Effects of a Multicomponent Exercise Program on Functional Ability in Community-Dwelling, Frail Older Adults

Charlotte H. Worm, Esther Vad, Lis Puggaard, Henrik Støvring, Jens Lauritsen, and Jakob Kragstrup

The purpose of this study was to determine the effects of a multicomponent exercise program on basic daily functions and muscle strength in community-dwelling frail older people. The randomized, controlled study comprised 46 community-dwelling frail older people (above 74 years of age and not able to leave their home without mobility aids). For 12 weeks the intervention group (n = 22) was transported to 2 class-based exercise sessions each week. Assessment of physical function was obtained using Berg’s Balance Scale and a walking test. Self-reported functional ability was assessed through SF-36. Maximal oxygen uptake and maximal voluntary contraction of the shoulders’ abductors were measured. The intervention group had a significant improvement in balance, muscle strength, walking function, and self-assessed functional ability compared with the control group. This study demonstrates that multicomponent exercise has a significant effect on basic daily functions and muscle strength in community-dwelling frail older people and might improve their ability to live an independent life.

Key Words: physical function, strength, balance

As individuals grow older, they experience an age-related decline in activities of daily living (Dickerson & Fisher, 1993). Frail older people living in the community might have difficulties with basic daily activities such as walking, taking a bath, dressing, and moving from one chair to another. The extent to which older people can live independently in the community depends on their ability to perform these and other related basic tasks (Shephard, 1990).

Many studies have focused on the impact of intensive single-component training on isolated functions in laboratory settings. Such intervention studies have documented a substantial increase in muscle strength and aerobic capacity in young older people (age 60–80) and in nursing-home residents. (Fiatarone et al., 1990; Kash, Boyer, Van Camp, Nettl, & Wallace, 1995; Porter, Vandervoort, & Lexell,

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1995). A few studies have also demonstrated improvement in functional ability (Fiatarone et al., 1994; Skelton & McAUghlin, 1996), but in a number of studies there was no significant functional benefit (Berg & Lapp, 1998; Skelton, Young, Greig, & Malbut, 1995; Wolfson et al., 1996). This could be because reduced functional ability in many older people is a result of critical deterioration of a complexity of functions, for example, balance, endurance, muscle strength, coordination, and reaction capacity. It is therefore likely that a multicomponent exercise program with the aim of improving these would be required in order to improve the ability to perform basic daily tasks in general. The possible benefit of multicomponent exercises to very frail community-dwelling older people, who because of their functional level need transport to and from training, has not previously been investigated.

The objective of this randomized, controlled study was to determine the effects of a multicomponent exercise program on basic daily functions and muscle strength in community-dwelling frail older people.

Methods

PARTICIPANTS

Frail older people (N = 46) were randomized into a control group (n = 24) and an intervention group (n = 22) receiving a 12-week multicomponent and comprehensive training program. The control group was not involved in any intervention. Before and at the end of the training program, both groups were examined and tested.

The study population comprised 46 frail older people sampled by 20 general practitioners according to the following criteria: above 74 years, living in their own home, and not able to leave their home unaided or unattended or without mobility aids. Patients with a life-threatening, symptom-giving somatic disease or confined to bed were excluded from the study.

A total of 103 patients fulfilled the criteria, and 46 were included in the study (41 did not wish to participate, 7 were excluded because their functional ability turned out to be too good, 7 withdrew from the study because of serious illness, and 2 died). After randomization, 1 person from each group dropped out, because of death and serious illness, respectively.

There were no restrictions with regard to activity level in the control group. This group was asked to continue if they already did exercise and told that they could freely accept any offers of training they might get during the intervention period.

TESTING PROCEDURE

All pre- and postintervention measurements were performed in the same order at the same testing location. All tests were carried out at the same time of the day and by the same observers without reference to the preintervention values.

Physical Function. Physical function was assessed using Berg’s Balance Scale (Berg, Wood-Dauphinee, Williams, & Maki, 1992). This test consists of 14 items that individuals would normally perform in their daily routines. The scores for the individual items were assigned by observing the performance and rating it on a scale from 0 to 4, 0 being the inability to perform the task with maximum support
and 4 the ability to perform the task safely and independently. The tasks include stable positions (e.g., standing and sitting unsupported), as well as a transition phase (e.g., moving from a sitting to a standing position and picking up an object from the floor). Total scores for all 14 items ranged from 0 to 56. Previous studies have reported that Berg’s Balance Scale represents a simple and reliable method for assessing functional performance in patients.

Self-reported functional ability was assessed through the SF-36, a standardized and validated questionnaire. Physical-function score was calculated from 10 items: the ability to perform demanding activities (e.g., running) and less demanding activities (e.g., vacuum cleaning), climb several flights of stairs, climb one flight of stairs, crouch, walk more than 1 km, walk several hundred meters, walk 100 m, take a bath, and dress (McHorney, 1996; McHorney, Ware, Raczek Lu, & Sherbourne, 1996). This score for physical function and the Danish version of the SF-36 questionnaire have been validated (Bjørner, Thunstedborg, Kristensen, Modvig, & Bech, 1998).

Walking Test. A 10-m walking test was performed at maximum speed. Walking speed and number of steps were measured indoors using a distance of 10 m. The test was done twice and the best result was recorded.

Muscle Strength. Maximal voluntary contraction of the shoulder abductors was performed using the Isobex measuring instrument (Leggin, Neuman, Iannotti, Williams, & Thompson, 1996). The test is performed with the participant sitting in a chair. The arm is stretched horizontally to the side in a 90° angle. The pulling point is placed on the ground vertically underneath the hand in a 90° angle. Each participant performed three maximal isometric contractions, and the mean measurement was recorded as the maximal voluntary contraction.

Aerobic Capacity. Maximal oxygen uptake (VO2max) was measured in a subgroup of 12 participants at baseline (Table 1) and postintervention. The participants performed a progressive, maximal test on a Cybex cycle ergometer. They bicycled with a rate of 50 revolutions per minute, starting with a workload of 25 W and increasing it by 15 W every 2.5 min until exhaustion. Heart rate was registered by a pulse watch every 30 s. O2, CO2, ventilation, and respiratory exchange ratio were continuously analyzed by an on-line system (Jaeger, Ro Oxy, Würzburg, Germany). Based on an earlier study of 80-year-old participants (Malbut, Dinan, Verhaar, & Young, 1995), respiratory exchange ratio ≥1 was used as a criterion for attainment of maximal oxygen uptake.

Patients with heart-valve disease, aortic stenosis, cardiac incompensation, heart-rhythm disturbance, or infections were excluded from this test. Based on these criteria, 34 patients could not be tested.

Medical Examination. A medical examination involving recording of medical history, lung and heart stethoscopy, resting blood pressure and pulse, peak flow, ECG, height, and weight was carried out. In this article a few of these data will be cited, but only for baseline description of the participants.

TRAINING

The training group was transported to two class-based exercise sessions per week for 12 weeks (three classes with 5, 7, and 9 older people, respectively). Each exercise session lasted 60 min and consisted of flexibility training, aerobics, rhythm, balance and reaction exercise, and muscle training (strength and endurance).
Table 1  Characteristics of the Participants at Baseline

<table>
<thead>
<tr>
<th></th>
<th>Group exercise ($n = 22$)</th>
<th>Control ($n = 24$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>$M$ 80.5 ($\pm$4.9),median 79.5</td>
<td>$M$ 81.9 ($\pm$3.6),median 81.5</td>
</tr>
<tr>
<td>Women ($n$)</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Men ($n$)</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Mini Mental State score (points)</td>
<td>$M$ 23.9 ($\pm$4.1),median 23.0</td>
<td>$M$ 23.5 ($\pm$5.2),median 25.0</td>
</tr>
<tr>
<td>Peak flow (L/min)</td>
<td>$M$ 265.0 ($\pm$120.2),median 265</td>
<td>$M$ 277.86 ($\pm$119.6),median 280</td>
</tr>
<tr>
<td>Regular medications (no.)</td>
<td>$M$ 5.2 ($\pm$3.2),median 5.0</td>
<td>$M$ 6.0 ($\pm$3.2),median 6.0</td>
</tr>
<tr>
<td>$VO_{2\text{max}}$ (mL $O_2 \cdot \text{min} \cdot \text{kg}^{-1}$)</td>
<td>$M$ 12.0 ($\pm$2.7),median 10.7 ($n = 5$)</td>
<td>$M$ 15.1 ($\pm$4.5),median 15.6 ($n = 6$)</td>
</tr>
<tr>
<td>Ambulatory assistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>none ($n$)</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>cane ($n$)</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>walker ($n$)</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>wheelchair ($n$)</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

Exercises and games involving complex functional movements were primarily used. The training group also performed a short (8–10 min) home-based program including muscle and flexibility training. The participants were instructed to perform these exercises every morning.

STATISTICAL ANALYSIS

Data obtained before and after intervention were analyzed using independent $t$ tests. For variables for which the absolute increase appeared to depend on the baseline level, the relative change was used, because this is independent of the baseline level. The conclusions were not affected by this because the effect tendency, both relative and in absolute numbers, was the same. Significance was assumed at the 5% level. Correlation between variables of interest was determined. All statistical analyses were carried out using the SPSS statistical package.

Results

Participant characteristics (age, sex, Mini-Mental State Examination score, peak flow, number of regular medications, $VO_{2\text{max}}$, and need for ambulatory assistance) at baseline are presented in Table 1.
BERG’S BALANCE SCALE

The total increase in Berg’s Balance Scale was significantly higher in the training group (17.8 points) than in the control group (0.43 points, $p < .001$; see Table 2). Figure 1 shows the absolute increase in score after intervention compared with the score before. The training-induced improvements in the individual items with $t$-test-based confidence intervals are presented in Figure 2. The improvement was statistically significant for all items.

Table 2 Increases in Berg’s Balance Scale and SF-36

<table>
<thead>
<tr>
<th>Physical function</th>
<th>Exercise $(n = 21)$</th>
<th>Control $(n = 23)$</th>
<th>95% CI of the difference between groups</th>
<th>$t$-test $p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berg’s Balance Scale</td>
<td>17.8</td>
<td>0.4</td>
<td>12.9, 21.6</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>(total score/points)</td>
<td>(30.1 to 47.1)</td>
<td>(28.6 to 29.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF-36</td>
<td>17.1</td>
<td>3.9</td>
<td>1.9, 24.4</td>
<td>.02</td>
</tr>
<tr>
<td>(total score/points)</td>
<td>(36.4 to 53.6)</td>
<td>(39.1 to 43.0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* The relative increase from pre- to postintervention in each group is shown by the mean total scores pre- and postintervention, respectively, in parentheses. CI = confidence interval.

![Figure 1](image-url)  
*Figure 1.* Increases in total score on Berg’s Balance Scale $(n = 44)$. 
Figure 2. Increases in the individual items on Berg’s Balance Scale (n = 21). Lines show each confidence interval at a 95% level. Black boxes indicate mean increases in score in the exercise group.

Figure 3. Correlation between increase in SF-36 and Berg’s Balance Scale in the exercise group (n = 21). Correlation = .34 and is significant at the .05 level (two-tailed).

SF-36

The intervention group had a higher increase in calculated score (17.1 points) than the control group did (3.9 points, p = .02; see Table 2). The correlation between the change in measured physical function (Berg’s Balance Scale) and change in self-perceived physical function (SF 36) was 0.34 (p < .05; see Figure 3).
WALKING FUNCTION

The relative improvement in walking speed for the training group compared with the control group was 14% \((p = .03)\). The relative decrease in number of steps used was 11\% \((p = .01; \text{see Table 3})\). The number of steps decreased from 20.5 \((SD 5.6)\) to 19.1 \((SD 5.2)\). At baseline the maximal walking speed was 0.8 m/s in both groups. The maximal walking speed increased to 1.0 m/s in the training group, compared with no change in the control group.

MUSCLE STRENGTH AND SHOULDER ABDUCTORS

The training group had a relative improvement compared with the control group of 37\% \((p = .02)\) for left-arm abductors and 55\% \((p = .001)\) for right-arm abductors (Table 3). Maximal voluntary contraction had increased in the training group from 2.3 kg \((SD 1.2)\) to 3.2 kg \((SD 1.6)\) on the left-hand side and from 2.5 kg \((SD 1.2)\) to 3.3 kg \((SD 1.7)\) on the right-hand side. The control group experienced a slight decrease on the right-hand side and a slight increase on the left-hand side. The changes in the control group were not statistically significant.

\(VO_{2\max}\)

Nine participants were tested both pre- and postintervention. The participants in the intervention group \((n = 4)\) had an average increase of 1.5 ml \(O_2\) \(\cdot\) min \(\cdot\) kg\(^{-1}\). The

| Table 3 | Improvements in Walking Function at Maximum Speed and in Muscle Strength in Shoulder Abductors |
|---|---|---|---|---|
| **Improvements (%)** | **Exercise** \((n = 21)\) | **Control** \((n = 18)\) | **Relative Improvement** | **95% CI of the Difference between Groups** | **t-test p** |
| **Walking function at maximum speed** | | | | | |
| Steps | \(-6\%\) \((20.5 \text{ to } 19.1)\) | \(5\%\) \((19.2 \text{ to } 20.0)\) | 11\% | 2.7\%, 22.1\% | .01 |
| Time | \(-15\%\) \((12.5 \text{ to } 10.5 \text{ s})\) | \(-0.6\%\) \((12.1 \text{ to } 11.9 \text{ s})\) | 14\% | 1.4\%, 31.8\% | .03 |
| **Muscle strength in shoulder abductors** | | | | | |
| Right shoulder | \(44\%\) \((2.5 \text{ to } 3.3 \text{ kg})\) | \(-8\%\) \((2.9 \text{ to } 2.7 \text{ kg})\) | 55\% | 17.1\%, 82.5\% | .001 |
| Left shoulder | \(44\%\) \((2.3 \text{ to } 3.2 \text{ kg})\) | \(5\%\) \((3.0 \text{ to } 3.1 \text{ kg})\) | 37\% | 5.9\%, 78.3\% | .02 |

*Note.* The relative increase from pre- to postintervention in each group, and the relative increase between groups. The means pre- and postintervention, respectively, are shown in parentheses. CI = confidence interval.
oxygen uptake was thus increased from 12.0 to 14.1 ml O₂ · min · kg⁻¹. The
participants in the control group (n = 5) had an average decrease of 1.4 ml O₂ · min
· kg⁻¹ (from 15.1 to 13.7). No statistical analysis has been carried out because of the
limited size of the sample.

COMPLIANCE

The intervention group had an 8.1% nonattendance rate (there were 41 cases of
nonattendance out of 504 possible). Two patients were the source of most of the
nonattendance (1 as the result of hip fracture sustained from falling at home, and the
other because of a planned stay in a sanatorium for rheumatic patients: 30 cases of
nonattendance). The remaining 19 people in the intervention group had a total of 2%
nonattendance (11 cases).

Discussion

This randomized, controlled study shows that a 12-week multicomponent training
program has a significant and marked effect on frail community-dwelling older
people’s ability to perform basic daily functions. In addition, the training induces
a significant increase in isometric muscle strength of the shoulders’ abductors.

The fact that this study used field tests (Berg’s Balance Scale and a walking
test), as well as a questionnaire interview, to determine physical-functional ability
must be considered a strength. It enables examination of whether the training effect
has an impact on two levels: measured physical functioning in test situations and the
patients’ self-perceived physical functioning. The latter level is interesting, because
it shows whether the training effect is of such a character that the individual in his
or her daily life can use the measured increase in functional ability. This evaluates
whether an actual increase in functional ability is involved. It is important that this
study documents a significant effect on both levels. Furthermore, it is worth noting
that the study population based on the inclusion criteria represents a relatively well-
deﬁned group of older people, seen from the point of view of a physical-
functional level. The results thus elucidate the training effect on a specific group of
community-dwelling frail older people who can be identiﬁed by their general
practitioners.

When computing conﬁdence intervals for the increase in single items of the
Berg score, we cannot assume normality for the individual responses. The t-test-
based conﬁdence intervals are, however, quite robust against this violation of the
assumptions. An alternative might have been to use the u test, which relies only on
the normality of the mean, but this would have neglected the problem of not
knowing the exact standard error of the mean.

It could be argued that the study should have had an additional control group
that only participated in social activities, in order to rule out the possibility that
social stimulation in itself could have resulted in the increased muscle strength and
improved functional ability. Because of limited financial resources, however, this
was not possible. It should also be mentioned, as Figure 1 illustrates, that the
individuals in the intervention group, who at baseline had a low total score in Berg’s
Balance Scale, had the biggest increase. This might result from the fact that a
maximum of 56 points can be obtained. Participants who obtained a high score
at the first test were therefore unable to have a similar increase on the second test. It is therefore possible that the actual increase is bigger than the measurable one.

This study differs from previous studies inasmuch as the studied group represents frail community-dwelling older people, for whom an improved functional ability is essential for being able to continue to manage life in their own homes. The mean age was 81.2 years. Of the participants, 80.4% used walking aids (e.g., walking sticks or crutches, rollator frames, wheelchairs); the rest needed personal assistance to leave their homes. The average peak flow was 230 L/min for the women and 308 L/min for the men. In comparison, the lower normal limit is 330 L/min for a 160-cm-tall 75 year-old woman and 450 L/min for a 175-cm-tall 75-year-old man (Nunn & Gregg, 1989). The group’s small capacity is further illustrated by the subgroup’s maximal oxygen uptake, which on average was 13.7 ml \( O_2 \cdot \text{min}^{-1} \cdot \text{kg}^{-1} \) body weight. It is important to note that this average is based on data from the participants whose heart function had not excluded them from testing. In comparison, a training study of healthy 85-year-olds showed that they had an average maximal oxygen uptake of 16.7 ml \( O_2 \cdot \text{min}^{-1} \cdot \text{kg}^{-1} \) (Puggaard, Larsen, Støvring, & Jeune, 2000). Previous studies have proposed that the lower limit for independent living is 13 ml \( O_2 \cdot \text{min}^{-1} \cdot \text{kg}^{-1} \) (Shephard, 1991).

Walking speed has been shown to decrease with age in both men and women, even if they participate in walking exercise (Frändin, Johannesson, & Grimby, 1992). A slow walking speed is associated with subsequent mobility-related disability (Guralnik, Ferrucci, Simonsick, Salive, & Wallace, 1995). It has been elucidated that the estimated risk of being dependent on others for activities of daily living was 7% in women and 14% in men with a maximal walking speed of 1.4 m/s. (Sonn, Frändin, & Grimby, 1995). In the present study the baseline values were considerably below this threshold—the average maximal walking speed was 0.8 m/s in both groups. After the intervention, the training group had increased their maximal walking speed to 1.0 m/s, whereas there was no change in the control group.

Training studies carried out on nursing home residents have demonstrated effects of 8 weeks of intensive strength training (Fiatarone et al., 1990, 1994). There was an explosive increase in muscle strength. In the first study by Fiatarone et al. (1990), tandem gait speed increased significantly, but habitual gait speed and chair-rise performance did not. In the second study, walking and stair-climbing speed significantly increased in the training group (Fiatarone et al., 1994). Those studies differ in important areas from the present study. First of all, the training of nursing home residents consisted of isolated muscle-strength training, and, second, only walking function and chair-rise performance or stair climbing, respectively, were used as measures of physical-functional ability in the participants. It is important, in this connection, to note that a recent training study of a large group of frail older people showed that strength gain was associated with increases in chair-rise performance, gait speed, and mobility tasks such as stair climbing but not with improved endurance or balance or lessening of disability (Candler, Duncan, Kochersberger, & Studenski, 1998). These results are in agreement with a number of training studies of older people that have shown that isolated muscle-strength training has only a limited or no effect on balance and mobility (Berg & Lapp, 1998; Skelton et al., 1995; Wolfson et al., 1996). Puggaard (1999) and Skelton and McLaughlin (1996) have documented a significant functional-ability increase in
selected parameters as a result of more comprehensive training, which involved the practice of functional tasks. The latter training study was carried out with 85-year-olds and 75+ year-olds who, according to the inclusion and exclusion criteria, were considerably more healthy than the participants in the present study.

Overall, the present study has established that (a) it is relevant to improve the functional ability of frail community-dwelling older people and (b) a multicomponent training program has a significant effect. It must therefore be considered relevant that, for instance, general practitioners can offer training to this group of patients in order to improve their physical-functional ability and thus possibly ensure that they can remain in their own homes and improve their ability to live independent lives.

This study leaves a number of unanswered questions. First of all, we do not know how the trained group copes in the years after the intervention. Is the group able to maintain the improved functional level, or will the cessation of training result in an explosive fall in functional level for physical, as well as mental, reasons? At the present time there is a need for studies on how an increase in functional ability can be maintained in frail community-dwelling older people.

References


