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Bed and Toilet Height as Potential Environmental Risk Factors

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Seat height that is too high (> 120% of lower leg length [LLL]) or too low (< 80% of LLL) can impede safe transfer and result in falls. This study examines the difference between LLL of frail nursing home residents and the height of their toilets and beds in the lowest position, compares the patient or environmental characteristics of those able to transfer from the bed or toilet to those who cannot, and determines the relationship of patient or environmental characteristics to bed-related falls. A retrospective observational design using secondary data from 263 nursing home residents finds that bed height of three fourths of participants was greater than 140% of LLL, whereas toilet height of more than half was 100% to 120% of LLL. Increased fall risk is associated with increased age, shorter length of stay, normal lower extremity range of motion, less cognitive impairment, more behavioral symptoms, and no complaints of pain during exam.

Keywords: *patient safety; accidental fall; nursing home; bed; mattress; body height*

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The ability to safely rise to a standing position is an important determinant of independence among older adults (Hughes & Schenkman, 1996). Similar to other functional tasks, it is the result of the interactive effect between an individual's personal competence (physical health, cognitive ability, and psychological adjustment) and the environment (Lawton & Nahemow, 1973). Personal competence includes many factors that are nonmodifiable. Thus, for individuals with impaired personal competence, the proportion of negative outcomes attributable to environmental factors increases (Lawton & Nahemow, 1973). Among frail nursing home residents, negative outcomes such as unsafe bed transfers and bed-related falls are highly dependent on environmental factors.

The ability to transfer out of bed from a sit to stand (STS) position is dependent on several general patient characteristics such as age, functional status, and disease state (Mazza, Benvenuti, Bimbi, & Stanhope, 2004; Mourey, Grishin, d'Athis, Pozzo, & Stapley, 2000). Because these characteristics are interrelated, however, it is difficult to pinpoint the exact determinants of impaired STS performance. Considerable research conducted in the past decade has uncovered several physical factors specific to STS movements. Lower extremity strength, especially knee extension and quadriceps strength, for example, has correlated with poor STS performance among those with functional impairments (Alexander, Schultz, & Warwick, 1991; Hughes, Myers, & Schenkman, 1996; Lord, Murray, Chapman, Munro, & Tiedemann, 2002; Schenkman, Hughes, Samsa, & Studenski, 1996). Other physical factors known to influence STS transfer include hip or knee joint range of motion, trunk flexibility or strength, postural control, balance, upper-arm strength, and visual contrast sensitivity (Alexander et al., 1991; Alexander, Galecki, et al., 2001; Alexander, Koester, Grunawalt, 1996; Lord et al., 2002; Schenkman et al., 1996). Fatigue and pain have also been identified as contributors to physical inability to perform STS functions (Alexander et al., 1991; Hughes et al., 1996; Lord et al., 2002). Psychological characteristics, such as cognitive level, anxiety, and motivation, also influence safety with transferring and standing (Hughes et al., 1996; Lord et al., 2002).

Environmental factors influencing STS transfer include seat height, seat compressibility (e.g., mattress firmness), and the presence of transfer enablers such as grab bars. STS transfer ability is greatly hampered at seat heights that are at or less than 80% of lower leg length (the distance from the heel to the joint line of the knee; Alexander, Galecki, et al., 2000; Hughes & Schenkman, 1996). Heights greater than 120% of lower leg length, especially when the feet can not touch the ground, also deter successful STS

transfer and create a higher risk for falls (Alexander et al., 1996; Weiner, Long, Hughes, Chandler, & Studenski, 1993). Seat height between 100% and 120% of lower leg length is considered optimal because it requires less knee extension, less work by the quadriceps muscles, and less forward leaning during transfer (Alexander et al., 1996; Alexander, Fry-Welch, Ward, Folkmier, 1992; Alexander, Galecki, et al., 2000; Alexander, Galecki, et al., 2001; Alexander, Gross, Medell, & Hofmeyer, 2001; Edlich, Heather, & Galumbeck, 2003; Hughes et al., 1996; Hughes & Schenkman, 1996; Kawagoe, Tajima, & Chosa, 2000; Kejonen, Kauranen, Ahasan, & Vanharanta, 2002; Lord et al., 2002; Schenkman et al., 1996; Schlicht, Camaione, & Owen, 2001; Weiner et al., 1993; Yamada & Demura, 2004). Seat height between 121% and 140% of lower leg length, also referred to as "bar stool" or counter seat height, deters standing in older adults because of foot placement instability (Alexander et al., 1996).

This study focuses on the nursing home environmental characteristics that affect nighttime falling, particularly the discrepancy between lower leg lengths of frail nursing home residents and the height of their toilets and beds in lowest position. Bed-related falls generally occur at night, when residents get out of bed to use the bathroom, and are a major safety concern for nursing homes. Thus, a secondary aim is to compare the patient and environmental characteristics of those able to independently transfer from bed and toilet to the characteristics of those who cannot to determine the relationship of those characteristics to bed-related falls.

Method

Design

This study used a retrospective, observational design using secondary data collected in a study that examined the effect of an advanced practice nurse (APN) intervention on side rail use (Capezuti et al., 2007).

Sites and Sample

Four medium-sized, Philadelphia metropolitan area nursing homes participated in the study. The homes varied in size (235, 205, 170, and 120 beds), type (three nonprofit and one for-profit), and affiliation (two religious, one chain member, and one part of an academic health center). Medicaid as the primary payer ranged from 41% to 93%. In two homes, few

residents were members of racial/ethnic minorities (0% and 7%), whereas in the other two homes, most (74% and 75%) represented racial/ethnic minorities, particularly African Americans.

Given that the focus of the primary study was side rail use, nighttime side rail observation rounds were conducted in each of the four participating nursing homes. Of the 710 nursing home residents present during these rounds prior to an APN evaluation, 376 met the study's inclusion criteria: They had resided in the nursing home for at least 3 months and were in beds with restrictive (full enclosure of two full-length or four half-length rails) side rails. Of these residents, 301 (80.05%) of them or their proxies (in cases of decision-making incapacity) consented to participate. The informed written consent procedure was approved by the University of Pennsylvania Institutional Review Board.

After obtaining consent, a trained research assistant determined each resident's cognitive, behavioral, mobility, and fall risk status using standardized instruments. Within a month of data collection, a master's-prepared gerontologic APN conducted a comprehensive evaluation and care plan aimed at restrictive side rail reduction (Capezuti, Talerico, et al., 1999; Capezuti, Talerico, Strumpf, & Evans, 1998). The physical examination portion of the APN assessment included measurement of each resident's lower leg length and bed in its lowest position. The final sample for this study included all of those with these two measurements ($n = 263$).

Measures

APN evaluation. The aim of the APN evaluation in the primary study was to develop an individualized plan of care addressing resident-specific interventions to reduce side rail use and prevent bed-related falls (Capezuti, Talerico, et al., 1999). The APN used the Individualized Assessment for Evaluation of Siderail Use tool (Capezuti et al., 1998) to identify factors that influence side rail usage, such as fall risk, in-bed mobility, transferring skills, sleep problems, and incontinence. The APN evaluation consisted of data collection in four areas: (a) review of resident history, staff reasons for using side rails, health care records, and incident reports; (b) physical examination; (c) environmental characteristics of residents' bedroom and bathroom; and (d) identification of resident-specific problems.

Data for this study were obtained from the physical examination and environmental assessment sections of the APN evaluation. Pertinent examination components included resident size (height and weight), lower leg

length in inches, joint mobility (range of motion in major joints of upper and lower extremities), strength testing (upper and lower extremities), and performance-based tests. Lower leg length was measured as the distance from the heel to the lateral tibial plateau (upper edge of bony prominence of outer aspect of the knee, at junction of tibia and femur). Performance-based testing included the observation of the resident rolling to either side of the bed, sitting up in bed, standing from sitting position, walking to the bathroom, getting on and off the toilet, and returning to bed. The head of the bed and bed height were placed in the positions that were usual for each resident; however, all residents had the directive of bed in "lowest position" documented in their nursing care plan. Only those who could perform the observed maneuvers with a minimum of one-person assistance participated in this section of the evaluation. The APN noted the residents' ability to perform these skills, including the need for human assistance (one or two persons) and/or assistive devices (cane, walker, etc.). The APN also noted if any of these maneuvers caused pain.

The residents' personal bedroom and bathroom environments were also directly assessed. The APN measured the distance from the floor to the top of the mattress with the resident sitting on the mattress and the bed in its lowest position. Mattress consistency (i.e., firmness), the use of a board under the mattress, and the presence of transfer enablers (half- or quarter-length upper side rail, grab bar, or pole) or other assistive devices at the bedside were noted. The APN measured the height of the toilet and assessed the placement of grab bars and handrails in the bathroom.

Demographic and clinical characteristics. Demographic, health history, and treatment data were collected from the residents' medical records. The research assistant interviewed the residents' primary nurses for fall-related factors (fall risk, nocturia, and history of getting out of bed with side rails raised). Mental health measures (cognition and behavioral symptoms) were assessed by resident and nursing staff interviews.

Cognitive status was evaluated with the Folstein Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), which has reported good intrarater reliability, interrater reliability, and construct validity across diverse populations (Tombaugh & McIntyre, 1992). *Behavioral symptoms* were assessed with the Nursing Home Behavior Problem Scale (Ray, Taylor, Lichtenstein, & Meador, 1992). This scale has an interrater reliability of .80, good face validity, and high convergent validity (Ray et al., 1992).

The Morse Fall Scale (Morse, 1997), used to measure *fall risk*, has demonstrated high sensitivity (72%), fair specificity (51%) in predicting

falls (Eagle et al., 1999), and high interrater reliability (Morse, 1997). *Falls data* were obtained from a review of nursing home incident reports for up to a 1-year period preceding each resident's APN evaluation. Only bed-related falls and serious injuries (all fractures, dislocated joints, lacerations requiring sutures, or subdural hematoma) occurring between 9 p.m. and 6 a.m. in the resident's bedroom were included. We were able to ensure that falls were bed-related because the time of day and its location were recorded for each fall.

Treatments that can affect fall status, such as *psychoactive medication* and *pain drug* use, were obtained from physician orders and nursing medication and treatment records for the month pre-evaluation. Psychoactive medications included all antipsychotic, sedative–hypnotic, and/or antidepressant drugs. None of these facilities used physical restraints in bed. *Institutional characteristics* of each facility (ownership type, religious affiliation, and nurse staffing data) were obtained from the Centers for Medicare and Medicaid Services Nursing Home Compare Web site for the period close to the data collection period (Centers for Medicare & Medicaid Services, U.S. Department of Health and Human Services, 2007).

Data Analysis

Frequency distributions and descriptive statistics were used to describe the sample. Comparisons of resident and environmental characteristics between those able to transfer out of bed and those who could not transfer without human assistance were completed using *t* tests, Wilcoxon rank sum tests, chi-square tests, or Fisher's exact tests, as appropriate. These same tests were applied, as appropriate, to investigate the relationships between resident or environmental characteristics and bed-related falls. Multivariable Poisson regression modeling techniques were used to identify an optimal set of independent predictors of falls.

Findings

The 263 resident–participants represent a typical sample of chronic care elder nursing home residents. Table 1 presents resident characteristics of the whole sample (column 2) and by transfer groups (columns 3 and 4). Column 5 shows the *p* values associated with the statistics used to compare characteristics by transfer groups, and column 6 shows the *p* values associated with the statistic used to examine the association between characteristic and

the frequency of bed-related falls. Results for variables treated as continuous are reported as means and standard deviations, whereas results for categorical or ordinal variables are reported as percentages.

The participants were predominantly female (77.6%) and widowed (60.8%), participants' mean age was 84.2 (SD = 9.11), their average length of stay was 25.2 months (SD = 35.90), and their primary payer was Medicaid (71.1%). Approximately one third of the participants were racial/ethnic minorities (mostly African Americans), which reflects the demographics of the metropolitan area of study. Most participants were cognitively impaired (MMSE M = 17.0, SD = 8.87), and more than half demonstrated weakness and decreased upper or lower extremity range of motion. Almost half were at risk for bed-related falls, with 29.7% having fallen at least once at night (78 of 263) and 23.2% having been identified by staff as getting up out of bed with side rails raised. Most (82.9%) experienced nocturia.

Only 24.0% were able to transfer out of bed independently (i.e., without human assistance). We explored differences between the two groups (Table 1, columns 3 and 4) and found that those unable to transfer out of bed without human assistance, compared to those who could, had a significantly longer length of stay (28.7 vs. 15.9 months) and were more likely to demonstrate weakness (66.5% vs. 33.3%), experienced more decrease in range of motion in upper (61.0% vs. 34.9%) and lower extremities (65.0% vs. 30.2%), and demonstrated greater impairment in cognition (MMSE = 15.0 vs. 21.0). Those able to transfer without human assistance were more likely to sleep on a firm mattress (69.8% vs. 42.7%) were more likely to use psychoactive medications (87.3% vs. 69.0%), experienced more bed-related falls (49.2% vs. 23.5%), and were more likely to get out of bed with side rails raised (50.8% vs. 14.5%).

The mean height and weight of participants was 63.07 in. (SD = 4.5, range = 48 to 75) and 136.21 pounds (SD = 36.59, range = 66 to 304). The average lower leg length was 15.45 in. (SD = 1.61, range = 11.5 to 21), whereas the average bed height was 24.0 in. (SD = 2.94, range = 17 to 30) and toilet height was 18.54 in. (SD = 0.93, range = 15 to 24). We categorized the ratio of bed or toilet to lower leg length into three groups: 100% to 120%, 121% to 140%, and greater than 140% (Table 2). The bed height of three fourths of participants was greater than 140% of lower leg length, whereas the toilet height for more than half of the participants was 100% to 120% of lower leg length.

We then considered whether bed or toilet height would differ depending on the resident's ability to transfer out of bed with human assistance.

Table 1
Personal (Demographic, Physical Health, Mental Health, Fall-Related) and Environmental (Treatment) Characteristics

Characteristics to Bed-Related Falls	All[a]			Transfer Groups: Able to Transfer Out of Bed[b]			Transfer Groups: Not Able to Transfer Out of Bed[c] Between Transfer Groups			*p* Value Difference Between Transfer Groups	*p* Value Relationship to Bed-Related Falls
	M	*SD*	%	*M*	*SD*	%	*M*	*SD*	%		
Demographics											
Age	84.2	9.11		86.3	10.14		84.0	8.79		.88	.15
White			71.5			79.4			69.0	.11	.12
Female			77.6			82.5			76.0	.28	.42
Widowed			60.8			65.1			59.5	.33	.55
Years of education[d]	11.0	2.92		11.0	2.57		11.0	3.02		.47	.94
Medicaid[e]			71.1			65.1			73.0	.23	.10
Length of stay (months)[d]	25.2	35.90		15.9	30.58		28.7	37.30		.04	.03
Physical exam findings											
Transfer ability[f]			23.9	—	—	—	—	—	—	—	< .0001
Lower or upper extremity weakness			58.6			33.3			66.5	< .0001	.12
Decreased upper extremity range of motion			54.7			34.9			61.0	.0003	.20
Decreased lower extremity range of motion			56.6			30.2			65.0	< .0001	.38
Pain			30.4			15.9			35.0	.004	.05

(continued)

Table 1 (continued)

Characteristics to Bed-Related Falls	All[a]			Transfer Groups: Able to Transfer Out of Bed[b]			Transfer Groups: Not Able to Transfer Out of Bed[c]			*p* Value Difference Between Transfer Groups	*p* Value Relationship to Bed-Related Falls	
	M	*SD*	%	*M*	*SD*	%	*M*	*SD*	%			
Mental health												
Cognition[d,g]		17.0	8.87		21.0	6.60		15.0	8.80		< .0001	.02
Behavioral symptoms[d,h]		1.0	8.46		1.0	9.74		1.0	8.02		.47	.16
Treatment												
Any psychoactive drug use				73.4			87.3			69.0	.004	.94
Any pain drug use				37.6			38.1			37.5	.93	.22
Firm mattress				49.4			69.8			42.7	.0009	.64
Fall-related factors												
Fall risk[d,i]		50.0	18.5		50.0	18.07		50.00	18.54		.064	< .0001
Bed-related falls				29.7			49.2			23.5	< .0001	—
Get out of bed with side rails up				23.2			50.8			14.5	< .0001	< .0001
Nocturia				82.9			84.5			77.85	.22	.40

Note: *t* test used for continuous variables; chi-square or Fisher's exact test used for percentages.

a. $N = 263$.

b. $n = 63$.

c. $n = 200$.

d. Wilcoxon Rank Sum Test used here because of markedly non-normally distributed data.

e. Medicaid refers to the percentage of residents for whom Medicaid is the primary payer of their nursing home care.

f. Transfer ability performance was evaluated by the advanced practice nurse during the physical examination.

g. Cognition is measured with the Mini-Mental State Examination. Scores range from 0 to 30, with lower scores indicating poorer cognitive function; a score of 17 or below is indicative of severe cognitive impairment.

h. Behavioral symptoms were measured with the Nursing Home Behavior Problem Scale. Scores range from 0 to 116, with higher scores representing a greater number of behavioral symptoms.

i. Fall risk was evaluated with the Morse Fall Scale, in which total scores range from 1 to 125, with scores greater than 44 indicating a high risk for falls.

Table 2
Comparison of Three Categories of Bed or Toilet Height to Lower Leg Length (LLL)

	100% to 120% LLL[a]		121% to 140% LLL		> 140% LLL	
	n	%	*n*	%	*n*	%
Bed height	16	6.1	51	19.4	196	74.5
Toilet height	144	54.8	100	38.0	19	7.2

Note: $N = 263$.
a. Optimal seating height for sit to stand transfer.

Although the percentage of those with a bed height greater than 140% of lower leg length was lower among those able to transfer compared to those who could not (68.2% vs. 76.5%), this was not a statistically or clinically significant. Only 7.2% of the entire sample had toilet heights greater than 140% of lower leg length, but more than twice of those able to transfer compared to those not able to transfer (12.7% vs. 5.5%) had these higher toilet heights.

The fall count was used as the primary endpoint for modeling the covariates in the data. Controlling for the different residents' number of months pre intervention, Poisson regression revealed that the following factors constituted an optimal set of independent predictors of falls: age, length of stay, range of motion of lower extremities, cognitive status, number of behavioral symptoms, and presence of pain during exam. Results of the final model are summarized in Table 3. Increased risk of falls was more likely associated with increased age, shorter length of stay, normal lower extremity range of motion, less cognitive impairment, more behavioral symptoms, and no complaints of pain during exam. There were only eight serious injuries, all of which occurred in those whose bed heights were greater than 120% of lower leg length.

Discussion

Although 76% of residents in this frail sample were unable to get out of bed without human assistance, approximately 60% of all nursing home residents have difficulty transferring out of bed independently (Mehr, Fries, & Williams, 1993). It remains unclear, however, what proportion of this problem is attributable to environmental constraints such as bed heights that are

Table 3
Poisson Regression Multivariable Model

Predictor	Risk Estimate	*SE*	95% Confidence Limits		Test Statistic	*p* Value
			Lower	Upper		
Intercept	–5.8400	1.5921	–8.9605	–2.7194	13.45	.0002
Months preintervention	1.0425	0.0550	0.9401	1.1560	0.62	.4301
Age	1.0442	0.0179	1.0096	1.0800	6.34	.0118
Length of stay	0.9825	0.0057	0.9713	0.9938	9.11	.0025
Lower extremity range of motion	0.5131	0.1346	0.3068	0.8579	6.47	.0110
Cognition	1.0512	0.0165	1.0192	1.0841	10.05	.0015
Behavioral symptoms	1.0338	0.0080	1.0182	1.0495	18.46	.0001
Pain during exam	3.4885	1.4252	1.5663	7.7696	9.35	.0022

too high or too low and/or the inaccessibility of appropriate transfer enablers. For the approximately 40% of nursing home residents who can transfer out of bed, bed environments that support safe transfer are essential (Mehr et al., 1993).

Despite strong evidence from studies utilizing biomechanical analyses and conducted in controlled experimental settings that the most optimal seat height is approximately 120% of an individual's lower leg length (Alexander et al., 1992; Alexander et al., 1996; Alexander, Galecki, et al., 2000; Alexander, Galecki, et al., 2001; Alexander, Gross, et al., 2001; Edlich et al., 2003; Hughes et al., 1996; Hughes & Schenkman, 1996; Kawagoe et al., 2000; Kejonen et al., 2002; Lord et al., 2002; Schenkman et al., 1996; Schlicht et al., 2001; Weiner et al., 1993; Yamada & Demura, 2004), this study found that almost all of the residents (93.9%) in the four nursing homes had bed heights greater than 120% of lower leg length, with three fourths having bed heights greater than 140%. Adjustment of bed height is a nursing intervention that can improve STS performance and potentially reduce fall risk. Bed in lowest position is the measure most frequently documented and employed to reduce bed-related fall risk and promote bed transfers. This directive is problematic, however, for three distinct, but related, reasons.

First, placing the bed in its lowest position stems from reliance on a priori practice rather than evidence-based outcomes. That is, given that bed heights vary by manufacturer and bed style, the encouragement of lowest position in standardized care plans and protocols will result in different lowest heights.

A bed placed in its lowest position, for example, if that position is less than 100% of the occupant's lower leg length, may actually contribute to unsafe transfer and falls. On the other hand, shorter bed occupants (with subsequently short lower leg lengths), may find that hospital beds, even in their lowest position, are still too high to safely transfer to a standing position. It is critical, therefore, that bed height adjustment depend on the individual patient's lower leg length rather than the height of a particular bed style.

Second, beds consistently placed in lowest position are not ergonomically optimal for nursing staff providing care and places them at risk for injury. Occupational-related back injury rates are very high among nursing staff working in nursing homes (Nelson et al., 2006). To reduce lumbar forces that lead to musculoskeletal strain associated with lifting and transferring residents, the use of adjustable height beds is encouraged (Caboor et al., 2000; Nelson et al., 2006). Thus, beds that provide the widest choice of bed heights that can be adjusted to a range of heights between 7 and 26 in. (including a 6-in. mattress) could accommodate the needs of residents with and without the ability to transfer and reduce injuries among nurses (Capezuti, Talerico, et al., 1999). Finally, even if measures were taken to appropriately gauge the bed occupant's leg length to bed height, difficulty in adjustment of bed height, especially in manually operated beds still commonly employed in many American nursing homes, may impede staff willingness or ability to do so.

Similarly, for those able to transfer and walk to the bathroom, toilet height also requires individual height considerations. In this sample, toilet height was more likely than bed height to be in the optimal range for STS performance (54.8% vs. 6.1%). This likely reflected facilities' compliance with the standard Americans with Disabilities Act (ADA) height toilets that must have a 17- to 19-in. floor-to-bowl rim height, including the seat (see http://www.usdoj.gov/crt/ada/adahom1.htm). Although this height range would accommodate almost all of the participants in this study, this height would be too high for the 24 residents with lower leg lengths less than 14 in.

Our study findings make clear that nursing home residents, regardless of physical or cognitive impairments or environmental barriers such as restrictive side rails or high bed heights, will continue to get out of bed. Although the 24% of residents able to transfer out of bed without human assistance had fewer physical or cognitive deficits, approximately half were known to get out of bed with raised side rails, and almost half experienced bed-related falls. This is consistent with other studies that demonstrate that ambulatory residents are more likely to fall and to suffer fall-related injuries (Capezuti, Evans, Strumpf, Maislin, 1996; Thapa, Brockman, Gideon,

Fought, & Ray, 1996). Inability to transfer independently was found to be associated with cognitive impairment and significant physical problems such as weakness and decreased joint range of motion that manifested in 65% expressing pain during a physical examination. These difficulties may have been associated with fewer attempts to get out of bed with raised side rails (14.5%); however, about one fourth still fell from bed. Those without the ability to transfer or walk may benefit the most from very low height beds, those that are less than 14 in. from the floor including the mattress (Capezuti, Talerico, et al., 1999).

We found, similar to other studies (Capezuti et al., 2007; Capezuti, Maislin, Strumpf, & Evans, 2002; Capezuti, Strumpf, Evans, Maislin, 1999) that restrictive side rails do not reduce the likelihood of falls. The side rails may have contributed to the 3% ($n = 8$) of residents who experienced at least one fall-related serious injury because they add up to 24 in. to the fall height, thus increasing the likelihood of patient injury (O'Keeffe, Jack, & Lye, 1996).

This study was limited by the data set available for secondary analysis. Because the primary study included only those with restrictive side rail use at baseline, the sample represented the most physically frail and cognitively impaired sector of the nursing home population. We were unable to examine the relationship between bed height and bed-related falls because only 6.1% ($n = 16$) of residents had bed heights in the optimal range. Although toilet height demonstrated greater variability among residents, bed-related falls were limited to the resident's bedroom. General muscle strength and range of motion of upper and lower extremities were tested; however, we did not use reliable instruments to measure actual performance (Guralnik et al., 2000). Furthermore, we did not specifically evaluate other physical factors known to be associated with STS ability, such as knee extension and quadriceps strength, hip or knee joint range, trunk flexibility and strength, or postural control and balance (Alexander, Gross, et al., 2001; Lord et al., 2002; Schenkman et al., 1996).

Bed rise, or the ability to move from a lying to sitting position, is also an important consideration when determining an individual's capacity to safely get out of bed. Upper extremity strength, postural control, trunk flexibility, strength, and balance are all associated with successful bed rise (Alexander, Galecki, et al., 2001), whereas lowering the head of the bed significantly below 30 degrees increases bed rise difficulty (Alexander, Galecki, et al., 2000; Alexander, Grunawalt, Carlos, & Augustine, 2000). This study did not address bed rise or the compensatory movement strategies used to improve bed rise and STS performances, such as when the older adults use their

hands or arms to steady or support themselves, move more slowly than they might otherwise, rock prior to standing to establish momentum and balance, and, if rising from a chair, lean and scoot forward in the seat to maximize balance and leg strength (Alexander et al., 1991; Bohannon & Corrigan, 2003; Hughes & Schenkman, 1996; Mazza et al., 2004).

In summary, reduced personal competence of frail nursing home residents requires clinicians to address potential environmental hazards to safe STS mobility. Individualization of bed height can both assist ambulatory residents in independently transferring out of bed and reduce injury risk among nonambulatory residents. Beds with the widest height options available can accommodate both categories of residents and reduce the risk of injury among nursing staff.

References

Alexander, N. B., Fry-Welch, D. K., Ward, M. E., & Folkmier, L. C. (1992). Quantitative assessment of bed rise difficulty in young and elderly women. *Journal of the American Geriatrics Society, 40*(7), 685-691.

Alexander, N. B., Galecki, A. T., Grenier, M. L., Nyquist, L. V., Hofmeyer, M. R., Grunawalt, J. C., et al. (2001). 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. *Journal of the American Geriatrics Society, 49*(11), 1418-1427.

Alexander, N. B., Galecki, A. T., Nyquist, L. V., Hofmeyer, M. R., Grunawalt, J. C., Grenier, M. L., et al. (2000). Chair and bed rise performance in ADL-impaired congregate housing residents. *Journal of the American Geriatrics Society, 48*(5), 526-533.

Alexander, N. B., Gross, M. M., Medell, J. L., & Hofmeyer, M. R. (2001). Effects of functional ability and training on chair-rise biomechanics in older adults. *Journals of Gerontology: Biological Sciences & Medical Sciences, 56*(9), M538-M547.

Alexander, N. B., Grunawalt, J. C., Carlos, S., & Augustine, J. (2000). Bed mobility task performance in older adults. *Journal of Rehabilitation Research & Development*, *37*(5), 633-638.

Alexander, N. B., Koester, D. J., & Grunawalt, J. A. (1996). Chair design affects how older adults rise from a chair. *Journal of the American Geriatrics Society, 44*(4), 356-362.

Alexander, N. B., Schultz, A. B., & Warwick, D. N. (1991). Rising from a chair: Effects of age and functional ability on performance biomechanics. *Journals of Gerontology: Biological Sciences & Medical Sciences*, *46*(3), M91-M98.

Bohannon, R. W., & Corrigan, D. L. (2003). Strategies community dwelling elderly women employ to ease the task of standing up from household surfaces. *Topics in Geriatric Rehabilitation, 19*(2), 137-144.

Caboor, D. E., Verlinden, M. O., Zinzen, E., Van Roy, P., Van Riel, M. P., & Clarys, J. P. (2000). Implications of an adjustable bed height during standard nursing tasks on spinal motion, perceived exertion and muscular activity. *Ergonomics, 43*(10), 1771-1780.

Capezuti, E., Evans, L., Strumpf, N., & Maislin, G. (1996). Physical restraint use and falls in nursing home residents. *Journal of the American Geriatrics Society, 44*, 627-633.

Capezuti, E., Maislin, G., Strumpf, N., & Evans, L. (2002). Siderail use and bed-related fall outcomes among nursing home residents. *Journal of the American Geriatrics Society, 50*, 90-96.

Capezuti, E., Strumpf, N., Evans, L., & Maislin, G. (1999). Outcomes of nighttime physical restraint removal for severely impaired nursing home residents. *American Journal of Alzheimer's Disease, 14*, 157-164.

Capezuti, E., Talerico, K. A., Cochran, I., Becker, H., Strumpf, N., & Evans, L. (1999). Individualized interventions to prevent bed-related falls and reduce siderail use. *Journals of Gerontology: Biological Sciences & Medical Sciences, 25*, 26-34.

Capezuti, E., Talerico, K. A., Strumpf, N., & Evans, L. (1998). Individualized assessment and intervention in bilateral siderail use. *Geriatric Nursing, 19*(6), 322-330.

Capezuti, E., Wagner, L. M., Brush, B. L., Boltz, M., Renz, S., & Talerico, K. A. (2007). Consequences of an intervention to reduce restrictive siderail use in nursing homes. *Journal of the American Geriatrics Society*, *55*, 334-341.

Centers for Medicare & Medicaid Services, U.S. Department of Health and Human Services. (2007). *Nursing home compare*. Retrieved April 27, 2007, http://www.medicare.gov/NHCompare/Static/Related/DataCollection.asp?dest=NAV|Home|DataDetails|DataCollection#TabTop

Eagle, D. J., Salama, S., Whitman, D., Evans, L. A., Ho, E., & Olde, J. (1999). Comparison of three instruments in predicting accidental falls in selected inpatients in a general teaching hospital. *Journal of Gerontological Nursing*, *25*(7), 40-45.

Edlich, R. F., Heather, C. L., & Galumbeck, M. H. (2003). Revolutionary advances in adaptive seating systems for the elderly and persons with disabilities that assist sit-to-stand transfers. *Journal of Long-Term Effects of Medical Implants, 13*(1), 31-39.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state": A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*(3), 189-198.

Guralnik, J. M., Ferrucci, L., Pieper, C. F., Leveille, S. G., Markides, K. S., Ostir, G. V., et al. (2000). Lower extremity function and subsequent disability: Consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. *Journals of Gerontology: Biological Sciences & Medical Sciences*, *55*(4), M221-M231.

Hughes, M. A., Myers, B. S., & Schenkman, M. L. (1996). The role of strength in rising from a chair in the functionally impaired elderly. *Journal of Biomechanics, 29*(12), 1509-1513.

Hughes, M. A., & Schenkman, M. L. (1996). Chair rise strategy in the functionally impaired elderly. *Journal of Rehabilitation Research & Development, 33*(4), 409-412.

Kawagoe, S., Tajima, N., & Chosa, E. (2000). Biomechanical analysis of effects of foot placement with varying chair height on the motion of standing up. *Journal of Orthopaedic Science, 5*(2), 124-133.

Kejonen, P., Kauranen, K., Ahasan, R., & Vanharanta, H. (2002). Motion analysis measurements of body movements during standing: Association with age and sex. *International Journal of Rehabilitation Research, 25*(4), 297-304.

Lawton, M. P., & Namehow, L. (1973). Ecology in the aging process. In C. Eisdorfer & M. P. Lawton (Eds.), *The psychology of adult development and aging* (pp. 619-674). Washington, DC: American Psychological Association.

Lord, S. R., Murray, S. M., Chapman, K., Munro, B., & Tiedemann, A. (2002). Sit-to-stand performance depends on sensation, speed, balance, and psychological status in addition to strength in older people. *Journals of Gerontology: Biological Sciences and Medical Sciences, 57A*(8), M539-M543.

Mazza, C., Benvenuti, F., Bimbi, C., & Stanhope, S. J. (2004). Association between subject functional status, seat height, and movement strategy in sit-to-stand performance. *Journal of the American Geriatrics Society, 52*(10), 1750-1754.

Mehr, D. R., Fries, B. E., & Williams, B. C. (1993). How different are VA nursing home residents? *Journal of the American Geriatrics Society*, *41*(10), 1095-1101.

Morse, J. (1997). *Preventing patient falls*. Thousand Oaks, CA: Sage.

Mourey, F., Grishin, A., d'Athis, P., Pozzo, T., & Stapley, P. (2000). Standing up from a chair as a dynamic equilibrium task: A comparison between young and elderly subjects. *Journals of Gerontology: Biological Sciences & Medical Sciences*, *55*(9), B425-B431.

Nelson, A., Matz, M., Chen, F., Siddharthan, K., Lloyd, J., & Fragala, G. (2006). Development and evaluation of a multifaceted ergonomics program to prevent injuries associated with patient handling tasks. *International Journal of Nursing Studies, 43*(6), 717-733.

O'Keeffe, S., Jack, C. I. A., & Lye, M. (1996). Use of restraints and bedrails in a British hospital. *Journal of the American Geriatrics Society, 44*(9), 1086-1088.

Ray, W. A., Taylor, J. A., Lichtenstein, M. J., & Meador, K. G. (1992). The Nursing Home Behavior Problem Scale. *Journals of Gerontology: Biological Sciences & Medical Sciences, 47*(1), M9-M16.

Schenkman, M., Hughes, M. A., Samsa, G., & Studenski, S. (1996). The relative importance of strength and balance in chair rise by functionally impaired older individuals. *Journal of the American Geriatrics Society, 44*(12), 1441-1446.

Schlicht, J., Camaione, D. N., & Owen, S. V. (2001). Effect of intense strength training on standing balance, walking speed, and sit-to-stand performance in older adults. *Journals of Gerontology Series: Biological Sciences and Medical Sciences, 56A*(5), M281-M286.

Thapa, P. B., Brockman, K. G., Gideon, P., Fought, R. L., & Ray, W. A. (1996). Injurious falls in non-ambulatory nursing home residents: A comparative study of circumstances, incidence, and risk factors. *Journal of the American Geriatrics Society, 44*(3), 273-278.

Tombaugh, T. N., & McIntyre, N. J. (1992). The Mini-Mental State Examination: A comprehensive review. *Journal of the American Geriatrics Society*, *40*(9), 922-935.

Weiner, D. K., Long, R., Hughes, M. A., Chandler, J., & Studenski, S. (1993). When older adults face the chair-rise challenge. A study of chair height availability and height-modified chair-rise performance in the elderly. *Journal of the American Geriatrics Society, 41*(1), 6-10.

Yamada, T., & Demura, S. (2004). Influence of the relative difference in chair seat height according to different lower thigh length on floor reaction force and lower-limb strength during sit-to-stand movement. *Journal of Physiological Anthropology & Applied Human Science, 23*(6), 197-203.

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