was the number of task modifications and timed performance on eight tasks of daily life. Secondary outcomes included knee and elbow extension (extension and flexion), body composition, self-reported physical function, single-leg balance time, walking speed, and time to vacuum a carpet. The RT group performed progressive intensity training, and the FT group performed task-specific exercises 2 days per week. The FRT group performed 1 day of each training type.

Results. No changes occurred in the control period. All three training groups reduced the need to modify tasks of everyday life (RT: 21%, FRT: 26%, and FT: 28%) and improved self-rated function and time to vacuum a carpet. The RT group also reduced their timed performance (RT: 2.5%, FRT: 18.5%, and FT: 23%). Strength gains were primarily found in groups that performed RT either 1 or 2 days per week (RT and FRT). No significant changes occurred in walking speed, single-leg balance, or body composition.

Conclusion. The benefits of exercise are dependent on tasks performed during training. Exercise recommendations for low-functioning older adults should reflect task-specific exercise to prevent the onset of disability.

Theoretically, the effect of resistance training (RT) on muscle strength should help preserve functional reserve needed to perform daily activities (1,2). However, empirical studies suggest that the influence of RT on physical function produces equivocal results (3). By using RT to improve muscle strength, previous exercise interventions have only attended to one factor associated with functional limitation (4,5). Functional training (FT), which requires older adults to practice specific tasks, has shown recent success at improving function (6–9) as it incorporates task specificity and highlights the neural control of movement (10). FT has the capability of improving several factors responsible for functional limitation such as avoidance, endurance, strength, and balance. In contrast, a combination of RT and FT may accentuate optimal benefits.

Individuals who self-report modification of, or reduction in everyday tasks are at risk of subsequent disability even if they have not yet presented clinically with disability (11,12). Such individuals offer insight into a stage between functional limitation and disability and have been rarely studied. Exercise interventions for older adults who modify the way they perform tasks of everyday life may offer understanding into whether improvements can be made to factors associated with transition into disability.

This study aimed to determine the efficacy of RT, FT, or a combination of resistance and functional training (FRT) in older adults who modify tasks of everyday life. We hypothesized that training-related adaptations would be dependent on the specific training performed. A portion of these results along with neuromuscular steadiness adaptations are presented elsewhere (13).

Methods. Participants (n ∼ 300) were recruited from community senior centers. During phone interviews (n = 162), individuals self-reported their ability to rise from a chair or climb a flight of stairs. Those reporting “some” or “a lot” of difficulty in either task were invited for qualification testing (n = 86). Participants then completed a health history questionnaire as a risk assessment (14). Forty-three of the 86 participants invited to the laboratory needed to provide clearance from their physician for the following conditions: cardiovascular (not in the past year) (n = 26), musculoskeletal (n = 10), shortness of breath (not in the past year) (n = 4), diabetes (n = 2), balance problems (n = 1).

During initial laboratory testing, participants were asked to...
perform a chair rise (seat pan = 38 cm), stair ascent/descent tasks, and a maximal isometric knee extension strength test. Participants with a peak knee extension strength to body weight ratio, $3.00 \text{ Nm/kg}$ (1) (a threshold of strength needed to walk 1.22 m/s and climb a flight of stairs without assistive devices) and who modified either rising from a chair or climbing a flight of stairs (i.e., use of hands) qualified for the study. Syracuse University and SUNY Upstate Medical University Institutional Review Boards approved the study, and participants gave written informed consent.

**Experimental Design**

Figure 1 shows the flow of participants through the study. Participants were initially tested (precontrol) and asked to continue their normal daily activities for an 8- to 10-week control period. The control period eliminated the need for a separate control group and acted as a “lead in” time to ensure that participants would complete the intervention. Participants were tested again (postcontrol) and randomly assigned to intervention groups by unrestricted randomization using lot drawing. Because participants qualified at different time points, random assignment was done in a sequential manner. Following 10 weeks of training, participants reported for a final testing session (posttraining). All measurements were obtained at precontrol, postcontrol, and posttraining sessions.

**Task Modification and Timed Performance**

Task modification is an essential characteristic for identifying older adults who are on the verge of disablement. Task modification has previously been quantified using self-report (11,16), but we developed an objective semicontinuous scale that quantifies subtle ways in which individuals complete simple (chair rise) and demanding tasks (rise from the floor). The task modification scale is reliable (intraclass correlation coefficient [ICC] > 0.90) and compares well with measures of functional and muscular performance (17). More importantly, evaluating task modification adds an important descriptive component—how older adults overcome environmental demands and continue to function in society.

Task modification and timed performance were evaluated during eight tasks: chair rise (30 cm, 38 cm, and 43 cm seat heights), stair ascent, stair descent, laundry basket lift and...
carry, kneel rise, and supine to stand. With the exception of the laundry basket lift and carry (described below), the other tasks were previously described (17).

Laundry Basket Lift and Carry Test
Participants were asked to lift a weighted laundry basket from the floor, carry it 3 m, and place it on a shelf located at shoulder height. The weight in the basket was normalized at 10% body weight. Participants were scored as follows: 0 = lifts, carries, and places basket on top of shelf; 1 = able to lift top of basket above shelf height, but then requires assistance; 2 = unable to lift the top of the basket past shelf height; 3 = unable to lift basket above carrying height; 4 = unable to lift basket from the floor; 5 = refuses to attempt the task. The test–retest reliability over 2 months (ICC = 0.92, n = 40) and inter-rater reliability (κ = 0.93, n = 30) of the categorical scores were good.

As described previously (17), we created a reliable and valid modification score (MOD score) by summing modifications from seven tasks (chair [30-, 38-, and 43-cm heights], stair ascent and descent, rise from one knee and from a supine position) (range = 0–35). The test–retest reliability over 2 months (ICC = 0.92, n = 40) and inter-rater reliability (r = 0.98, n = 30) of the MOD score was good. For the current study, we added a measure of upper body function via the basket lift and carry task. The MOD score previously described was highly correlated (r = 0.99, n = 82) with the basket lift and carry task–adapted MOD score (range = 0–40).

Vacuuming
We also evaluated upper body function by quantifying the time to vacuum a carpet. Participants were asked to vacuum a 1.5 m × 1.5 m square carpet as fast as possible using an upright vacuum cleaner. The weight of the vacuum was normalized to 15% of body weight. The test–retest reliability of vacuum timed performance was good (ICC = 0.91, n = 35). No modifications could be identified for the vacuuming test and thus were not included with the MOD score.

All tasks were evaluated for timed performance. To directly compare timed performance and task modification, we summed the timed performance values for the same tasks evaluated for task modification. Some participants refused to perform the basket lift and carry, supine and kneel rise tasks, so imputations were made with group- and time-specific 90th percentile timed performance (Imputations at baseline: supine rise = 4, kneel rise = 3, lift and carry = 1; Imputations following training: supine rise = 4, kneel rise = 1, lift and carry = 1). Although imputation is controversial, this method had little impact on the results of this study.

Muscle Strength
An isokinetic dynamometer (Biodex Medical Systems, Shirley, NY) measured work performed during knee and elbow extension and flexion movements over a five repetition concentric protocol set at 60 degrees per second. There was no Side × Time interaction (p > .40), suggesting that the right and left sides changed similarly following training. Therefore, the work performed for the last three of five repetitions was averaged across right and left sides.

Body Composition, SF-12, Gait Speed, and Single-Leg Balance
Appendicular lean and fat mass were estimated using Dual-energy x-ray absorptiometry (DEXA) (Lunar DPX; GE Medical Systems, Waukesha, WI) (18,19). Several participants did not fit inside the scan table lines, thus only the right side was used for data analysis. This approach did not alter our findings, as there was no Side × Time interaction (p = .99). Lean and fat mass values were calculated from the arms and legs, and a ratio of lean to fat mass was created. We did not find a Body part (arm and leg) × Time interaction (p > .80), so we collapsed data across the arms and legs. Self-reported physical function was documented using the SF-12v2 survey (20). Gait speed measured over 7.62 m was measured during a usual and rapid pace. Single-leg balance was assessed while participants stood behind a chair, where they were asked to place their hands across their chest, lift their left leg, and stand for as long as possible. Participants who could stand for > 30 seconds (excellent balance) were asked to stop the test. The time recorded from two trials was summed.

Training
All participants reported to the training facility two times per week for 10 weeks. Each session lasted 30–45 minutes, and all protocols were developed for progressive intensity. An exercise physiologist supervised all training sessions.

Participants in the RT group performed three lower body exercises (leg press, leg extension, and leg curl) and three upper body exercises (sitting dip [tricep extension], arm curl, and shoulder press) (Life-Fitness Inc., Schiller Park, IL). A 10-repetition maximum was established on the first training session and repeated on the second training session. All training sessions began with one warm-up set using a light load and then two work sets. The load was increased when a participant was able to complete > 10 repetitions.

Participants in the FT group performed five exercises 2 days per week: rising from a chair, rising from a kneeling position, stair climbing, vacuuming a carpet with a weighted vacuum cleaner, and lifting and carrying a weighted laundry basket. Because many of the participants were unable to do these tasks without using modification, the intervention was centered on task form and intensity according to Table 1. Participants in the FRT group performed 1 day of resistance and 1 day of FT per week.

Statistical Analysis
Sample size calculations were estimated for significant changes in muscle strength and task modification. Forty-two participants (14 per group) were needed to detect a 25% improvement in muscle strength with a premeasure correlation of 0.70, power of 80%, α = 0.05, two-tailed, repeated-measures design, a standard deviation of 30% of the mean, and a 20% dropout rate. Forty-five (15 per group) participants were needed to detect a 20% reduction in task modification, analyzed with same criteria as muscle strength. Forty-nine older adults were recruited for the study.

We first tested whether there was an overall time main effect across precontrol, postcontrol, and posttraining testing.
sessions. A significant time main effect was followed by examining differences in the two control periods. As expected, we observed few differences over the control period. Therefore, an average of the two control periods was calculated and used in separate analyses to compare to post-training (average control period vs posttraining). The average control period (as opposed to precontrol or post-control data) was chosen because it represents baseline performance over time.

A two-way repeated-measures analysis of covariance (ANCOVA), controlling for baseline values, was used to determine interactions between training groups over time. When significant interactions occurred, a one-way repeated-measures analysis of variance (ANOVA) was used to determine interactions between training groups over time. When significant interactions occurred, a one-way repeated-measures analysis of variance (ANOVA) was used to determine interactions between training groups over time.

RESULTS

Forty-nine of 86 participants who visited the laboratory qualified for the training intervention. Participants who qualified for the study had lower isometric strength, higher summed MOD score, were more likely to be women, and were older than individuals who did not qualify for the study (Table 2). Differences remained after adjusting for the gender imbalance between those who qualified and those who did not qualify.

Six participants dropped out of the study before randomization (during the control period), and 11 participants dropped out after random placement into training groups. Participants who dropped out before and after randomization were not statistically different in age, body mass, height, knee extension isometric strength, or MOD score when compared to individuals who completed the training (Table 2).

At baseline there were no statistical differences in age, weight, height, body mass index, knee extension strength, self-reported physical function, or summed timed performance

Table 1. Functional Training Protocol

<table>
<thead>
<tr>
<th>Task</th>
<th>Level</th>
<th>Chair</th>
<th>Stair</th>
<th>Kneel</th>
<th>Lift and Carry a Laundry Basket</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form 1</td>
<td>Rise from a large inflated ball</td>
<td>Stair marching</td>
<td>Hard hand support</td>
<td>Lift empty basket to low shelf</td>
<td>Use one hand</td>
<td></td>
</tr>
<tr>
<td>Intensity 4</td>
<td>Chair with 38-cm seat pan height</td>
<td>Increase velocity</td>
<td>15-cm knee pad support</td>
<td>Increase weight in basket (5%–8% of body weight)</td>
<td>Increase friction of vacuum on carpet (adjust pile setting)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Chair with 35-cm seat pan height</td>
<td>Increase weight through vest</td>
<td>5-cm knee support</td>
<td>Increase weight in basket (10%–15% of body weight)</td>
<td>Increase weight to 15% of body weight</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Descriptive Characteristics for Participants

<table>
<thead>
<tr>
<th>Participant Type</th>
<th>N</th>
<th>Age (y)</th>
<th>Mass (kg)</th>
<th>Height (cm)</th>
<th>MVC (Nm)</th>
<th>MVC/WT (Nm/kg)</th>
<th>Percent Female (%)</th>
<th>MOD Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonqualifying</td>
<td>37</td>
<td>71.6 ± 7.6*</td>
<td>83.8 ± 21.1</td>
<td>161.9 ± 6.9</td>
<td>250.7 ± 81.3*</td>
<td>3.0 ± 0.80*</td>
<td>54</td>
<td>4.5 ± 4.6*</td>
</tr>
<tr>
<td>Qualifying</td>
<td>49</td>
<td>75.9 ± 8.2</td>
<td>76.4 ± 17.9</td>
<td>158.2 ± 9.4</td>
<td>170.2 ± 65.8</td>
<td>2.2 ± 0.56</td>
<td>90</td>
<td>15.3 ± 5.7</td>
</tr>
<tr>
<td>Completed training</td>
<td>32</td>
<td>75.8 ± 8.4</td>
<td>75.3 ± 17.7</td>
<td>158.4 ± 9.8</td>
<td>171.4 ± 59.9</td>
<td>2.27 ± 0.48</td>
<td>90.6</td>
<td>14.5 ± 6.5</td>
</tr>
<tr>
<td>Dropped before randomization (during the control period)</td>
<td>6</td>
<td>76.7 ± 11.5</td>
<td>87.0 ± 22.8</td>
<td>158.0 ± 6.0</td>
<td>162.1 ± 32.7</td>
<td>1.92 ± 0.44</td>
<td>100</td>
<td>18 ± 4.9</td>
</tr>
<tr>
<td>Dropped after randomization (RT = 3, FRT = 7, FT = 1)</td>
<td>11</td>
<td>76.6 ± 6.7</td>
<td>75.8 ± 15.9</td>
<td>158.3 ± 9.3</td>
<td>171.1 ± 82.0</td>
<td>2.18 ± 0.70</td>
<td>81.2</td>
<td>16.0 ± 6.2</td>
</tr>
</tbody>
</table>

Notes: Values are mean ± standard deviation.

*p ≤ .05; statistically different than participants who qualified for the study. Differences remained after adjustment for the gender imbalance between those who qualified and did not qualify. There were no statistical differences between participants who dropped out of the study before or after randomization when compared to individuals who completed the training.

n = number of participants; MVC = knee extensor maximal isometric contraction; MVC/WT = MVC divided by body weight in kilograms; MOD score = summed number of modifications for eight tasks of daily living; RT = resistance training; FRT = functional plus resistance training; FT = functional training.
between training groups (Table 3). There was a trend for the FRT group to have fewer modifications at baseline (precontrol) ($p = .06$).

**Training**

Participants completed 20 training sessions within approximately 10 weeks (RT = 10.8 ± 0.39, FRT = 10.9 ± 0.76, and FT = 10.5 ± 0.41 weeks). The RT and FRT groups showed similar increases in 10 repetition-maximum (10-RM) training weight (RT lower = 40%, RT upper = 29%; FRT lower = 42%, FRT upper = 35%). The weight added to alter task intensity during FT increased to a small extent in all tasks (Lift and carry: FRT: 2.58 ± 0.38 kg; Stair: FRT: 1.00 ± 0.85 kg; Chair: FRT: 0.80 ± 0.72; FT: 1.7 ± 0.88 kg; Vacuum: FRT: 2.50 ± 0.66; FT: 2.84 ± 0.38 kg; Kneel: FRT: 0.56 ± 0.18; FT: 0.20 ± 0.48 kg).

**Task Modification and Timed Performance on Everyday Tasks**

The absolute changes in task modification and timed performance are displayed in Figure 2. Neither task modification ($p = .52$) nor timed performance ($p = .96$) changed during the control period. Following training, all groups showed similar reductions in task modification (Group × Time: $p = .34$). The FT and FRT groups demonstrated similar reductions in timed performance without significant changes in the RT group (Group × Time interaction, $p = .07$). All training groups lowered their time to vacuum a 1.5 m × 1.5 m carpet (Group × Time: $p = .85$) (Table 4).

**Muscle Strength**

Absolute changes during the control period and following training (posttraining - average of the control period) are illustrated in Figure 2. No changes were seen during the control period in knee extension (time main effect: $p = .48$) or flexion work ($p = .15$). Knee extension work significantly increased from the average control period in RT and FRT groups, with no change in the FT group ($p = .24$) (Group × Time: $p = .05$). Knee flexion work increased in the both the RT and FRT groups, with little change in the FT group ($p = .09$) (Group × Time: $p = .04$).

Arm extension and flexion work for the precontrol, postcontrol, and posttraining sessions are listed in Table 4. There was a slight increase in arm extension work in the RT, but no change in the FRT and FT groups during the control period. No changes were detected in arm flexion work during the control period. When compared to the average control period, training increased in arm extension work across all groups, but there were greater increases in arm flexion work for the RT and FRT groups (p = .28) (Group × Time: $p = .037$).

**Body Composition, SF-12, Gait Speed, and Single-Leg Balance**

Mean changes in appendicular fat mass, lean mass, and lean to fat ratio in the control period and following training are displayed Table 4. There were no changes in appendicular fat mass (time main effect: $p = .35$), lean mass (p = .49), or lean to fat ratio (p = .44) during the control period. There were no significant changes in fat mass (time main effect: p = .11) or lean mass (p = .14) following training. Lean to fat ratio demonstrated a small increase that was not statically significant (p = .035) after correcting for multiple comparison tests ($\alpha = 0.025$).

No change occurred in self-reported physical function, gait speed, single-leg balance time, or vacuum time during the control period. All groups increased their self-rated physical function to a similar extent (Group × Time: $p = .20$). Gait speed at either a usual or rapid pace showed no significant change following training. Single-leg balance time had no evidence of a training-related effect.

**Discussion**

The major finding of this study is that older adults who modify tasks of everyday life adapt according to their specific training regimen. Those who performed only FT improved in both components of functional ability (task modification and timed performance), but did not have consistent adaptations in muscle strength. Those individuals who performed only RT increased muscle strength but only reduced task modification. Individuals who performed 1 day of each training type had less dramatic changes in muscle strength and function ability than the other two groups, but had consistent improvements in both components of functional ability and muscle strength. These data suggest an important role of task specificity when designing exercise programs to improve physical function in lower functioning older adults.

Timed performance decreased in only those participants performing FT (FRT and FT groups). This finding is somewhat contradictory to those from other reports where increased strength reduced timed performance (22–24). This
discrepancy is likely explained by differences in measurement of functional performance. Timed performance requires participants to perform tasks without using assistive devices (armrests on a chair), and thus precludes many frail older adults from undertaking the task. We devised a different approach in which we allowed participants to modify the task while timing their performance. Those performing RT modified tasks less, but continued to complete the tasks at the same speed. In contrast, FT resulted in reductions in both task modification and timed performance.

Regardless of training type, participants showed improvements in their self-rated physical function and vacuum performance and a trend to increase lean to fat ratio. We did not, however, find improvements in usual or rapid gait speed. Regarding body composition, we expected to find greater increases in the RT and FRT groups, with little changes in the FT group. However, we found statistically similar increases in lean mass and lean to fat ratios across training groups. These findings suggest that short duration training induces self-perceived improvement in function with some evidence for initial building of lean mass.

Quantifying task modification is a unique feature of this study that allowed us to document important qualitative adaptations that occur in lower-functioning older adults. These findings may provide insight into mechanisms about relearning functional skills by first reducing task modification and then increasing speed. This observation is similar to childhood motor development, where skill acquisition is obtained through the most efficient action of the task’s spatial and temporal requirement (25). Modifying tasks may provide an inefficient, but necessary action for lower-functioning older adults, whereas training may stimulate a reduction in modification that carries over to increased efficiency. However, it is unknown whether lower-functioning older adults can relearn to adapt to continuously changing environmental circumstances (outside the laboratory) or can perform more complex movements in response to exercise training.

Because FT was specifically designed to parallel everyday tasks, improvements in neural control of movement are likely contributors to functional adaptations. It is well known that strength gains are specific to tasks...
performed during RT (10). However, the transfer of these adaptations to functional movements occurs less often and the mechanisms behind this transfer is less understood. Borrowing from physiological adaptations in skill acquisition, FT may reduce the variability of motor unit firing rate (26), increase motor cortex plasticity (27), or help older adults learn (or relearn) to recruit their muscles to optimally perform the task (28). Interestingly, recent evidence suggests that skill training is closely related to increased corticospinal excitability, a finding not revealed with RT (29). Importantly, neural adaptations caused by training seem to be maintained for long periods of time (9, 29, 30), thus further implicating the importance of task specificity. Therefore, we propose that, if the goal of exercise for older adults is to gain function, training that incorporates task-specific movements may be needed to optimize benefits.

There are several limitations to this efficacy trial. First, exercise and control periods were not conducted concurrently; thus, seasonal variations may have influenced our results. Secondly, although there were no adverse events due to training, there was a high dropout rate (35%) that contributed to a low sample size. This suggests that we specifically enrolled older adults with underlying diseases that surfaced during the trial. The larger number of dropouts in the FRT group (n = 7) negatively affected the randomization by increasing the probability of being included in the FRT treatment group, which may have resulted in the FRT group being slightly higher functioning than the other groups. We statistically controlled for baseline performance to counteract these differences.

This was an efficacy study and not analyzed using intention-to-treat (including lost to follow-up) methodology. Future studies should consider oversampling lower-functioning older adults to neutralize high dropout rates. We also found that careful screening is needed to identify potential subclinical conditions that may arise during a trial.

Conclusion

This study provides preliminary evidence that benefits of exercise are related to tasks performed during training among low-functioning older adults. These results have important implications when correcting deficits in physical functioning of older adults.

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