Task-Specific Resistance Training to Improve the Ability of Activities of Daily Living–Impaired Older Adults to Rise from a Bed and from a Chair

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OBJECTIVES: To determine the effect of a 12-week intervention to improve the ability of disabled older adults to rise from a bed and from a chair.

DESIGN: Subjects were randomly allocated to either a 12-week task-specific resistance-training intervention (training in bed- and chair-rise subtasks, such as sliding forward to the edge of a chair with the addition of weights) or a control flexibility intervention.

SETTING: Seven congregate housing facilities.

PARTICIPANTS: Congregate housing residents age 65 and older (n = 161, mean age 82) who reported requiring assistance (such as from a person, equipment, or device) in performing at least one of the following mobility-related activities of daily living: transferring, walking, bathing, and toileting.

MEASUREMENTS: At baseline, 6 weeks, and 12 weeks, subjects performed a series of bed- and chair-rise tasks where the rise task demand varied according to height of the head of the bed, chair seat height, and use of hands. Outcomes were able or unable to rise and, if able, the time taken to rise. Logistic regression for repeated measures was used to test for differences between tasks in the ability to rise. Following log transformation of rise time, a linear effects model was used to compare rise time between tasks.

RESULTS: Regarding the maximum total number of bed- and chair-rise tasks that could be successfully completed, a significant training effect was seen at 12 weeks ($P = .03$); the training effect decreased as the total number of tasks increased. No statistically significant training effects were noted for rise ability according to individual tasks. Bed- and chair-rise time showed a significant training effect for each rise task, with analytic models suggesting a range of approximately 11% to 20% rise-time (up to 1.5 seconds) improvement in the training group over controls. Training effects were also noted in musculoskeletal capacities, particularly in trunk range of motion, strength, and balance.

CONCLUSIONS: Task-specific resistance training increased the overall ability and decreased the rise time required to perform a series of bed- and chair-rise tasks. The actual rise-time improvement was clinically small but may be useful over the long term. Future studies might consider adapting this exercise program and the focus on trunk function to a frailer cohort, such as in rehabilitation settings. In these settings, the less challenging rise tasks (such as rising from an elevated chair) and the ability to perform intermediate tasks (such as hip bridging) may become important intermediate rehabilitation goals. **J Am Geriatr Soc 49:1418–1427, 2001.**

Key words: activities of daily living; disability; exercise

Difficulty in transferring (the ability to move into and out of a chair or bed) is common in people age 65 and older, affecting over 6% of community-dwelling older adults[1] and over 60% of nursing home residents.[2] Currently used descriptive, categorical scales may not be able to detect subtle, clinically significant changes in function or quantify mild to moderate ranges of impairment.[3–5] Transferring function may decline as a result of acute illness and hospitalization[6] or improve as a result of rehabilitation. More quantitative methods, such as the time taken to rise from a bed and a chair, may be useful in detecting more subtle yet clinically significant declines or improvements in transferring function. Presenting a battery of bed-

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and chair-rise tasks of varying difficulty may further enhance analyzing bed- and chair-rise performance. Such a battery was recently developed by altering aspects of the chair or bed apparatus (such as by raising or lowering the performance surface) or by constraining aspects of performance (such as by limiting the use of hand support).[7]

Training to improve transfers, specifically rising from a bed and a chair, is described commonly in the physical therapy literature,[8] but few data quantitatively support the efficacy of these training methods in older adults. Following leg resistance training, one frail older adult became able to rise from a chair without armrest use[9] and others felt that rising from a chair was easier.[10] In frail nursing home residents (dependent in ≥2 activities of daily living (ADLs)), individually adjusted physical therapy decreased bed mobility and chair-transfer performance time.[11] Chair-rise time also decreased following chair-based flexibility training in residents of "old people's homes."[12] However, in highly functional community-dwelling older adults, neither resistance training, balance training, nor combined resistance-balance training improved chair-rise time.[13] Thus, exercise may improve transfer-related task performance, although usually more so in frailer individuals. Recently, a controlled study demonstrated that leg strength training may decrease chair-rise difficulty, as evidenced by alterations in chair-rise biomechanics.[14] The types of exercises that best improve the ability to rise from a chair and from a bed have yet to be examined in a controlled study.

For the present study, we proposed a task-specific training program (i.e., learning an activity through practice[15]) with the addition of resistance training. The task-specific training program to improve bed- and chair-rise performance presented the participant with a series of tasks directly relevant to rising from a bed or chair, somewhat akin to descriptions in classical physical therapy texts.[16] Of particular importance was the focus of the training program on trunk function (range of motion (ROM), strength, and balance), in recognition of the influence of spinal mobility on physical performance.[17] We then added a progressive resistance component to the task-specific program (what we termed "task-specific resistance training"), hypothesizing further improvements in bed- and chair-rise function. Task-specific strength training, instead of typical isolated extremity flexion-extension strength training, has been proposed for rehabilitation settings.[18]

The goal of this project was to train community-dwelling older adults with self-reported difficulty in mobility-related ADLs to improve their ability to rise from both a bed and a chair. We hypothesized that subjects undergoing the task-specific training intervention would be more successful than controls in completing bed- and chair-rise tasks and, if successful, would take less time in rising.

METHODS

Subjects and Training Group Allocation

Older adult residents (age 65 and older) of congregate housing facilities in southeastern Michigan were recruited to participate in an exercise program designed to improve their ability to rise from a bed and a chair. A complete description of the subject screening and eligibility criteria and rationale appears in Alexander et al.[7] and is summarized below. Volunteers were medically stable, with no evidence of substantial dementia (Folstein Mini-Mental State Examination[19] score >23) or depression (Geriatric Depression Scale[20] score ≤4), and were not participating in regular, strenuous exercise (walking up to half a mile per day was acceptable). Subjects must also have reported needing assistance (such as from a person, equipment, or device), that is, were dependent, in performing at least one of four mobility-related ADL tasks, namely transferring, bathing, toileting, and walking, as per a standardized instrument used in the Established Populations for the Epidemiologic Study of the Elderly studies.[21] Although the present study focused on transferring, and some of these subjects denied dependency in transferring, dependency in the other three ADLs is highly interrelated[22–24] and relates directly to timed chair-rise performance.[23,24] These subjects represent a cohort of disabled residents who maintain themselves independently in a congregate housing facility. They would thus benefit from interventions to maintain their independence and be motivated to improve or maintain their independence.

Seven congregate housing facilities throughout southeastern Michigan were involved. All residents were sent a letter describing the exercise program and asked to respond regarding their functional status if they were interested in participating. Of 1,733 residents contacted, 485 completed the ADL screening; 254 of these (52%) were found to be eligible based on reports of dependency in mobility-related ADLs (see above). Fifty-two of these 254 refused to participate in the exercise program (mainly because of the time commitment involved), 29 were excluded medically (including unstable cardiac status, ongoing acute illness, and presently undergoing physical therapy), and 12 were excluded because of dementia or depression.

Following baseline testing, the remaining 161 subjects were allocated into either the task-specific resistance training (training) or the control flexibility intervention (control) based on a minimization scheme. Subjects were assigned to training or control group based on the following variables: age (65–79 vs 80 and older), gender (male vs female), overall self-reported ADL difficulty (1, 2, or 3 of the mobility ADLs noted above), and self-reported transferring difficulty (yes vs no). Because the number of stratification cells generated by these factors was large, we used minimization techniques for subject assignment to either group.[25] Minimization stipulated that the next subject to enter the trial was assigned to a group with a probability greater than 0.5. This minimized the strata imbalance between the training and control groups at a given stage of enrollment and reduced confounding of the outcome with prognostic factors, similar to stratified randomization. A computer generated the group assignment for a particular subject after input of the appropriate variable level.

Bed-Rise and Chair-Rise Task Assessment

The bed- and chair-rise tasks were chosen because of their relevance to the daily challenges faced by many older adults. The easier tasks reflected situations where raising the head of the bed (HOB) and seat height facilitated the rise; the more difficult tasks tested the ability to rise under common challenging situations. The challenges in these tasks, presented for example when the seat height is lowered or when hand use is limited, indicate apparent chair-rise difficulty and may predict future ADL-related outcomes.[23,26] A complete description of the bed- and chair-rise assessment below and its relationship to ADL disability appeared in Alexander et al.[7] For the assessment below, test-retest reliability was generally good for both the ability to rise during a chair- or bed-rise task (range of Kappas 0.6–1.0) and, if able, the time taken to rise during these tasks (range of Intraclass Correlation Coefficients (ICCs) 0.6–0.9).[7] In addition, the total number of rise tasks successfully performed correlated strongly with both self-reported transfer disability and total number of mobility-related ADL disabilities.[7]

Subjects performed the following tests at a comfortable rate in approximate order of difficulty based on the starting configuration. Subjects completed a task successfully when they reached the end position safely without experimenter facilitation and without violations (such as touching the upper extremities to the bed surface when sitting up without hand use). Subjects who failed to perform a task had a 1-minute rest period, after which the task trial was repeated. After a second failed attempt, subjects moved to the next task. All successful rises were timed using a hand-held stopwatch.

Bed-Rise Tasks

All bed-rise tasks were performed on a simulated bed surface, namely a padded plinth with hinges so that the HOB could be placed in one of three positions, at 0°, 30°, and 45° elevations. Unless otherwise noted, subjects had full, unrestricted use of their upper extremities to facilitate rising. The actual order of performance differed from what appears below, in that all tasks were performed from easier to more difficult; that is, tasks were performed at 45° elevations before dropping to 30°.

- Supine to sit to edge. Rise from supine (HOB 45°, 30°, 0°) to sit at the edge of the bed with legs dangling.
- Sit up, with hands. Starting with knees and hips flexed, rise from supine (HOB 45°, 30°, 0°) to sit while keeping the legs in the bed.
- Sit up, without hands. Starting with knees and hips flexed, rise from supine (HOB 45°, 30°, 0°) to sit while keeping the legs in the bed, with arms folded across the chest.
- Roll to side lying then rise. Roll onto the side (HOB 0°) and then rise from a side lying position to sitting on the edge of the bed.
- Supine to stand. Rise from supine (HOB 0°) to standing on the floor at the edge of the bed.

Chair-Rise Tasks

All chair-rise tasks were performed using a laboratory chair that could be adjusted for seat height and tilt.[27] Chair seat height was adjusted to percentages of floor to knee (lateral condyle) height (abbreviated as % FK). The standard starting seat height configuration was at 100% FK. In the 140% FK and 120% FK conditions, simulating a posture between sitting and standing (140%) and a typical elevated seat (120%), feet were still flat on the floor, but only the ischial tuberosities were in contact with the seat. Additional chair-rise challenge was provided when seat tilt (105° vs standard 90°) and backrest recline (10° vs standard 5°) were added to the 100% FK position, simulating a semireclining position. Addition of a block of 4-inch upholstery foam to 80% FK simulated a soft cushioned chair or sofa. The actual order of performance differed from what appears below, in that all tasks are performed from easier to more difficult; that is, tasks were performed at 140% elevations before dropping to 120%. Hand use on the armrests was unrestricted, except in without-hand situations, when arms were folded across the chest.

- Rise from different heights, with hands (140%, 120%, 100%, 80% FK).
- Rise from recline/tilt chair, with hands (100% FK). Rise from a chair with the seat tilted 10° posteriorly and the chair back reclined at 105°.
- Rise from different heights, no hands (140%, 120%, 100%, 80% FK).
- Rise from 80% FK with 4-inch cushion on seat, hands and no hands. Rise from a chair with the seat at 80% height and a 4-inch block of foam placed on the seat.

Musculoskeletal Assessment

Strength Assessment

A reinforced chair instrumented with load cells was used for isometric strength tests. The chair contained a number of load cells, restraining straps, and two handles so that the maximum efforts of a subject were tested in a posture with limbs adducted and 90° angles between the trunk, thigh, shank, and foot. Restraining straps attached to the seat and backrest enabled trunk flexion and extension to be measured. Following a practice trial at 50% warm-up effort, two trials were performed, with the best of the two used for the analysis. Subjects received feedback about their performance from a 2-foot-high light tower calibrated so that increased strength output also increased the number of rows that were lit. We chose only a subset of possible tests to minimize testing time and subject fatigue. The subset chosen, namely trunk flexion and extension, shoulder depression (pushing downward with flexed elbow and shoulder adducted), elbow extension, hip extension, knee extension, and ankle plantar- and dorsiflexion, reflected key muscle groups used while performing the various bed- and chair-rise tasks. Test-retest reliability (1 week apart, ICCs) for the strength measurements at each joint were uniformly excellent (greater than 0.75), with fair to good reliability (0.55 and 0.63, left and right respectively) at one joint only (ankle plantar flexion).

Range of Motion (ROM) Assessment and Trunk Lateral Balance

Bilateral passive ROM of elbow extension, shoulder abduction, hip flexion, knee flexion and extension, and ankle dorsi- and plantar flexion were measured with the subject in a supine position using hand-held goniometers and standard techniques.[28] In addition, the Back Range of Motion instrument (BROM II, Performance Attainment Associates, Roseville, MN), was used to assess active lumbar sagittal flexion and extension and lateral flexion (bending) according to standard techniques developed by the manufacturer. The positioning techniques used while standing were similar to other standardized techniques.[29,30] The output was provided both in degrees and centimeters. The BROM was also used to ascertain the largest amount of lateral trunk lean (in degrees, termed lateral balance) that the subject could maintain for 3 seconds. For this lateral balance test, subjects sat on a firm wooden platform placed on top of the padded plinth used for the bed-rise tasks. To maintain a controlled body configuration, the subjects' knees were strapped together, and their arms were folded across the chest. Their legs dangled over the edge of the plinth so that two-thirds of the femur was supported on the platform. Test-retest reliability for the trunk tests using the BROM was generally good, with ICCs ranging from 0.65 to 0.86 (0.71–0.73 for lateral trunk lean).

Training and Control Interventions

Both training and control groups met for 12 weeks, three times per week, for 1 hour per day, on-site at the congregate housing facilities.

Bed- and Chair-Rise Task-Specific Resistance-Training Intervention

Subjects were trained based on their ability or inability to perform a series of tasks with or without an additional load. These tasks were chosen to focus on what we believed to be key contributors to rising, namely proximal upper- and lower-extremity musculature and the trunk. Subjects used these contributors in a number of tasks that were related to the rises from a bed and a chair. Strength, ROM, and maintaining the body in certain key positions ("balancing," in a sense) were emphasized, within the context of the task-specific requirements. The intervention included a 5-minute warm-up and 5-minute cool-down, consisting of gentle neck, trunk, upper-extremity, and lower-extremity stretches. Although the intervention was designed and directed by a physical therapist, the trainers who conducted the intervention had minimal background in exercise training.

A single trainer supervised each subject. Subjects performed the bed-rise intervention (BRI) and chair-rise intervention (CRI) tasks at a comfortable rate and as specified for three repetitions. If the task was too difficult, the trainer facilitated the exercise by helping to move the required body part (such as lifting the leg) or by raising the chair seat height. If not challenged enough, subjects performed the tasks against an increased load, accomplished either by increasing weights worn or lowering the seat height. The increased weight was achieved in three ways: (1) donning a canvas weight vest, with weights distributed symmetrically in pockets on the front and back to achieve a total load ranging from 2 to 32 pounds (by 2-pound increments); (2) wearing ankle bands with pockets that accommodated 1- to 10-pound weights to achieve a maximum 14 pounds per leg (increased at 1-pound increments per leg); or (3) in the case of the bridging exercise, wearing 1- to 10-pound weights on the lower abdomen. Most subjects practiced, although did not necessarily complete, all 16 tasks during each exercise session. Progression in each task by moving to a higher challenge level was encouraged weekly.

Bed-Rise Intervention (BRI) Tasks

Subjects practiced these tasks on their preferred side of exit from a standard twin bed, except as noted below.

1. Arm reach and trunk lift. With the arm opposite the preferred exit side, subjects reach forward and over to the side of exit while lifting their trunk slightly. For one drill, subjects were asked to contact the trainer's hand held at the midline about 2 feet above the umbilicus.
   Purpose: Practice elevating and turning the trunk for the initial portion of rise.
2. Lateral leg movement, single leg. Subjects moved one leg toward the side of exit and then the other leg to the opposite side.
   Purpose: Practice moving (hips) legs laterally for initial portion of rise.
3. Unilateral heel raise. With one knee and hip flexed and the opposite leg extended, the opposite heel was raised 4 to 6 inches off the bed and held for 3 seconds. Task was repeated for the other heel.
   Purpose: Practice elevating the legs in preparation for rise.
4. Roll to side lying. Subjects rolled onto their side by pushing their opposite heel down.
   Purpose: Practice moving trunk and pelvis onto side with foot push off in preparation for rise.
5. Side lying to sit. While lying on their preferred side with hips and knees flexed and heels supported by the bed, subjects pushed down with their preferred side elbow (the elbow contacting the bed surface) and the opposite hand. Subjects came to a sitting position with their legs dangling off the edge of the bed.
   Purpose: Practice alternate way to rise after a full roll onto the side.
6. Weight on hip and hold. From a sitting position at the edge of the bed with legs dangling and arms folded across the chest, subjects placed all of their weight on one hip, leaned as far as they could to one side, holding the position for 3 seconds, and then repeated this task to the opposite side. The trainer was at the subject's side to offer support and prevent a fall.
   Purpose: Practice balancing trunk on one side of the hip.
7. Trunk elevation by upper extremity extension. From a lying position, subjects first extended an arm, then pushed off and extended the elbow to achieve trunk elevation.
   Purpose: Practice elevating the trunk using shoulder and elbow extension.
8. Bridging. With knees flexed and hands at the sides, subjects raised their buttocks off the surface of the bed and held this position for 3 seconds.
   Purpose: Practice elevating the pelvis and utilizing arm support.
9. Supine to sit. Subjects rose from a supine position to sitting at the edge of the bed. Subjects were encouraged to grab the edge of the bed to help them rise.
   Purpose: Practice usual methods of rising from supine to sitting.

Subjects completing the 12-week intervention were able to perform essentially all bed-rise tasks, averaging approximately seven to eight repetitions (depending upon the task, based on a maximum target of nine repetitions) per task per week. Weights were gradually increased so that by the final week, the average vest weight used was 11 pounds (range 0 to 32 pounds) and the average ankle weight used was 5 pounds (range 0 to 14 pounds).

Chair-Rise Intervention (CRI) Tasks

Chair-rise tasks were performed from an upholstered chair with a standard seat height (18 inches), minimal seat tilt, adequate space under the chair for foot placement during the rise, and padded arm rests that extended approximately 1 inch past the seat edge. For an additional challenge, some subjects placed their feet on a 6-inch-high wooden platform while rising from the chair, which in effect lowered the seat height (to 12 inches) and thereby provided an additional challenge. This lowered seating position simulated a low seat or stool. When more disabled subjects required a reduced challenge, an elevated chair with armrests (a bar stool with seat height of 24 inches) was used.

1. Slide forward. From the standard starting position and while using both armrests for assistance, subjects slid forward to the edge of the seat, shifting their weight from one hip to the other.
   Purpose: Practice moving the pelvis forward on the seat.
2. Maximum trunk flexion. From the standard starting position and while using both armrests for assistance, subjects leaned forward from the hip joint as far as possible while keeping the neck and upper back straight.
   Purpose: Practice leaning forward from the hips.
3. Trunk rock and lift. While seated at the edge of the chair and using both armrests for assistance, subjects rocked back and forth to lift the buttocks off the seat. The usual sequence to be mastered was rock forward and back twice followed by lifting on the third rock.
   Purpose: Practice developing sufficient trunk momentum to elevate the buttocks off the seat.
4. Pelvic elevation. While seated in the starting position, subjects pushed down on both armrests to elevate the pelvis off the seat surface. The legs are extended and feet out in front so that leg assistance will be minimal. More disabled subjects could not fully elevate the pelvis, but the goal was to at least try to unload the buttocks.
   Purpose: Practice using the arms only to help elevate the pelvis.
5. Flexed configuration after lift-off. Subjects rose from the seat using the armrests and maintained their buttocks off the seat without rising to a full standing position. The hips and knees were to remain flexed as if the subject was still seated.
   Purpose: Practice balancing at the critical moment of lift-off from the seat.
6. Rise from chair, with and without use of hands. Subjects rose from the seat using any method they desired (including placement of hands in any location, such as the seat). Task was repeated without the use of hands.
   Purpose: Practice rising from the chair in a comfortable manner.
7. Hip and knee bends. While standing, subjects bent their hips and knees and then raised themselves up again. The goal was for subjects to reach at least 30° of hip flexion and then to lower themselves further.
   Purpose: Practice knee and hip extension at the final phase of the chair rise.

Subjects completing the 12-week intervention were able to perform essentially all of the with-hands chair-rise tasks, averaging approximately five repetitions (based on a maximum target of six repetitions) per task per week. Weights were gradually increased so that by the final week the average vest weight used was 9 pounds (range 0–24 pounds) for the standard height, 8 pounds for the low chair (range 0–20), and 10 pounds for the no-hand chair rise at the standard height (range 0–28 pounds). The goal was to have the subject complete six full chair rises per session, whether under standard-height, low-height, no-hand, or elevated-height conditions. Less than one-third of the group (17 of the 60 who completed 12 weeks) was unable to perform the two most difficult tasks: no-hand chair-rise task at the standard height or the low-chair rise with hands. Essentially all of these subjects were able to perform the no-hand chair-rise task at the elevated height. Of the 17 unable to perform the two most difficult tasks, approximately half (nine) needed assistance from the trainers to safely complete these no-hand tasks.

Ten of the 60 subjects had exercise-induced exacerbations of preexisting chronic back or leg pain such that the exercises were individualized (reduction in weight, increased trainer facilitation, decreased repetitions, or, if necessary, discontinuation of a particular task). Ultimately, only two subjects dropped out of the program due to exacerbation of musculoskeletal symptoms (see below).

Control Flexibility Intervention

The flexibility exercises consisted of neck and extremity movements in a seated position, with only mild trunk sagittal flexion, extension, or lateral flexion. These exercises included (examples): elbow flexion and extension and arm abduction and adduction movements (swings); shoulder shrug and roll, hip adduction and rotation (cross leg while extended), knee flexion and extension (kicks), ankle plantar and dorsiflexion (lifting and lowering heels with feet in contact with floor), and trunk twist at waist (gentle bending forward, backward, and to each side). The group leader demonstrated these exercises in a gentle, low-intensity manner, without facilitating or encouraging the subjects to perform through a particular joint range, so that the focus was on gentle stretches, not strength training.

Data Analysis

All rise task data presented here represent baseline and 12-week postintervention performance. Outcomes were able or unable to rise and, if able, time taken to rise. The number of tasks successfully completed, a total task score, was also computed. These effects were analyzed after adjusting for baseline and for the self-reported ADL disability items above and, specifically, the disability in transfers item. Logistic regression for repeated measures was used in analyses of rise success because of the several dichotomous outcomes measured under different conditions. Calculations were performed using the SAS/GENMOD procedure. The corresponding estimation procedure is known as the generalized estimating equations method.[31] A linear mixed effects model[32] was used in analyses of rise time because several continuous variables were measured under different conditions. Some subjects were unable to perform certain tasks (up to three-quarters of subjects for some no-hand rise tasks, see Table 1). Missing data were treated as missing at random.[33] With this approach, multiple outcomes were analyzed simultaneously, using all information available from all subjects. Thus, the analysis was based on "all subjects," but some of the outcomes were observed on a limited number of subjects. Calculations were performed using the SAS/MIXED procedure.

A particular focus of these models was on dependent variables arranged in the following manner: (1) a 3 × 3 table spanned by three bed-rise tasks, namely supine to sit to edge, sit up with hands, and sit up without hands, and for three HOB heights, 0°, 30°, and 45° and (2) a 4 × 2 table spanned by four chair-rise tasks, namely 140%, 120%, 100%, and 80% FK tabulated according to hand or no-hand use. For analysis purposes, the seat height was considered a continuous variable so that the regression estimate represents a difference in rise time (measured on the log scale) per 1% of seat-height change. The referent for training effect was control performance, whereas the other referents included 45° performance (for comparison with 30° and 0° bed-rise performance), 80% FK (for comparison with 140%, 120%, and 100% performance), and with hands (for comparison with no hands).

Musculoskeletal capacity measures were analyzed using analysis of variance (ANOVA) and, after adjustment for baseline, examining for a group effect at 12 weeks. Left-right differences in extremity strength and ROM were minimal and had essentially no significant group or 12-week effect. Accordingly, left- and right-side measures were averaged.

RESULTS

Subject Description

Eighty-one subjects were allocated to the training group and 80 to the control intervention. Women predominated in both groups. Mean age was 82 years and mean ADL disabilities was 2.7 (see Table 2). Forty-one percent of each group reported disability in transferring. Both groups had equivalent impairment in balance and gait based on Performance Oriented Mobility Assessment score.[34] One hundred twenty-four subjects completed the 12-week intervention (60 training and 64 controls). Thus, 21 dropped out of training group and 16 dropped out of the control group, for a 26% and 20% dropout rate, respectively. Most subjects dropped out because of personal reasons (such as time commitment) or new or progressive unrelated medical conditions. Two training and two control subjects dropped out because of back or leg pain induced by the interventions. Analysis of the baseline data (by ANOVA) showed no significant differences in age, ADL disabilities, or bed- and chair-rise performance between dropouts and those who completed the 12-week program. Subjects who completed the 12-week program attended a mean 81% of the possible exercise sessions.

Table 1. Training and Control Group Characteristics

Characteristics	Training	Control
n	81	80
Female %	84	88
Age, years (mean ± SD)	82.0 ± 6.4	82.4 ± 6.3
Age range, years	70–97	70–94
Transfer disability, %	41	41
ADL disability (mean ± SD)	2.7 ± 1.6	2.7 ± 1.6
ADL disability, range	1–7	1–7
POMA (mean ± SD)	19.4 ± 6.3	19.2 ± 5.8
Retested at 12 weeks (n)	60	64
Dropout rate (%)	26	20

SD = standard deviation; ADL = activities of daily living; POMA = performance-oriented mobility assessment.

Table 2. Percentage Unable To Complete Bed and Chair Rise Task by Group: Baseline versus 12 Weeks

	Training		Control	
Tasks	Baseline	12 Weeks	Baseline	12 Weeks
Bed rise task*				
Supine to sit to edge				
45°	1	0	0	0
30°	1	0	0	0
0°	2	2	3	3
Sit up, with hands				
45°	1	0	0	0
30°	1	0	0	0
0°	5	3	4	5
Sit up, without hands				
45°	7	5	9	8
30°	12	12	16	16
0°	74	73	73	71
Side lying to sit (0°)	5	2	8	3
Supine to stand (0°)	5	2	4	6
Chair rise task†				
With hands				
140%	1	0	0	2
120%	1	2	0	2
100%	1	2	0	2
100% tilt/recline	2	2	4	3
80% cushion	2	2	4	3
80%	7	3	4	5
Without hands				
140%	6	5	6	5
120%	14	5	15	13
100%	28	22	26	22
80% cushion	40	37	45	35
80%	75	64	76	70

*For bed rise tasks, starting position is the elevation of the head of the bed relative to the horizontal, 0° (no elevation), 30°, and 45°.

†Chair rise tasks were performed both with and without use of hands on armrests; starting position is given in percentage of floor-to-knee height, resulting in a range from high (140%) to low (80%) seat heights. For additional description of tasks, see text.

Bed- and Chair-Rise Task Performance Ability

Of the 22 bed- and chair-rise tasks that could be successfully completed, the training group improved from a mean 18.8 tasks at baseline (range 3–22) to 19.4 tasks at 12 weeks (range 4–22), whereas the controls decreased from a mean of 19.2 tasks (range 13–22) to 19.0 tasks (range 7–22). Figure 1 compares total number of baseline tasks with baseline-adjusted 12-week total number of tasks performed (excluding four outliers with task scores below 15). The difference between slopes of the training group (slope = 0.6) and the control group (slope = 0.8) was significant (P = .03), identifying a significant training effect that decreased as the total number of tasks performed increased. This suggested that the training effect was evident for those who were poorer performers at baseline and minimal for those who were better performers at baseline.

When analyzing performance ability by individual task, nearly all subjects were able to rise when the HOB was elevated or when the seat height was elevated, as long as hand use was not limited (see Table 1). The most difficult tasks (approximately three-quarters of each group unable for each task at both baseline and 12 weeks) were sit up without hands at 0° HOB and 80% no-hands chair rise. From baseline to 12 weeks, the percentage unable declined slightly in both groups for most tasks but more strikingly for no-hands chair-rise tasks. The declines in percentage unable tended to favor the training group, particularly in the chair-rise tasks, but after adjustment were not statistically significant.

Bed- and Chair-Rise Task Performance Time

Because of the skewed distribution of performance times, performance time was logarithmically transformed before modeling. After covarying baseline performance time (given in Table 3), there were two statistically significant effects for every task: (1) a reduction in performance time favoring the training group over controls (training effect, P generally < .0001) and (2) an increase in performance time with increased task demand (when the HOB is lowered, when the seat height is lowered, and when hands are not allowed, P generally < .0001). Percentage change in rise time between baseline and 12 weeks for individual subjects of each group is shown in Figures 2 and 3. Combined models using the tasks that varied HOB height (45°, 30°, and 0°) and seat height (140%, 120%, 100%, and 80% FK) are presented in Table 4 with the parameter estimate (±95% CI) of the effect favoring the training group over the controls. These estimates translate into a range of approximately 11% to 20% improvement in mean rise time per model. Given baseline rise times ranging generally from 2 to 7 seconds, this 20% improvement translates into improvements of 0.5 to 1.5 seconds.

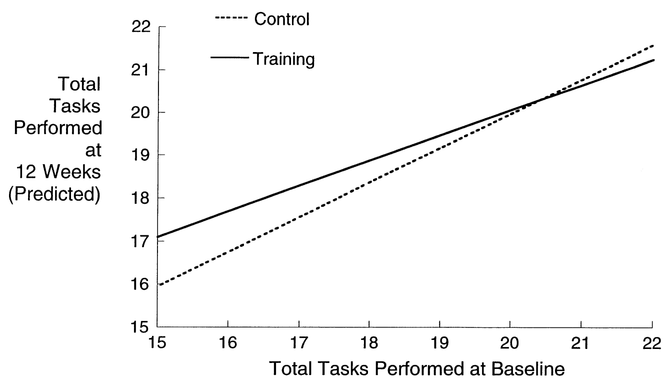

Figure 1. The total number of bed- and chair-rise tasks performed at baseline appears on the x-axis. The total number of tasks at 12 weeks (as predicted from a baseline-adjusted model) appears on the y-axis. The difference between slopes of the training group and the control group was significant (P = .03), suggesting a significant training effect that decreased as the total number of tasks increased.

Musculoskeletal Capacity

Musculoskeletal capacity means at baseline and 12 weeks are shown in Table 5. The most consistent training effects from baseline to 12 weeks (compared with the controls) are seen in the trunk measures, including lateral flexion, forward flexion and extension ROM, lateral trunk balance, and flexion and extension strength. Training effects are also noted in shoulder, elbow, knee, and ankle ROM, although the magnitude of the effects appears smaller. Few training effects were seen in arm and leg strength.

Table 3. Baseline Bed- and Chair-Rise Task Performance Time

Tasks	Training	Control
	(mean ± standard deviation)	
Bed-rise task		
Supine to sit to edge		
45°	5.0 ± 2.7	5.3 ± 3.5
30°	5.8 ± 4.1	5.7 ± 3.6
0°	6.7 ± 3.9	6.7 ± 3.5
Sit up, with hands		
45°	2.1 ± 0.8	2.1 ± 0.7
30°	2.6 ± 1.3	2.5 ± 1.0
0°	4.6 ± 3.4	4.1 ± 1.8
Sit up, without hands		
45°	2.1 ± 1.0	2.0 ± 0.6
30°	3.0 ± 2.2	2.6 ± 1.3
0°	4.5 ± 2.0	4.2 ± 2.0
Side lying to sit (0°)	9.2 ± 7.3	9.6 ± 5.6
Supine to stand (0°)	12.8 ± 6.5	15.6 ± 21.7
Chair-rise task		
With hands		
140%	2.7 ± 1.5	2.7 ± 1.2
120%	3.3 ± 2.1	3.2 ± 1.8
100%	3.6 ± 4.2	3.6 ± 2.6
100% tilt/recline	3.9 ± 2.2	4.0 ± 2.0
80% cushion	3.7 ± 2.2	4.1 ± 4.0
80%	5.2 ± 4.3	5.3 ± 4.4
Without hands		
140%	2.7 ± 1.2	2.9 ± 1.6
120%	4.2 ± 2.8	3.9 ± 3.6
100%	4.5 ± 3.1	4.3 ± 3.5
80%	6.3 ± 4.1	5.6 ± 2.9
80% cushion	4.5 ± 2.8	4.9 ± 2.4

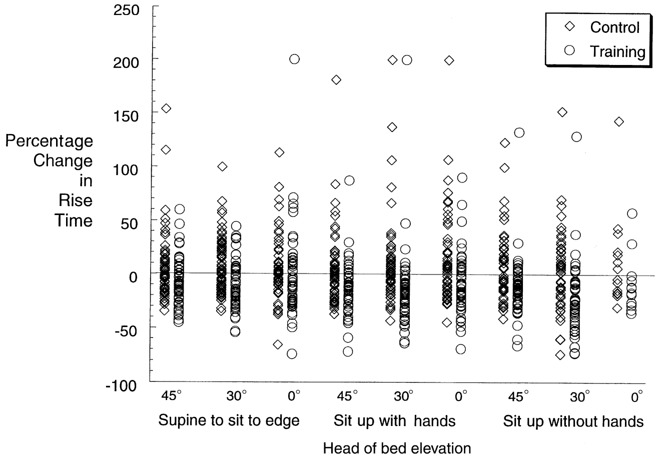

Figure 2. Percentage change in rise time from baseline to 12 weeks in individual training and control subjects. Tasks are shown according to type of task and position of head of bed. Positive percentage change represents poorer 12-week (versus baseline) performance or slower rise time over time. Negative percentage change represents improved 12-week (versus baseline) performance or faster rise time over time. For graphing purposes only, percentage changes of 200% or greater are placed at the 200% level.

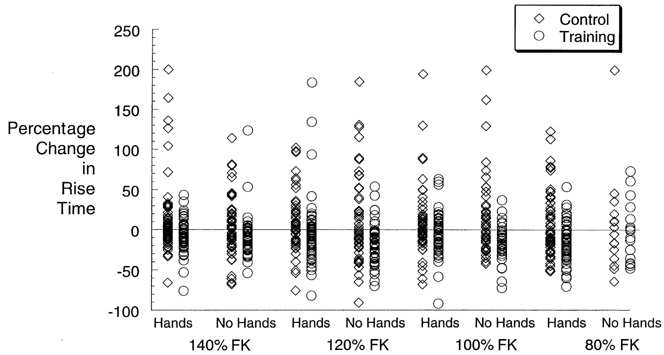

Figure 3. Percentage change in rise time from baseline to 12 weeks in individual training and control subjects. Tasks are shown according to type of task and percentage of floor to knee (lateral condyle) height (%FK). Positive percentage change represents poorer 12-week (versus baseline) performance or slower rise time over time. Negative percentage change represents improved 12-week (versus baseline) performance or faster rise time over time. For graphing purposes only, percentage changes of 200% or greater are placed at the 200% level.

DISCUSSION

To our knowledge, this is the first controlled exercise study to focus on improving transfers, specifically the ability to rise from a bed and chair, in frail older adults. Overall, task-specific resistance training increased the ability of these frail older adults to perform a set of bed- and chair-rise tasks. This training effect, although clinically small, was more marked in those with poorer baseline ability. This improved ability tended to occur most in a few individual chair-rise tasks, but these trends were not statistically significant. Given these trends, large sample sizes would have been required to demonstrate a statistically significant improvement in ability for an individual task. (For example, for the no-hands 80% chair rise task, and with $P = .05$ and power = 0.8, 963 subjects per group would have been required).

In addition, reductions in bed- and chair-rise time favored the training group (up to 20% training effect) but were clinically small (approximately 1 second). However, this small decrement in rise time may still be clinically significant. First, it is known that decrements in chair-rise performance, such in timed multiple chair rises, predict future disability.[24] In these subjects, assuming no intervening illness creates a new catastrophic impairment, there may be a slow decline in performance as a result of disease and deconditioning,[35] at some point reaching a threshold of disability. A maintenance program with long-term (up to 1-year) follow-up may be necessary to determine whether these small clinical improvements can be maintained.

A number of factors may have reduced the training effect. Instead of participating as nonexercise controls (attending, for example, health education lectures), the controls participated in a group flexibility program. Given the wide use of chair-based flexibility programs in congregate housing in our geographic area, we felt that this activity represented the standard to which other interventions should be compared. It is possible that a nonexercise control group would have increased the apparent training effect.

Secondly, a number of the bed- and chair-rise tasks did not challenge the participants and a number of tasks may have been too challenging. The majority of participants were able to perform bed- and chair-rise tasks allowing use of hands. Thus, the only possible change in intervention outcome could have been rise time. Although a rise-time training effect was noted in either hands or no-hands tasks, neither the training protocol nor the outcome

Table 4. Effect Favoring Improvement in the Training Group

Tasks	Effect	95% CI	*P*-value	% Effect Range
Supine to sit to edge	0.115	0.049–0.181	.0008	5.0–19.8
Sit up with hands	0.197	0.140–0.255	.0001	15.0–28.9
Sit up without hands	0.171	0.102–0.240	.0001	10.7–27.2
Chair rise with hands	0.141	0.072–0.209	.0001	7.5–23.2
Chair rise without hands	0.112	0.036–0.188	.0045	3.7–20.7

Note: Modeled using the log of time, when adjusted for baseline, activities of daily living level, and head of bed or seat height.
CI = confidence interval.

Table 5. Musculoskeletal Capacity by Group: Baseline versus 12 Weeks

	Control		Training	
	Baseline	12 Weeks	Baseline	12 Weeks
Capacity	(mean ± standard deviation)			
Trunk measures				
Lateral flexion ROM (deg)	19.9 ± 7.3	20.3 ± 5.8	18.9 ± 7.0	23.8 ± 5.8*
Forward flexion ROM (deg)	23.8 ± 8.6	22.3 ± 7.8	21.7 ± 8.3	24.9 ± 8.2*
Forward flexion ROM (cm)	5.3 ± 1.5	5.4 ± 1.7	5.2 ± 1.8	5.5 ± 1.9
Extension ROM (deg)	3.1 ± 2.5	2.7 ± 2.1	3.2 ± 2.3	5.0 ± 3.0*
Extension ROM (cm)	1.6 ± 1.0	1.6 ± 0.8	1.6 ± 0.8	1.9 ± 0.8
Lateral balance (deg)	25.4 ± 6.6	24.2 ± 6.2	25.0 ± 6.6	29.7 ± 7.1*
Trunk flexion strength (Nm)	95.1 ± 44.1	98.0 ± 47.2	91.1 ± 45.3	107.8 ± 43.4*
Trunk extension strength (Nm)	50.9 ± 24.0	49.9 ± 26.4	47.1 ± 26.8	53.8 ± 22.9*
Arm and leg ROM (deg)				
Shoulder abduction	161.6 ± 26.9	159.1 ± 23.6	157.3 ± 29.3	161.5 ± 25.9*
Elbow extension	−0.4 ± 2.2	−0.6 ± 3.5	−0.3 ± 2.2	−0.3 ± 2.4*
Hip abduction	25.1 ± 6.6	23.2 ± 6.9	23.1 ± 6.7	24.8 ± 6.4
Hip flexion	116.0 ± 7.8	116.4 ± 6.9	116.0 ± 7.4	117.1 ± 6.6
Knee flexion	129.5 ± 9.2	129.2 ± 9.0	129.5 ± 8.0	130.7 ± 7.7*
Knee extension	−2.6 ± 5.0	−3.8 ± 5.7	−3.6 ± 5.9	−2.5 ± 5.2*
Ankle dorsiflexion	15.3 ± 5.5	14.5 ± 5.8	15.3 ± 5.2	16.5 ± 4.8*
Arm and leg strength (Nm)				
Shoulder depression	21.6 ± 10.8	17.1 ± 11.6	21.8 ± 13.0	19.2 ± 10.8
Elbow extension	23.1 ± 9.1	17.0 ± 9.4	22.4 ± 10.1	18.7 ± 8.7
Ankle dorsiflexion	24.3 ± 9.6	25.4 ± 11.0	23.3 ± 8.6	26.1 ± 9.7
Ankle plantar flexion	26.8 ± 11.4	29.5 ± 13.3	25.6 ± 8.8	31.0 ± 11.0*
Hip extension	100.1 ± 46.5	108.9 ± 50.6	100.7 ± 53.2	121.7 ± 52.5
Knee extension	33.9 ± 19.8	33.5 ± 19.5	33.2 ± 18.6	36.7 ± 16.4

*$P < .05$ for intervention effect.
ROM = range of motion.

measures focused on maximal rise speed. Our focus was on safe, comfortable rise speed in both testing and training; perhaps a focus on maximal rise speed, a relatively artificial outcome measure, might have led to a larger training effect. However, there are also data suggesting that frail older adults are not able to speed up their comfortable rise time significantly when asked to rise as fast as possible.[14]

In addition, the no-hands tasks, particularly the sit up at 0° and rise at 80% chair height, were quite difficult, and may have been beyond the capability of these frail older adults. Even with adequate training, their ability to complete these tasks or improve their rise time may have been limited. Yet, the rise tasks were chosen to represent situations that disabled older adults may encounter. For example, upper extremity use for rising from a bed or chair may be limited in certain conditions (such as painful shoulders or arm weakness). Chair seat heights, even in healthcare environments, may be suboptimally low.[26] Beds with head height adjustments are rare in standard residential environments, although they are ordered periodically for frail patients posthospitalization.

The bed- and chair-rise training effect was paralleled by training-related improvements in musculoskeletal capacities, particularly in trunk ROM, strength, and balance. A number of studies have recently focused on the contribution of trunk function to physical performance.[17,36] For bed- and chair-rise tasks, trunk motion and trunk stabilization appear to be key contributors to rise biomechanics.[37–41] It is not clear whether ROM, strength, or balance contributed to the training effect. The training effect might have occurred without the resistance component. Perhaps merely practicing rising from a bed and a chair may have been sufficient to demonstrate a training effect. However, the training effect did carry over to bed- and chair-rise tasks that were performed under different initial body configuration and testing equipment situations. Further work may be needed to clarify which parts of the training program were most essential in providing the training stimulus. Finally, whether this training program might generalize to improvements in other functional tasks such as walking is yet to be determined. The training focus on the trunk and arms and the legs may be unique to training rises from a seated or supine position.

Future studies might also consider adapting this exercise program and the focus on trunk function to a frailer cohort, such as in rehabilitation settings. In these settings, the less challenging rise tasks (such as rising from an elevated chair) and the ability to perform intermediate tasks (such as hip bridging) can become important intermediate outcomes of rehabilitation. The completion of the proposed exercises themselves, particularly as the patient tolerates increasing resistance and decreasing stand-by assistance, may also serve as worthy intermediate rehabilitation goals.

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