Body Positions Used by Healthy and Frail Older Adults to Rise from the Floor

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OBJECTIVE: The purpose of this study was to describe how older adults, particularly more physically impaired older adults, might differ from healthy controls in the body positions used to rise from the floor.

DESIGN: Cross-sectional analysis of young, healthy older, and congregate housing older women.

SETTING: University-based laboratory and congregate housing facility.

PARTICIPANTS: Healthy young university student controls (n = 22, mean age 23 years); healthy old adults living independently in the community (n = 24, mean age 73 years); and congregate housing older adults (n = 29, mean age 81 years).

INTERVENTION: Videotaping and timing of rising from a supine position on the floor to standing.

MAIN OUTCOME MEASURES: In addition to the time taken to rise from the floor, 10 specific trunk and extremity positions used during the rise, termed Intermediate Positions (IP), were identified.

RESULTS: The Young controls had the fastest rise time and used the fewest number of IP, whereas the Congregate residents had the slowest rise time and used the most IP, with the Healthy old adults intermediate in both time and IP use. Prevalence of certain IP, together with correlational and factor analyses, suggest that use of Sit and Crouch was the most preferred rise strategy for the Young controls, whereas use of Tuck, Crouch-Kneel, All Fours, and Bearwalk was the most preferred rise strategy among the Congregate residents. The Healthy old used IP common to both Young and Congregate residents, reflecting a rise strategy intermediate to the latter groups. A substantial subset of the Congregate residents (38%) were unable to rise without assistance and appeared to use certain preparatory positions (Sit, Kneel, Tuck) but were unable to get into presumably more challenging positions (Crouch-Kneel, All Fours, Bearwalk).

CONCLUSIONS: With increasing age and physical impairment, body positions used during rising from the floor suggest a preference for maintaining upper and lower extremity contact with the floor, presumably minimizing the lower extremity strength requirements to rise and maximizing stability and postural control. These intermediate body positions may be useful as the basis for training older adults to rise from the floor. **J Am Geriatr Soc 48:1626–1632, 2000.**

Key words: aging; falls; rising from floor; ADL; assessment

Difficulty in rising from the floor after a fall is common in older adults, is associated with substantial morbidity, and tends to be underappreciated. Only 49% of community-dwelling fallers are able to get up after a fall without assistance, and most of the falls associated with the inability to get up without help (85%) are not associated with serious injury.[1] Thus, the inability to get up after a fall is common and not simply a consequence of the injury. Despite the high risk of difficulty in rising from the floor after a fall, few therapists teach older adults how to rise from the floor.[2]

To our knowledge, no studies have examined how movement patterns used when rising from the floor differ between healthy young, healthy old, and older adults with more advanced age and disease-related impairment. Some studies have utilized a semi-quantitative video scale to analyze the arm, leg, and trunk movement patterns used to rise from a supine position on the floor to a standing position.[3] Although none of these studies includes healthy or frail adults older than age 65, movement patterns differ somewhat when comparing sedentary to physically active adults aged 30 to 39.[4] Presumably, these patterns would also differ with advanced age and disease-related impairments. Alexander[5] recently found that a subset of congregate housing older adults were unable to rise from the floor, and among those congregate residents who were able to rise, the time taken to rise was significantly longer than the time required by healthy older adults. Why are these older adults less able to rise and why do they take more time in rising? Are there characteristic changes in floor rise movement strategies that account for this loss of ability to rise and slowing in rise time?

The purpose of this study was to describe how older adults, particularly more physically impaired older adults, might differ from healthy controls in the floor rise movement strategies used to rise from the floor. As an indicator of these movement strategies, we investigated the specific trunk and extremity positions, termed Intermediate Positions (IP) used

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during the rise. We hypothesized that when comparing groups by age (Young Controls (YC) vs Healthy Old (HO)) and by increasing age and physical impairment (Healthy Old vs Congregate Housing Residents (CO)), HO compared with YC and CO compared with HO would be less successful in rising and, when successful, would require more time to rise. We also hypothesized that the number of IP exhibited per rise would be higher in the HO versus YC and in CO versus HO and that certain IP would be more prevalent in one group than another. Use of these IP may herald impending difficulty or eventual inability to rise from the floor in the assessment of older adults. Knowledge of the group differences in using these IP may be incorporated into programs to teach effective strategies for rising from the floor. Ultimately, these strategies may be applied in interventions to improve floor rise ability and, thus, decrease the fear and the morbidity associated with falling.

METHODS

Subjects

Three groups of volunteers were sought. Volunteers who had either responded to newspaper advertisements or had previously indicated interest in participating in university-based research were recruited to constitute a group of healthy young (≤30 years) university student controls (group YC, n = 22, 11 women and 11 men, mean age 23 years, range 19–30 years) and a group of healthy old (≥65 years) adults living independently in the community (group HO, n = 24, 12 women and 12 men, mean age 73 years, range 66–87 years). A third group, congregate housing older adults (group CO, n = 29, all female, mean age 81 years, range 68–94 years), volunteered in response to a mailing sent to all independent apartment-dwelling residents (n = 170) of a continuing care retirement community. Six CO men volunteered and were tested, but because of their disproportionately small number compared with CO women, they were not included in the analysis.

Although all of the YC and HO were able to rise successfully, 11 CO subjects (38% of the 29 CO subjects) were unable to complete the rise without assistance (group CO Unable). Characteristics of the 11 CO Unable are compared below with the 18 CO subjects able to successfully rise (CO Able).

Both YC and HO denied any significant underlying musculoskeletal, otological, or neurological abnormality. After further screening history and physical examination by a gerontological clinical nurse specialist, several subtle abnormalities were found in the HO and more overt abnormalities in the CO (see Table 1). Inasmuch as no potential CO subject was excluded based on particular diagnoses or disabilities, the extent of the impairments was larger in the CO than in the HO. Nevertheless, nearly all (83%) of the HO were involved at least three times per week in an exercise routine that included walking, biking, rowing, swimming, tennis, and/or yardwork. In addition, 83% of the CO were involved in some form of regular (three times per week) exercise, primarily walking or group flexibility sessions.

Protocol

Subjects rose from a 1.85 × 1.2 m simulated floor made from 1.9 cm (3/4 inch) plywood covered with 0.3 cm (1/8 inch) industrial carpeting. They were instructed to rise at a comfortable rate from a supine starting position on the floor to a standing position using any motions necessary to complete the rise except for using the edge of the simulated floor or any other object for assistance. Subjects lay supine with

Table 1. Clinical Characteristics of Young Controls, Healthy Old Adults, and Congregate Old Adults

Characteristic	Young Controls YC	Healthy Old HO	Congregate Old All CO	Congregate Old CO Able	Congregate Old CO Unable
N (female/male)	22 (11/11)	24 (12/12)	29 (29/0)	18/0	11/0
Mean (±SD) Age (range)	23 ± 3 (19–30)	73 ± 6 (66–87)	81 ± 7 (68–94)	81 ± 7	83 ± 7
Mean (±SD) BMI (range)	22 ± 2 (19–26)	23 ± 3 (19–30)	26 ± 5 (19–39)	26 ± 6	26 ± 4
Mean Folstein MMSE*		29	28	28	28
Percent of group with abnormal history and physical examination item					
History					
Rare back/leg pain		17	45	44	45
Daily back/leg pain		0	38	33	45
Falls in past year		8	21	6	45
Poor balance		0	59	50	73
Hip operation, or hip or knee replacement	0	41	28	64	
Requires assistive device for ambulation		0	28	17	45
Physical examination					
Altered lower extremity reflexes		42	93	94	91
Decreased vibration sense		13	55	50	64
Decreased position sense		0	24	17	36
Upper extremity weakness		0	34	28	45
Lower extremity weakness	0	41	33	55	
Positive Romberg test	0	28	22	36	

*Folstein Mini-Mental State Examination.

arms and legs extended alongside the body. HO and CO subjects were permitted to use a pillow beneath their necks for comfort. When necessary, CO subjects were assisted by the experimenter from a standing position to the supine starting position. In addition, CO subjects wore a 2-inch wide transfer belt to assist in lowering as well as to ensure safety. A rise was considered complete when the subject assumed an upright standing position. As they attempted each rise, subjects were videotaped using a video camera on a tripod that stood 2 m above and 3 m from the center of the short side of the simulated floor.

Rating System

Using previous literature[3] and videotaped rises of young, healthy old, and congregate housing old adults from a previous pilot study, a set of key trunk and extremity positions were identified from the video record, using both normal and slow playback speed. These 10 trunk and extremity positions assumed by these subjects, termed Intermediate Positions, are pictured in Figure 1 and defined in Table 2. The presence of one IP did not automatically exclude the presence of another IP. Consequently, ratings for each rise included multiple IP items. Two raters performed independent IP ratings on 21 subjects from the pilot study, and percent observer agreement on individual IP items ranged from 86% to complete agreement (Cohen's Kappa from 0.6 to 1.0).

Data Analysis

For the present video data set, a single rater analyzed this study cohort of YC, HO, and CO to determine which IP were present during each subject's rise. Separate statistical comparisons between YC and HO, HO and CO Able, and CO Able and CO Unable were performed using two approaches. First, ANOVA with Fisher's PLSD for pairwise comparisons was used for continuous scale data: age, BMI in kg/m^2, mean total rise time (with the exception of CO Unable who could not complete the rise), and mean number of IP used. Second, Fisher's Exact Test was used for the presence or absence of an individual IP item. Pearson's r coefficient was used to analyze the relation between individual IP items. Finally, a principal components analysis with varimax rotation and restriction to two factors was performed using the individual IP items. Statistical significance was considered at a level of $P < .05$.

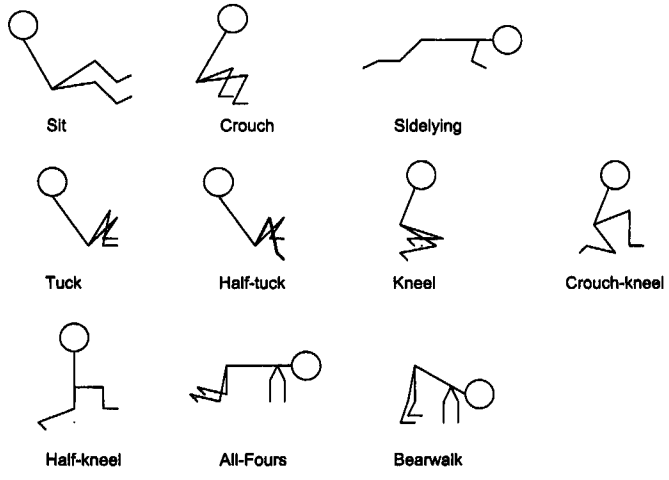

Figure 1. Intermediate positions assumed while rising from supine to standing.

RESULTS

Age and BMI

Healthy Old (mean age 73) were significantly older than YC (mean age 23), and CO (mean age 81) were significantly older than HO (see Table 1, $P < .0001$). Body mass index was significantly higher in the CO (mean 26) compared with the HO (mean 23, $P < .03$) but did not differ between the HO and YC (mean 22). The CO Able did not differ from the CO Unable with respect to age or BMI.

Total Rise Time

Mean total rise time (mean 5.5 sec, range 2.3–10.4, 95% CI 4.6–6.4) for HO was more than twice that of the YC (mean 2.6 sec, range 1.8–4.0, 95% CI 2.4–2.8), but the difference was not statistically ($P = .06$) significant (see Figure 2). The CO Able group took more than three times as long as the HO to complete the rise successfully, with a mean total rise time of 17.1 sec (range 4.0–41.2 sec, 95% CI 13.7–20.5, $P < .0001$).

Intermediate Positions (IP)

Mean number of IP did not differ between YC (mean 2.0, range 1–2, 95% CI 1.9–2.0) and HO (mean 2.1, range 1–4, 95% CI 1.8–2.5)(see Figure 3). In contrast, mean IP was increased in CO Able versus HO. Compared with the HO, CO Able had significantly higher IP (mean 3.4, range 1–5, 95% CI 3.0–3.8, $P < .0001$).

The percent of each group that exhibited each individual IP is illustrated in Table 3 and Figure 4. Key IP were used commonly in YC and CO whereas HO generally used a variety of positions. Nearly all of the YC used the Sit (100%) and Crouch (86%) positions, compared with HO (46% for each, $P < .0001$ and .01, respectively). Compared with the HO, most of the CO Able used the Crouch-Kneel (89% vs 33%, $P < .001$), All Fours (78% vs 13%, $P < .0001$), and Bearwalk (67% vs 29%, $P < .05$). CO Able were also less likely to use Crouch (6%) than were the HO ($P < .01$).

Relationships between Intermediate Positions

A correlation matrix was examined to determine the relationship between the individual IP items, and thus determine whether a particular rise strategy was present (see Table 4). Sit and Crouch were significantly and inversely related to Tuck, Crouch-kneel, All Fours, and Bearwalk. Furthermore, Tuck, Crouch-kneel, All Fours, and Bearwalk were significantly correlated to one another. These correlations were further supported by a factor analysis. Exploratory factor analysis was performed using orthogonal (varimax) rotation and specifying an eigenvalue of 1.0, such that two factors were extracted. For the main factor, high positive loadings (0.73 or greater) were noted for Crouch-Kneel, All Fours, and Bearwalk (plus a loading of 0.63 for Tuck) and high negative loadings (0.72 or greater) were noted for Sit and Crouch. This factor explained 51% of the total variance. These data suggest Tuck, Crouch-Kneel, All Fours plus Bearwalk as one rise strategy and Sit plus Crouch as a second strategy.

Intermediate Positions in CO Unable

As noted above, 11 CO Unable were unable to rise to a standing position without assistance. Mean number of IP was

Table 2. Floor Rise Intermediate Position Definitions

Position	Definition
Sit	Subject's hips and knees are flexed at obtuse angles, buttocks contact the floor.
Crouch	Subject's hips and knees are flexed at acute angles, such that the trunk is upright or leaning toward the subject's knees. The subject's knees do not contact the floor surface.
Sidelying	Subject lies on one side with shoulder, trunk, hips and at least one lower extremity (LE) contacting the floor.
Tuck	The subject's buttocks contact the floor with both knees flexed, 1 hip in external rotation and the other hip in internal rotation so that the internally rotated LE rests on the externally rotated LE.
Half Tuck	Subject is sitting on buttocks with one LE flexed at the hip and at the knee; the other LE is externally rotated at the hip and flexed at the knee. The foot or leg of the externally rotated LE often rests underneath the other knee (the other knee is elevated due to the flexion at hip and knee).
Kneel	Both knees on the floor as the base of support; knees, hips and shoulders in line roughly perpendicular to the floor; buttocks may or may not rest on heels.
Half-kneel	One knee contacts the floor, the other knee is flexed at approximately 90° and the foot is on the floor.
Crouch-kneel	Knee of one LE contacts the floor and the knee of the other LE is flexed with the foot on the floor. Knee angles are flexed acutely (<90 degrees). The trunk can be upright or flexed toward the subject's knees.
All Fours	Both knees contact the floor and the upper extremities contact the floor via hands or elbows; hips and shoulders are flexed such that the subject's trunk faces the floor in a prone manner.
Bearwalk	Subject faces the floor with legs extended and with the balls or soles of foot/feet contacting the floor. One or both hands remain in contact with the floor. As a result, the shoulders and pelvis are in alignment, and the pelvis and LE are in alignment, but the hips are flexed so that the trunk is not in alignment with the LE. Due to the leg extension, the hips will be higher than, or at the same level as, the subject's head.

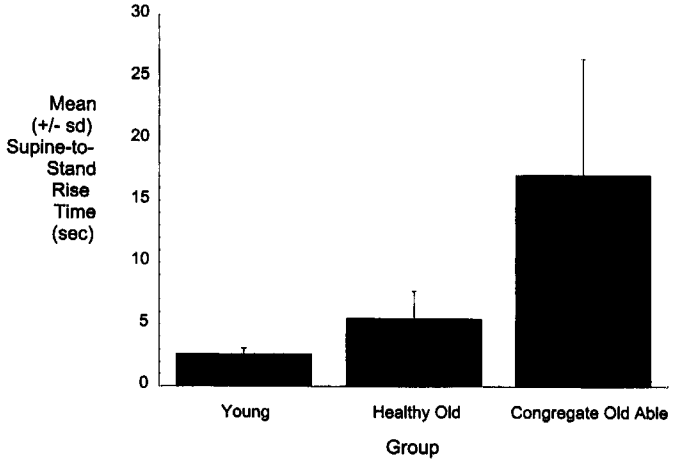

Figure 2. Mean total time (seconds) to rise from supine to standing in Young Controls, Healthy Old, and Congregate Old Able.

not significantly different in CO Unable (mean 2.5, range 0–6) versus CO Able (3.4, range 1–5). Nevertheless, the CO Unable differed slightly from the CO Able in IP items used. Compared to the CO Able, the CO Unable were less likely to Crouch-kneel (36% vs 89%, $P < .05$) and tended to be less likely to Bearwalk (27% vs 67%, $P = .06$) (see Table 3). The majority of the CO Unable (eight of the eleven CO Unable) could not achieve an upright, standing position, and subsequently, asked to terminate the unsuccessful rise attempt. Four of these eight subjects could not move past the IP Sit; in other words, they could not move past contacting the floor with the buttocks. The other four of the eight subjects rolled over or used Tuck to achieve a four-point contact position facing the floor, e.g., All Fours, Crouch-Kneel or Bearwalk, and then could go no further. One of the 11 CO Unable achieved an upright standing position and then began to fall and was caught by an experimenter. Two of the 11 CO Unable subjects sought a piece of furniture nearby to use during this rise but were otherwise unable to rise without the furniture assist.

DISCUSSION

Old adults have more difficulty in rising from the floor than young adults. The CO Able took more than three times as long as the HO to rise successfully from the floor, and the HO took twice as long as the YC to rise. A gradient might be described for the mean rise time and the mean number of intermediate positions (IP) so that CO Able were slowest in rising and used the most IP, followed by HO and then YC. This gradient might also be described for the presence of specific IP items, some (Sit, Crouch) are high in YC and low in CO Able, whereas some (Tuck, Crouch-kneel, All Fours and Bearwalk) are low in YC and high in CO Able. In both cases, the frequency of these IP items is intermediate in HO between

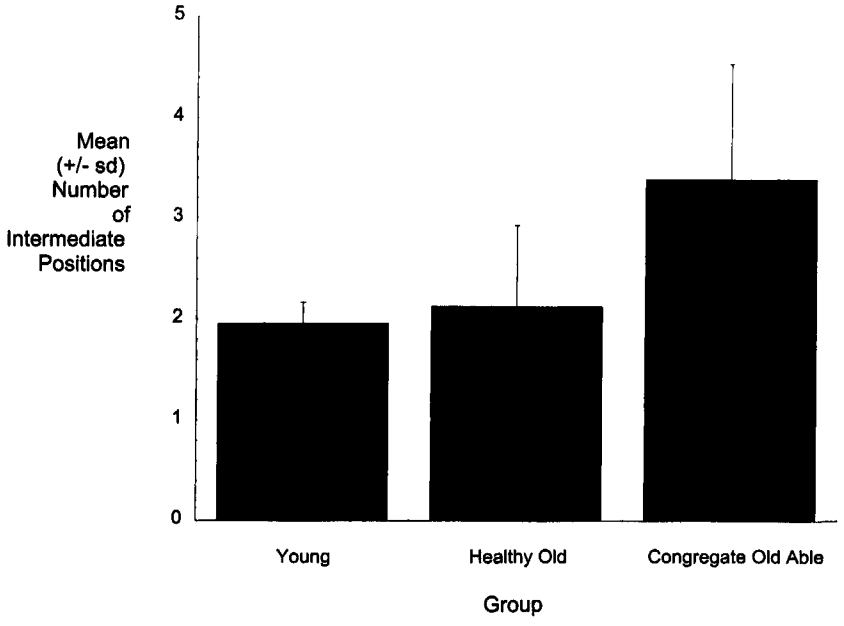

Figure 3. Mean total number of Intermediate Positions assumed by Young Controls, Healthy Old, and Congregate Old Able while rising from supine to standing.

Table 3. Percent (n) of Group Exhibiting Intermediate Positions

Item	Young Controls YC (n = 22)	Healthy Old HO (n = 24)	Congregate Old	
			CO Able (n = 18)	CO Unable (n = 11)
Sit	100 (22)[a]	46 (11)	39 (7)	45 (5)
Crouch	86 (19)[b]	46 (11)	6 (1)[c]	0
Sidelying	0	8 (2)	17 (3)	9 (1)
Tuck	0	8 (2)	28 (5)	55 (6)
Half-tuck	0	8 (2)	11 (2)	0
Kneel	0	4 (1)	6 (1)	27 (3)
Crouch-kneel	9 (2)	33 (8)	89 (16)[d]	36 (4)[g]
Half-kneel	0	17 (4)	0	0
All Fours	0	13 (3)	78 (14)[e]	55 (6)
Bearwalk	0[b]	29 (7)	67 (12)[f]	27 (3)

Significant differences
YC vs HO: [a]$P < .0001$; [b]$P < .01$.
HO vs CO Able: [c]$P < .01$; [d]$P < .001$; [e]$P < .0001$; [f]$P < .05$.
CO Able vs CO Unable: [g]$P < .05$.

YC and CO Able. The increased number of IP used and the specific IP items used by CO Able may account for the increased rise time observed in CO Able versus the other two groups. Note that only women were analyzed in the CO group, which may restrict generalizability of these data, although no gender effects were noted in the YC and HO groups.

Correlational and factor analysis data suggest that two basic rise strategies exist among those successfully able to rise from the floor. One rise strategy utilizes Tuck, Crouch-kneel, All Fours, and Bearwalk, and the other rise strategy utilizes Sit and Crouch. The frequency of Sit and Crouch is highest among YC and seems to be their preferred rise strategy, and, accordingly, Tuck, Crouch-Kneel, All Fours, and Bearwalk are essentially absent among YC. This pattern was also the most common supine to stand pattern seen in Van Sant's young adults (mean age 29),[3] although the description differed, namely symmetrical upper extremity push followed by forward trunk flexion and squatting on both legs symmetrically. Analogously, Sit and Crouch are infrequent among CO Able, whereas Tuck, Crouch-Kneel, All Fours, and Bearwalk are common among CO Able, suggesting the latter as the preferred CO Able rise strategy. The HO rise strategy seems to incorporate elements of both strategies, perhaps reflecting heterogeneity in HO performance ability.

One might hypothesize that IP occur in a specific order, although the present data were acquired and analyzed correlationally without strict regard for ordinal relationships. For example, one might expect Sit to be followed by Crouch for one strategy (as noted in Van Sant[3] and Green[4]), whereas a progression from Tuck to Crouch-Kneel to All-Fours to Bearwalk might be a typical order for the second strategy.

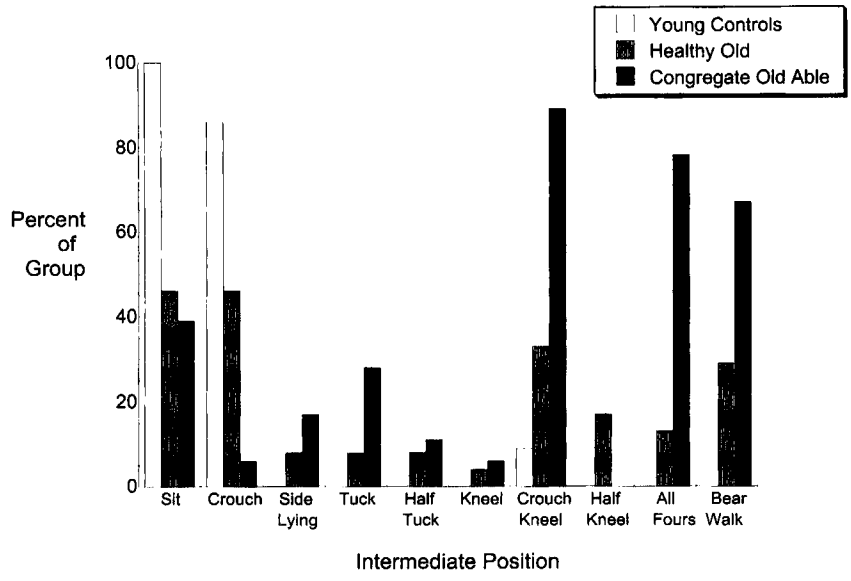

Figure 4. Percent of Young controls, Healthy Old and Congregate Old Able using individual Intermediate Positions.

Table 4. Correlations between Intermediate Positions for Young Controls, Healthy Old, and Congregate Old Able

	Sit	Crouch	Side-Lying	Tuck	Half-Tuck	Kneel	Half-Kneel	Crouch-Kneel	All Fours
Sit									
Crouch	0.62*								
Sidelying	−0.14	−0.17							
Tuck	−0.35*	−0.34*	−0.10						
Half Tuck	−0.20	−0.25	0.17	−0.09					
Kneel	−0.23	−0.17	−0.05	−0.06	−0.05				
Half-kneel	−0.07	−0.25	−0.08	−0.09	−0.07	0.33			
Crouch-kneel	−0.54*	−0.80*	0.23	0.42*	0.18	0.03	−0.21		
All Fours	−0.41*	−0.51*	0.22	0.58*	−0.01	0.10	−0.16	0.58*	
Bearwalk	−0.42*	−0.56*	0.19	0.32*	0.40*	−0.12	−0.03	0.51*	0.54*

*$P < .05$.

The second strategy suggests a preference for maintaining upper and lower extremity contact with the floor, presumably minimizing the lower extremity strength requirements to rise and maximizing stability and postural control. Given the general increase in neuromuscular abnormalities on history and examination between HO and CO Able, it is possible that use of the second strategy reflects the burden of increased physical impairment, specifically joint pain, muscle weakness, sensory loss, and postural instability. Because of the small sample size, it is difficult to determine which specific impairment had the greatest impact on CO Able rise performance; rise time, for example, correlated significantly with only one impairment item in the CO Able, lower extremity weakness ($r = 0.48$, $P < .05$).

A substantial subset of the congregate housing old (38%) was unable to rise without assistance (CO Unable). IP use in the CO Unable differed from the CO Able, in significantly lower use of Crouch-Kneel, as well as trends in lower usage of All Fours and Bearwalk and in higher usage of Sit, Kneel, and Tuck. The CO Unable seemed to be able to get into certain preparatory positions (Sit, Kneel, Tuck) but were unable to get into more presumably more challenging positions (Crouch-Kneel, All Fours, Bearwalk) requiring higher leg joint ranges of motion, better strength, and better postural control. Though CO Unable and CO Able were similar in age and gender, there is a suggestion that there was a higher prevalence of reported falls, reports of poor balance, increased requirements for assistive devices, and weakness and sensory loss on examination (see Table 1).

Data from this study may serve as the foundation for future interventions to improve the ability to rise from the floor. The optimal approach for training floor rise ability has not been clearly identified. Pilot studies in Parkinson's patients who practiced whole-body movements related to rising from the floor (including kneeling and half-kneeling) found floor rise time improvements of more than 40%.[6] For older adults with musculoskeletal and neurological impairment, use of positions such as Sit, Kneel, and Tuck, followed by instruction in positions such as Crouch-Kneel, All Fours, and Bearwalk may be useful in decreasing floor rise disability. Future studies might analyze these positions biomechanically and explore further why certain impaired older adults do not (or cannot) utilize some favorable intermediate positions. Analyzing rising from the floor is complex because the joint

motions are multisegmental (neck, arm, leg, trunk, and different components of each) as well as multiplanar (3-dimensional). Multiple muscle groups are activated and the force output, such as at the knee,[7] may fluctuate at different stages of the rise perhaps in order to maintain postural control while rising.[7]

Data from this study may also be used in assessment of physical performance in older adults when use of certain intermediate positions heralds a decline in floor rise ability. The loss of the ability to utilize the more challenging positions (such as Crouch-Kneel) may also serve as a marker to identify an older adult who is at high risk for the inability to rise from the floor. Future studies should also examine the impact of other starting positions (such as prone or side-lying) and the importance of assistive devices or furniture in facilitating rising from the floor.

REFERENCES

1. Tinetti ME, Liu WL, Claus EBB. Predictors and prognosis of inability to get up after falls among elderly persons. JAMA 1993;269:65–70.
2. Simpson JM, Salkin S. Are elderly people at risk of falling taught how to get up again? Age Ageing 1993;22:294–296.
3. Van Sant AF. Rising from a supine to erect stance: Description of adult movement and a developmental hypothesis. Phys Ther 1988;68:185–192.
4. Green LN, Williams K. Differences in developmental movement patterns used by active versus sedentary middle-aged adults coming from a supine position to erect stance. Phys Ther 1992;72:560–568.
5. Alexander NB, Ulbrich J, Raheja A, Channer D. Rising from the floor in older adults. J Am Geriatr Soc 1997;45:564–569.
6. Yekutiel MP, Pinhasov A, Shahar G et al. A clinical trial of the re-education of movement in patients with Parkinson's disease. Clin Rehab 1991;5:207–214.
7. Dahlkvist NJ, Mayo P, Seedhom BB. Forces during squatting and rising from a deep squat. Eng Med 1982;11:69–76.