Department of Veterans Affairs

Journal of Rehabilitation Research and Development Vol. 37 No. 5 September/October 2000
Pages 633–638

CLINICAL REPORT

Bed mobility task performance in older adults

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Abstract—Difficulty in transferring, the ability to rise in and out of a bed and chair, is a common problem in older adults, particularly those residing in skilled nursing facilities. Focusing on one aspect of transferring, rising from supine to sitting position, we devised a set of bed mobility tasks to test key arm, leg, and trunk movements that likely contribute to successful rising from bed. Healthy young controls (YC, n=22, mean age 23), and older adults (aged 60 and over) either residing independently in congregate housing (CH, n=29, mean age 84) or undergoing rehabilitation in a skilled nursing facility (SNF, mean age 77) were assessed in the time to rise from supine to sitting and in the ability or inability to perform 16 other bed mobility tasks. Trunk function-related tasks, specifically those requiring trunk elevation and trunk balance, were most difficult for the SNF, followed by CH, and then YC. Tasks focusing on trunk flexion strength (sit up arms crossed, bilateral heel raise) and lateral trunk strength/balance were the most difficult for both SNF and CH, although there was minimal difference in the percent unable to complete each task. The major CH-SNF differences occurred in trunk elevation tasks where the upper limb was important in facilitating trunk elevation (sit up with head of bed elevation with use of arms, sit up with the use of a trapeze, or sit up with use of arms from a flat bed position). These findings suggest that to improve frail older adult performance on bed mobility tasks, and specifically in rising from supine to sitting, training should move beyond improving trunk function (i.e., trunk strength). There should be an additional focus, either through therapy or bed design modifications, on how upper limb movements and positioning can be used to assist in trunk elevation.

Key words: *activities of daily living, aging, disability*

BACKGROUND

Difficulty in transferring, the ability to rise in and out of a bed and chair, is a common problem in older adults, affecting from 6–8 percent of community-dwelling adults aged 65 and over (1,2) and at least 63 percent of adults over age 65 residing in nursing homes (3). Transferring function may decline as a result of acute illness and hospitalization (4), or analogously, improve as a result of rehabilitation. A physical performance battery for hospitalized older adults includes transferring tasks and may be used to identify those at risk for decline in physical performance post-hospitalization (5,6). More quantitative methods, such as testing the key movements

This material is based upon work supported by the Office of Research and Development, Rehabilitation Research and Development Service, Department of Veterans Affairs; and the National Institute on Aging grants AG10542, AG00519 and AG08808.

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contributing to successful transfers and the time taken to rise may be useful: 1) in quantifying mild-moderate transferring impairment; 2) in detecting more subtle yet clinically significant declines or improvements in transferring function; and 3) in devising a series of tasks that may be used in a therapy program to enhance transfer ability. One key component of transferring is the task of rising from supine to sitting (7), and this is the primary focus of the present paper.

In addition to the trunk strength required, the supine-to-sit task involves substantial trunk coordination and balance (8) as evidenced by the thoracic and spinal musculature recruited for axial rotation (9,10). In addition, leg muscles (8) often supplement trunk muscles in completing trunk flexion past 45 degrees of elevation (11). Descriptions of supine to sit movement patterns suggest that the trunk and limbs may or may not move synchronously and usually show left-right asymmetric limb use throughout the rise (7). Age-related and physical impairment-related differences in movement patterns also appear in supine-to-sit movement patterns. Healthy older adults differ from congregate housing older adults with self-reported rise difficulty in the leg movements used and in the synchronization of trunk and pelvic motions to facilitate the rise (12). In addition, when comparing healthy old with healthy young, the healthy old differ in how they use either upper limb for support, and are more likely to laterally flex their trunks and use their elbow and hip to achieve a pivot while rising from supine to sitting (13). Thus, the interaction (i.e., synchrony and symmetry) of these lower limb, upper limb, and trunk motions determines supine-to-sit performance.

We drew upon these previous studies of how older adults rose from a supine-to-sit position to devise a series of bed mobility tasks. The tasks were designed to test key arm, leg, and trunk movements that might contribute to successful rising from a bed. The bed rise tasks might eventually be used to quantify improvements in function or as refinements in physical therapy programs to enhance transfer performance. In addition, bed design parameters that are modifiable, such as head of bed elevation, are embedded in these tasks. Our data may thus have an impact on design specifications of living environments for older adults who are mobility-impaired and/or undergoing rehabilitation, such as in an assisted living or nursing home milieu.

We sought to compare the bed mobility task performance of three groups of adult volunteers, young adult controls, independent older adult congregate housing residents, and nursing home older adults with difficulty in transferring. We hypothesized that the nursing home residents would have the most difficulty performing these tasks, followed by the congregate housing residents, and then the young controls.

METHODS

Subjects

We recruited three groups of volunteers. Healthy young adult controls (YC, n=22, 11 men and 11 women, mean age 23, age range 20–28), were recruited from a local university. Older adults aged 60 and over were recruited either from: 1) a local life care community, i.e., those residing independently in a congregate housing facility (CH, n=29, 5 men and 24 women, mean age 84, age range 73–93); or 2) from one of two skilled nursing facilities (SNF, N=20, 15 men and 5 women, mean age 77, age range 60–90).

Following a screening history and physical examination by a nurse clinician, older adults were excluded if they: 1) could not follow simple commands and cooperate with the protocol; 2) had unstable fractures or were on movement precautions postoperatively; 3) had unstable cardiorespiratory status; 4) had an acute infection or inflammation such as an acute joint pain flare; 5) had tetraplegia, hemiplegia, paraplegia or a major limb amputation; and 6) were demented or depressed based on Folstein Mini-Mental State Examination (MMSE) score <24 (14) or Geriatric Depression Scale score (short version) >5 (15). All older adults were required to be able to rise from a supine to sitting position without human assistance.

The CH residents were volunteers who responded to a recruitment letter. All the CH subjects were able to rise independently from a bed without human assistance, but nine (31 percent) required assistance from a device or person to perform at least one activity of daily living (ADL's), usually bathing or walking.

The SNF residents were undergoing rehabilitation at either a community-based nursing home (4 men and 5 women) or a nursing home attached to a Department of Veterans' Affairs hospital (11 men). The SNF were considered eligible if they were assessed by their physical therapist or nurse as having difficulty in transferring, namely in rising from a bed to a chair, such that the therapy plan was to include transfer training. Charts from 165 nursing home residents were reviewed to determine eligibility to participate in the study and 20 (12 percent) met study criteria and agreed to participate. Of the rest of the 165 screened, 36 (22 percent) residents declined to participate, 32 (19 percent) did not meet MMSE criteria, 30 (18 percent) did not require assistance in transferring, 22 (13 percent) had an acute medical condition, 18 (11 percent) needed more than one person to assist in transferring, and 7 (4 percent) subjects had hemiplegia. Nearly all of the participants (18; 90 percent) required assistance from a device or a person to perform at least one of their ADL's, particularly walking.

Based on the nurse clinician screening, both CH and SNF residents had significant physical impairment, although SNF may have had more difficulty with upright balance. On history, over half of each group complained of chronic back and/or leg pain and over half of each group complained of difficulty with standing balance. Although 59 percent of CH admitted to at least one fall in the past year, nearly all (95 percent) of SNF admitted falling ($p<0.01$, by Fisher Exact Test). On examination and by manual muscle testing, at least one-third of each group had shoulder or elbow weakness and nearly half of each group had hip or knee weakness (at most 4 out of 5 in one joint). Nearly half of each group had at least partial loss of distal position sense at the great toe. Although 24 percent of CH failed the Romberg test (eyes closed bipedal stance), 85 percent of SNF failed the test ($p<0.001$ by Fisher Exact Test).

Protocol and Equipment

Bed mobility tasks were performed on a "bed," which was actually a plinth measuring 81 inches long and 42 inches wide, with a 3 inch firm padded[1] surface. The plinth was attached to a wooden frame such that the floor-to-plinth surface height was approximately 22 inches. The width of 42 inches and height of 22 inches was chosen to simulate a standard twin mattress, box spring, and frame. A standard hospital pillow was used for head support when needed. An overhead frame was connected to the headboard and footboard such that the frame was 55 inches above the bed surface; a chain and trapeze bar were then attached to the frame when needed (see below). A 10-inch-long removable side handle was attached so that the handle was 7 inches above the plinth surface.

Subjects began in the following starting configuration unless otherwise stated: supine position with knees and hips extended, feet together, and arms at their sides, while being centered on the plinth. Subjects were asked to perform the tasks at a self-selected rate. A second trial was allowed if the first trial was unsuccessful. A hand-held stopwatch was used for timed tasks. By altering aspects of the bed (such as by raising or lowering the head of the bed) or by constraining aspects of performance (such as by limiting the use of hand support), the investigators tested key arm, leg, and trunk movements that likely contribute to successful rising from a bed.

Bed Mobility Tasks

Timed supine-to-sit task: Subjects rose from supine to sitting at the edge of bed, with use of both arms and legs, including grabbing the edge of the bed to facilitate rising (task 1). Two trials were performed and timing for the second trial was used for the data analysis.

Roll-in-bed tasks: Each subject rolled onto the side with and without use of hands and arms and with assistance of a side rail. Specific tasks included: roll to side while hands grab a side rail (task 2); roll onto side without use of a side rail (task 3); roll to side with arms crossed on chest (task 4).

Sit-up-in-bed tasks: With knees and hips flexed, subjects rose from supine to sitting up in bed with and without use of hands and arms, with the use of a trapeze, and with the head of the bed elevated. Specific tasks included: sit up in bed with head of bed elevated to 30 degrees with use of arms (task 5); sit up in bed while using a trapeze adjusted so that the subject's arms were elevated 45 degrees above horizontal at onset of task (task 6); sit up in bed with use of arms while bed is flat (task 7); sit up in bed with arms crossed on chest while bed is flat (task 8).

Side-lying tasks: While lying on the side at the edge of the bed, each subject rose from side lying to sitting up at the edge of the bed with and without use of a side rail: side lying to sit at edge of bed while using a side rail (task 9); side lying to sit at edge of bed without use of side rail (task 10).

One-handed supine-to-sit tasks: To model the effect of the inability to utilize one limb to facilitate rising (such as in hemiplegia or frozen shoulder) subjects rose from supine to sitting at the edge of the bed while only using one limb (ipsilateral or contralateral limb denoted by relationship to side of bed exit): with use of ipsilateral arm and hand only (task 11); with use of contralateral arm and hand only (task 12).

Seated upright to edge of bed: Subjects were assisted to a seated position in bed (equivalent to the end posi-

[1]Density 0.85 in/sq ft, indentor force displacement of 25 percent under 27 lb test load applied to a test area of 50 sq in.

tion of a successful sit-up), and then instructed to move to a seated position at the edge of the bed (equivalent to the end position of supine to sit; task 13).

Bed Mobility Component Tasks

Maintaining lateral trunk balance: Subjects maintained trunk balance while leaning onto unilateral hip for 10 seconds (task 14).

Heel raise: Subjects raised the left heel 10 inches above bed surface for 10 seconds while right heel maintained contact with bed surface (task 15) and then repeated the raise for the right heel (task 16) and finally raised both heels (task 17).

DATA ANALYSIS

Two separate analyses were performed, between YC and CH and between CH and SNF. Supine-to-sit rise time was compared using an independent t-test, while the percent of subjects unable to complete a task was compared using Fisher's Exact Test using standard statistical software (16).

RESULTS

Mean (±SD, in sec) supine-to-sit rise time was significantly longer in CH (4.4± 2.4) *versus* SNF (9.8±9.5, p=0.001) and tended (p=NS) to be longer in CH *versus* YC (2.6±0.4) (see **Figure 1**).

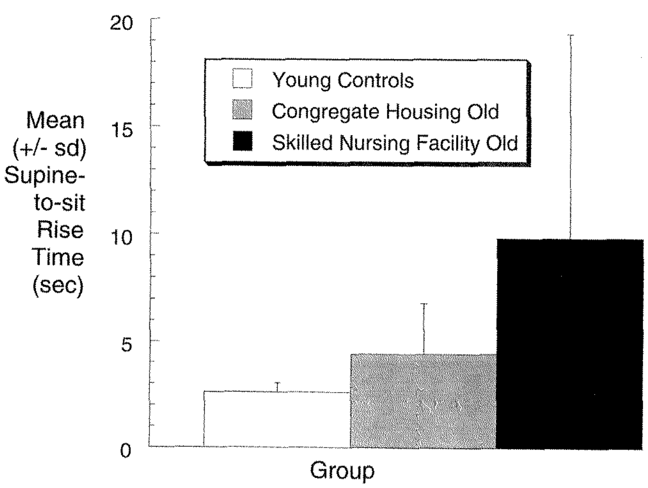

Figure 1.
Mean (±sd) time (in seconds) to rise from supine to sitting in young controls, congregate housing, and skilled nursing facility groups.

Table 1 illustrates the number and percent of each group unable to complete a bed mobility and bed mobility component task. None of the YC subjects was unable to perform a bed mobility task. Compared to YC, significantly more of the CH were unable to complete tasks that placed demands on trunk strength and balance, limited arm use, and placed demands on leg strength. Specifically, the CH: 1) were less able to sit up in bed with arms crossed (without the use of their hands, 62 percent of CH unable); 2) were less able to rise from supine to sitting when using the contralateral arm/hand only (38 percent of CH unable); 3) were less able to maintain lateral trunk balance (41 percent of CH unable); and 4) were less able to maintain both heels off the surface of the plinth (69 percent of CH unable). Compared to CH, a higher percent of SNF were unable to perform tasks requiring trunk elevation (sitting up in bed) with the use of arms, with either the head of bed up to 30° (3 percent CH unable *versus* 30 percent SNF unable) or flat (7 percent CH unable *versus* 30 percent SNF unable) or with the use of a trapeze (25 percent SNF unable). Using only one arm to rise tended to be more difficult for the SNF, particularly for ipsilateral use only, but did not reach statistical significance. Rising without use of arms (arms crossed) was nearly equally difficult for CH and SNF.

DISCUSSION

Based on timed supine to sit performance as well as the ability or inability to perform other bed mobility tasks, SNF residents with difficulty in transferring exhibited the most difficulty in bed mobility task performance, YC the least difficulty, with the CH older adults intermediate in difficulty. Group differences, however, were not consistent across all bed mobility tasks, and in fact centered on tasks involving trunk function, specifically on tasks where the upper limb facilitated trunk elevation.

Some tasks were easily performed (such as the roll), even by a debilitated rehabilitation population (the SNF residents). As expected, trunk function-related tasks, specifically those requiring trunk elevation and trunk balance, were most difficult for the SNF, followed by CH, and then YC. Tasks focusing on trunk flexion strength (sit up with arms crossed, bilateral heel raising) and lateral strength/balance (lateral trunk balance) were the most difficult for both SNF and CH, although there was minimal group difference in percent unable to complete each task

Table 1.
Number (%) of Subjects Unable to Complete Task.

	Young Controls	Congregate Housing	Skilled Nursing
Roll, Use Siderail,	0(0)	1(3)	0(0)
Roll, No Siderail,	0(0)	1(3)	0(0)
Roll, Arms Crossed,	0(0)	1(3)	0(0)
Sit Up, HOB 30°, Use Arms	0(0)	1(3)	6(30)[d]
Sit Up, Use Trapeze	0(0)	0(0)	5(25)[e]
Sit Up, Use Arms	0(0)	2(7)	6(30)[d]
Sit Up, Arms Crossed	0(0)	18(62)[a]	15(75)
Side Lying to Sit, Use Siderail	0(0)	2(7)	4(20)
Side Lying to Sit, No Siderail	0(0)	5(17)	2(10)
Supine to Sit, Use Ipsilateral Arm	0(0)	5(17)	8(40)
Supine to SIt, Use Contralateral Arm	0(0)	11(38)[b]	11(55)
Seated Upright to the Edge of Bed	0(0)	0(0)	4(20)
Lateral Trunk Balance	0(0)	12(41)[c]	9(45)
Left Heel Raise	0(0)	4(14)	4(20)
Right Heel Raise	0(0)	4(14)	1(5)
Bilateral Heel Raise	2(9)	20(69)[a]	10(50)

Based on Fisher Exact Test comparisons:
Significant differences between Young Controls and Congregate Housing Old: [a]$p<0.0001$; [b]$p<0.005$; [c]$p<0.001$.
Significant differences between Congregate Housing Old and Nursing Home Old: [d]$p<0.05$; [e]$p<0.01$.

Other interesting comparisons concerned trunk elevation tasks involving one upper limb. Rising from supine to sit using the contralateral arm only, requiring extensive trunk strength, was more difficult for CH than YC, and again with minimal difference between CH and SNF.

The major CH-SNF differences occurred in trunk elevation tasks where the upper limb was important in facilitating trunk elevation (sit up with head of bed elevated and with use of arms, sit up with the trapeze, or sit up with use of arms from a flat position). The SNF were apparently less able to use upper limb facilitation to elevate the trunk and complete the task. Whether the incidence of upper limb dysfunction (such as weakness) was higher in SNF than CH cannot be clearly answered by the present study; no objective measures such as isometric strength were made, although hemiplegics and severe hemiparetics were excluded from the study.

These findings, one might speculate, suggest that to improve older adult performance on bed mobility tasks, and specifically rising from supine to sitting, training should move beyond improving trunk function (i.e., strength). Additional focus on how the upper limb can be used to assist in trunk elevation is needed. Implications are present for both therapy as well as bed design. Further consideration of proper upper limb motion strategies and proper upper limb positioning during the rise, particularly when considering the deficits of the person, seem important. Furthermore, enhancements of support for limb use might go beyond trapeze systems and standard bed rails, to include areas of stiffened mattress support or additional handholds (beyond standard bed rails) that would optimize upper limb facilitation of trunk elevation. Facilitation by the upper limb might also differ depending upon different phases of the rise cycle (13), so that initial trunk elevation might require a different support system and rise strategy than that required to pivot and turn to a seated position at the edge of the bed.

The bed mobility tasks in the present study might be considered the first step in the development of a series of bed mobility tasks that might ultimately predict successful supine-to-sit performance. We chose to test potentially overlapping items (i.e., Sit Up, Use Trapeze *versus* Sit Up, Use Arms) to capture a wider range of performance among these three experimental groups. Future studies might consider reducing the number of tasks and designing an instrument that predicts supine-to-sit performance, i.e., an instrument that may be tested for typical psychometric properties such as reliability and validity.

ACKNOWLEDGMENTS

The authors acknowledge the assistance of Rhonda Keller, RN, MS and Virginia Skiba, BS in data acquisition and analysis.

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Submitted for publication September 28, 1999. Accepted in revised form January 19, 2000.