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Movement Patterns of Transient and Prolonged Positioning Events in Nursing Home Residents: Results from the TEAM-UP Trial

Kais Gadhoumi, PhD; Sharon Eve Sonenblum, PhD; Susan M. Kennerly, PhD, RN, CNE, WCC, FAAN; Jenny Alderden, PhD, APRN; Phoebe D. Sharkey, PhD; Susan D. Horn, PhD; and Tracey L. Yap, PhD, RN, WCC, CNE, FGSA, FAAN

ABSTRACT

OBJECTIVE: To characterize transient and prolonged body position patterns in a large sample of nursing home (NH) residents and describe the variability in movement patterns based on time of occurrence.

METHODS: This study is a descriptive, exploratory analysis of up to 28 days of longitudinal accelerometer data for 1,100 NH residents from the TEAM-UP (Turn Everyone and Move for Ulcer Prevention) clinical trial. Investigators analyzed rates of transient events (TEs; less than 60 seconds) and prolonged events (PEs; 60 seconds or longer) and their interrelationships by nursing shift.

RESULTS: Residents' positions changed for at least 1 minute (PEs) nearly three times per hour. Shorter-duration movements (TEs) occurred almost eight times per hour. Residents' PE rates were highest in shift 2 (3 PM to 11 PM), when the median duration and maximum lengths of PEs were lowest; the least active time of day was shift 3 (11 PM to 7 AM). Three-quarters of all PEs lasted less than 15 minutes. The rate of TEs within PEs decreased significantly as the duration of PEs increased.

CONCLUSIONS: The NH residents demonstrate complex patterns of movements of both short and prolonged duration while lying and sitting. Findings represent how NH residents naturally move in real-world conditions and provide a new set of metrics to study tissue offloading and its role in pressure injury prevention.

KEYWORDS: duration, movement, nursing home, pressure injury, pressure ulcer, repositioning, sensor data

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INTRODUCTION

Pressure injuries (PrIs), localized damage to the skin and/or underlying tissue as a result of pressure or pressure combined with shear,[1] occur in more than one in four nursing home (NH) residents in the US and are responsible for nearly $26 billion in healthcare costs.[2,3] Preventive efforts generally focus on regular repositioning protocols to relieve pressure. Current clinical guidelines recommend that providers individualize repositioning intervals. Evidence supports the use of up to 4-hour intervals in most individuals,[4,5] but more detailed examination of actual movements is needed.[6–11]

Self-initiated movements may enable tolerance of longer time periods between repositioning intervals without increased risk of PrIs in residents, but these movements have not been routinely measured in prior studies. An exception was a study by Schnelle and colleagues,[12] who reported that NH residents experiencing incontinence initiated multiple gross motor movements and episodes of wakefulness during nighttime hours.

The TEAM-UP (Turn Everyone and Move for Ulcer Prevention) cluster-randomized clinical trial demonstrated that repositioning NH residents every 3 or even 4 hours does not negatively impact PrI incidence.[5,13] Subsequent analyses using TEAM-UP data showed that NH residents engage in multiple position changes of short duration, as well as distinguishable patterns of both transient and prolonged positioning while lying and upright.[14] Such transient or episodic movements may serve to offload pressure shown to impair long-term tissue oxygenation within 30 minutes of pressure loading.[15–17] In fact, discrete pressure-reducing or pressure-relieving movements

Kais Gadhoumi, PhD, is Assistant Professor, School of Nursing, Duke University, Durham, North Carolina. Sharon Eve Sonenblum, PhD, is Principal Research Scientist, Rehabilitation Engineering and Applied Research Laboratory, George W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta. Susan M. Kennerly, PhD, RN, CNE, WCC, FAAN, is Professor, College of Nursing, East Carolina University, Greenville, North Carolina. Jenny Alderden, PhD, APRN, is Associate Professor, Boise State University, Idaho. Phoebe D. Sharkey, PhD, is Professor Emerita, Sellinger School of Business, Loyola University Maryland, Baltimore. Susan D. Horn, PhD, is Adjunct Professor, School of Medicine, University of Utah, Salt Lake City. Tracey L. Yap, PhD, RN, WCC, CNE, FGSA, FAAN, is Associate Professor, School of Nursing, Duke University. **Acknowledgments:** The research reported in this publication was supported by the National Institute of Nursing Research of the National Institutes of Health under award R01NR0166001. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. The authors have disclosed no other financial relationships related to this article. Submitted June 20, 2022; accepted in revised form August 11, 2022.

may be occurring when residents are thought not to be moving, offering a protective effect against PrI development. However, previous analyses of TEAM-UP data were limited by a focus on (1) movement between lying and upright positions only, obscuring movement to the left, right, or back while lying or upright; and (2) mean daily time spent in lying and upright positions, obscuring variability in the patterns of movement within a 24-hour day.[14] A further examination of NH residents' movements between multiple positions and in shorter time increments using objective data would inform development of data-driven PrI prevention strategies.

Accordingly, the primary aim of the current study was to characterize all movements of transient and prolonged duration over time in a large sample of residents from a randomly selected group of NHs. A secondary aim was to describe variability in movement patterns based on time of occurrence. Using the TEAM-UP trial's data from triaxial sensors, which provided continuous data recordings of resident movements, this study builds on the foundational knowledge developed in earlier TEAM-UP trial analyses to extend evidence related to PrI risk factors.

METHODS

Design and Sample

This descriptive, exploratory study used longitudinal data from the TEAM-UP clinical trial.[5,13] To assess risk of PrIs, the trial randomly assigned nine NHs to one of three arms (three NHs per arm) that implemented NH-wide 2-, 3-, or 4-hour repositioning intervals, respectively, for NH residents for up to 28 days.[5,13] The monitoring system (MS; FDA-approved wearable sensors [Leaf System; Smith & Nephew]) continuously detected and recorded the body movements of NH residents (N = 1,100) who participated in the trial.[14]

The methods and findings of the trial are reported elsewhere.[5,13] The trial was approved by the Duke University Institutional Review Board (#Pro00069413). The board approved a waiver of informed consent per the US Department of Health and Human Services guidelines 21 CFR 46.

Trial participants were at least 18 years old, without a PrI on admission or within 72 hours, had scores 10 or more on the Braden Scale,[18] and did not have an adhesive allergy or other clinical contraindications such as do-not-turn orders. The sample extracted for current analyses included all participants who had at least 8 hours of uninterrupted movement data recorded during the trial (N = 1,056).

Measures

Two parameters of participants' body movement patterns were of interest: body position and position duration. Body position as detected by the MS was based on measures of three orthogonal accelerometer angles. Movement was detected if a resident changed any two of nine possible positions. The study assessed three upright positions (right, left, prone) and three lying positions (right [including right-lying and right-prone], left [including left-lying and left-prone], back); ambulation was excluded from the analyses. Position changes had to meet minimum thresholds: changes between lying and upright required the trunk angle to reach 45° to 50° or more, moving from upright to upright-right or upright-left required at least a 10° tilt, and rolling to the right or left while supine required crossing a 20° threshold. Upright positions did not indicate if a resident was sitting or standing; lying positions did not indicate if a resident was lying in a bed or on a recliner chair.

Position duration was detected by the MS and time-stamped in 10-second increments across each 24-hour period for up to 28 days. Movement events were classified as either a transient event (TE), if the same body position was maintained for less than 60 seconds, or a prolonged event (PE), if the same position was maintained for 60 seconds or longer.

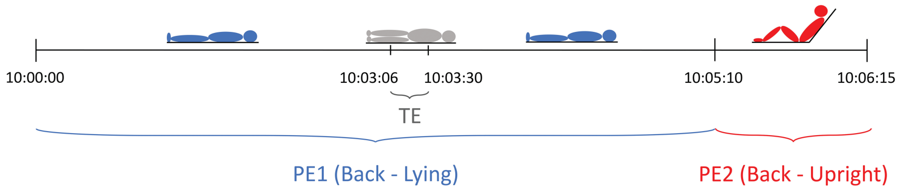
Transient events may occur as a transition to a PE, such as the preparation for movement, for example, positioning a sheet or transfer device under a resident to assist with a turn or for an independent resident rocking and adopting multiple positions in an effort to change positions more permanently. Transient events may also be part of nursing care; for example, a nurse might briefly reposition a patient to check BP. However, these activities are few, and it is expected that the majority of TEs are initiated independently by the resident. These events might be functional in nature (eg, mobility-related activities of daily living such as dressing or toileting, eating, or movements associated with an activity such as playing bingo), or they might be short-duration postural changes associated with discomfort or pain.[19]

A PE might be interrupted by one or more TEs, provided the resident returned to the same position after the TE. For example, sitting on a chair, reading a book, and occasionally leaning to the side to grab a coffee mug, take a brief sip, return the mug on the table, and resume reading would count as one upright PE. Thus, a PE may be composed of sequential time segments lasting longer than 60 seconds in a single position interrupted by different positions lasting less than 60 seconds. Figure 1 illustrates two PEs, one interrupted by a TE and one uninterrupted.

Positional and duration measures were used to construct rates of PEs and TEs within several subgroups. The PEs were grouped into duration bins. Six contiguous but distinct ranges of PE duration were defined: 1 to <15 minutes, 15 to <60 minutes, 60 to <120 minutes,

Figure 1. ILLUSTRATION OF PROLONGED EVENTS

Two prolonged events (PEs) are shown. PE 1 is a sequence of two (back-lying) positions, each maintained for more than 60 seconds, separated by (left-lying) position lasting less than 60 seconds (transient event [TE]). The duration of PE 1 is the sum of the durations of all positions (ie, 5 minutes 10 seconds). PE 2 is an uninterrupted PE lasting 1 minute and 5 seconds.



120 to <180 minutes, 180 to <240 minutes, and 240 to 300 minutes. Bins counted all PEs of the indicated duration for each resident, not the resident's mean or median PE duration.

Duration measures were time-stamped, enabling assessment by time of day, specifically as related to nursing shifts: shift 1 (7:00 AM to 3:00 PM), shift 2 (3:00 PM to 11:00 PM), and shift 3 (11:00 PM to 7:00 AM). The TEs and PEs that started in one shift and ended in another shift (cross-shift TEs and PEs) were assigned to the shift in which they began. Relatively long PEs can be physiologic (eg, sleep, impaired mobility) or nonphysiologic (eg, sensor is detached from resident and is still recording); the MS cannot differentiate between them. Therefore, PEs longer than the duration of a shift (ie, over 8 hours) were excluded from all analyses to exclude nonphysiologic data and events, as these were not the focus of this study.

Measures of three hourly rates (TE, PE, and TE within PE) were constructed, as well as the overall duration and maximum duration of residents' PEs and TEs. These variables were also examined selectively across duration bins and nursing shifts. Definitions of and formulas for all variables are presented in Table 1.

The rate of TEs (TE rate) is the average number of TEs recorded per hour of sensor recording and captures the overall tendency to engage in short-duration movements. The rate of TEs in a shift (TE $rate_{shift}$) measures the average number of TEs per hour during a particular shift. Likewise, the rate of PEs (PE rate) is the average number of PEs recorded per hour and measures overall how often a resident tends to change prolonged positions; the rate of PEs in a shift (PE $rate_{shift}$) measures the average number of PEs per hour during a particular shift.

The duration of PEs (PE dur) is calculated as the median duration of all PEs recorded across a single resident's data; the duration of PEs in a shift (PE dur_{shift}) uses only PEs beginning in each of the three shifts. The PE durations can range from minutes to hours by resident. The maximum duration of PEs (PE max) is the duration of the longest PE a resident experienced in all recorded time. The maximum duration of PEs in a shift (PE max_{shift}) is the maximum PE duration using PEs that began in the shift, that is, the maximum amount of time a resident remained in a prolonged position that began in that shift. Finally, the count of PEs in a shift within a duration bin (PE count bin_{shift}) is the number of PEs beginning in a given shift that have durations within a given bin.

The rate of TEs within a prolonged event (TE within PE rate) captures the tendency to move briefly while in prolonged positions and indicates the consistency of this tendency over PEs of different durations. It is calculated as the number of TEs per hour of PE and is the average of all rates obtained for all PEs recorded. The shift version, TE within PE $rate_{shift}$, uses the same definition but includes only PEs that occurred within the shift.

Data Analysis

Descriptive statistics assessed the characteristics of the study sample, frequency of TEs and PEs, and rates and duration of these events. One-way analysis of variance (ANOVA) tests assessed differences in the values of PE and TE across shifts. Based on the number of residents displaying PEs of six distinct duration bin ranges and the number of recorded PEs in that duration bin, ANOVA was used to assess differences in the frequency of PEs per resident across the three shifts. Finally, TE within PE rate was analyzed across PE duration bins, separately by shift, and tested for statistical significance using ANOVA.

RESULTS

Demographic, clinical, and PrI risk characteristics of the sample are presented in Table 2. Participants averaged 77.4 years and were primarily non-Hispanic White women. Although none of the residents developed PrI by the end of the 4-week intervention period, 52 of the 1,056 residents (4.9%) had a clinical history of one or more PrI events that healed in the year preceding the TEAM-UP trial, 12 of whom had scored as moderate or high risk on the first Braden Scale assessment during the TEAM-UP trial.[15] The mean duration of movement data recorded by the MS for participants was 377 (SD, 254) hours (minimum-maximum, 8–676 hours).

Table 1. DEFINITIONS OF AND FORMULAE FOR TE AND PE MEASURES

Measure	Definition	Formula
Rate of PEs (*PE rate*)	The average number of PEs recorded per hour of sensor recording	$\text{PE rate} = \frac{\text{Total number of PEs}}{\text{Total number of sensor recording hours}}$
Rate of PEs per shift ($PE\ rate_{shift}$)	The average number of PEs per hour of sensor recording, using data recorded in all daily instances of a particular shift	$\text{PE rate}_{\text{shift } \#i} = \frac{\text{Total no.of PEs in shifts } \#i}{\text{Total no.of sensor recording } h \text{ in shifts } \#i}; i = 1, 2, 3$
Duration of PEs (*PE dur*)	Median duration of PEs recorded across a single resident's data	
Duration of PEs per shift ($PE\ dur_{shift}$)	Median duration of PEs recorded in the daily instances of the shift for each of the three shifts	
Count of PEs ($PE\ count^{bin}_{shift}$)	Number of PEs occurring in a given shift that have durations within a given duration range	
Maximum duration of PEs (*PE max*)	Duration of the longest PE a resident experienced in all recording hours	
Maximum duration of PEs per shift ($PE\ max_{shift}$)	Duration of the longest PE a resident experienced in the daily instances of a shift	
Rate of TEs (*TE rate*)	Average number of TEs recorded per hour of sensor recording	$\text{TE rate} = \frac{\text{Total number of TEs}}{\text{Total number of sensor recording } h}$
Rate of transient events per shift ($TE\ rate_{shift}$)	Average number of TEs per hour of sensor recording, using data recorded in all daily instances of a particular shift	$\text{TE rate}_{\text{shift } \#i} = \frac{\text{Total no. of TEs in shifts } \#i}{\text{Total no. of sensor recording hours in shifts } \#i}; i = 1, 2, 3$
Rate of TEs within PEs (*TE within PE rate*)	Rate of TE occurrences to the duration of the PE within which they occurred, measured in number of TEs per hour of PE. For each PE, the number of TEs and the duration of PE are measured, and a rate is calculated as defined previously. The average of all rates obtained for all PEs was recorded.	$\text{TE within PE rate} = \frac{\sum_{\text{PEs}} \rho^{\text{TE}}_{\text{PE}}}{\text{Total number of PEs}}$, where $\rho^{\text{TE}}_{\text{PE}}$ is the rate of TEs within a given PE and is calculated as: $\rho^{\text{TE}}_{\text{PE}} = \frac{\text{Number of TEs in PE}}{\text{Duration (in hours) of PE}}$
Rate of TEs within PEs per shift ($TE\ within\ PE\ rate_{shift}$)	The same definition as *TE within PE rate* but includes only PEs that occurred within the specific shift	$\text{TE within PE rate}_{\text{shift } \#i} = \frac{\sum_{\text{PEs in shifts } \#i} \rho^{\text{TE}}_{\text{PE}}}{\text{Total number of PEs in shifts } \#i}$

Abbreviations: PE, prolonged event; TE, transient event.

PEs and TEs among Residents

A total of 3,074,875 TEs and 1,130,623 PEs were calculated across residents. The TE durations averaged 22.64 (median, 19 seconds; interquartile range, 10-32 seconds). The distribution of PE durations across residents revealed that 8 hours was at the 99.8th percentile of the distribution. Accordingly, those PEs that lasted more than 8 hours (n = 2,299 [0.2%]) were excluded, resulting in 1,128,324 PEs for all analyses (except by bins). Cross-shift PEs across all residents (n = 45,657 [4.0%]) had a mean duration of 108 (SD, 109) minutes and were evenly distributed among residents and shifts. On average, residents had 43 cross-shift PEs over their total days (mean, 16 days) of recording movements. Approximately 34% of cross-shift PEs started in shift 1, 34% started in shift 2, and 32% started in shift 3.

On average, residents had 2.89 PEs every hour (PE rate) and had 7.99 TEs every hour (TE rate). The average duration of a PE was 7.04 minutes, with half of all residents maintaining a PE for approximately 6 minutes; the average maximum PE duration was 6.0 hours. Within a PE, residents experienced frequent TEs, as indicated by the relatively high TE within PE rate (15.33 TEs per hour of PE). Table 3 summarizes the means, CIs, medians, and interquartile ranges for residents' PE rate, TE rate, PE dur, PE max, and TE within PE rate.

PEs and TEs across Shifts

The PE and TE rates were significantly higher in shift 2 (mean, 3.81 PEs/hour and 10.75 TEs/hour, respectively) than in shifts 1 and 3 (one-way ANOVA, $P < .001$). Further, PE dur and PE max were significantly lower in shift 2 (mean, 6.13 minutes and 3.36 hours, respectively) compared with shifts 1 and 3 (one-way ANOVA, $P < .001$). There were no statistically significant differences among values of TE within PE rate across the three shifts. Figure 2 presents these comparisons.

PEs by Duration Bins

The frequency of PEs in duration bins by shift is shown in Table 4. Of the total number of PEs lasting between 1 and 300 minutes, the majority (n = 846,866 [75.0%]) lasted less than 15 minutes. The remainder of PEs varied from 17.1% (n = 192,505) lasting 15 to <60 minutes to 4.4% (n = 49,345) lasting 60 to <120 minutes and to <2% each for lasting 120 to <180 minutes, 180 to <240 minutes, and 240 to 300 minutes. Those PEs longer than 300 minutes (n = 4,332) were excluded only from analyses of duration bins. On average, there were approximately 12 1- to <15-minute PEs per shift during shifts 1 and 3 and 24 1- to <15-minute PEs during shift 2.

Based on ANOVA (untabled), there were fewer 15- to <60-minute PEs in all shifts compared with 1- to <15-minute

Table 2. CHARACTERISTICS OF PARTICIPANTS WITH 8 OR MORE HOURS OF UNINTERRUPTED MOVEMENT MONITORING

Characteristics (n = 1,056)	Values
Age, mean (SD), y	77.4 (13.1)
Residents per study arm, n (%)	
Arm 2 h	313 (29.6)
Arm 3 h	356 (33.7)
Arm 4 h	387 (36.6)
Male sex, n (%)	406 (38.4)
Hispanic or Latino ethnicity, n (%)	24 (2.3)
Race, n (%)	
Black	286 (27.1)
White	704 (66.7)
Asian	3 (0.3)
Unknown	63 (6.0)
Comorbidities, n (%)	
Difficulty walking	900 (85.2)
Muscle weakness wasting	866 (82)
Difficulty with swallowing and speech	568 (53.8)
Hypertension	495 (46.9)
Alzheimer disease related dementias	310 (29.4)
Gastroesophageal reflux disease	303 (28.7)
Cerebrovascular disease	217 (20.5)
Type 2 diabetes	225 (21.3)
Depression	244 (23.1)
Atherosclerotic heart disease	464 (43.9)
Obesity	335 (31.7)
Dementia	475 (45)
Pressure injury during y prior to trial, n (%)[a]	52 (4.9)
Braden mobility score, n (%)[b]	
1	31 (2.9)
2	267 (25.3)
3	405 (38.3)
4	353 (33.4)
Braden activity score, n (%)[b]	
1	70 (6.6)
2	529 (50.1)
3	310 (29.3)
4	147 (13.9)
Total Braden Scale score, mean (SD)	17.5 (3.1)
Body mass index, mean (SD), kg/m^2	27.7 (8.6)

[a]During 1 y prior to trial start.
[b]Resident's first Braden assessment during the trial.

PEs (two-way ANOVA, $P < .001$) and relatively more 15- to <60-minute PEs in shift 2 than in shifts 1 and 3 (two-way ANOVA, $P < .001$). Similar and small numbers of 60-minute or longer PEs were recorded in all shifts. Although nearly all residents had PEs in the 1- to <15-minute and 15- to <60-minute bins, as PE durations increased (ie, PE duration bins 60 minutes or longer), fewer residents had long PEs. Across the second two shifts, 413 residents had PEs between 240 and 300 minutes in shift 2, and 692 residents had PEs between 240 and 300 minutes in shift 3 (Table 4).

Residents moved more frequently during short PEs than they did during long PEs (Figure 3) in all three shifts (one-way ANOVA, $P < .001$). During 1- to <15-minute PEs, residents averaged 17 to 19 TEs per hour of PE. The TE within PE rate decreased significantly as PE duration increased (one-way ANOVA, $P < .001$). In PEs longer than 2 hours, residents averaged 1.71 TEs per hour of PE for shift 1, 2.72 TEs per hour of PE for shift 2, and 1.17 TEs per hour of PE for shift 3 (untabled).

DISCUSSION

This study extends earlier work on staff-initiated repositioning of NH residents by documenting the extent to which residents are experiencing position changes for short and long periods and is the first study to explore TEs in NH residents. The findings expand evidence of the real-world variability in actual movement behaviors of NH residents, including movements that may be either nurse- or self-initiated. Over and above intervention protocols requiring repositioning every 2, 3, or 4 hours, patients' positions are also changing for at least 1 minute on average nearly three times per hour. In addition, small-duration movements occurred almost eight times per hour.

TEs within PEs

These results suggest that measures of position changes among NH residents that focus on staff-initiated turns only may be too blunt an instrument to reflect the on- and off-loading of pressure and may partially explain the lack of clarity in the evidence for optimal frequency and position for repositioning.[9] For example, if a resident briefly repositioned herself to reach for a television control and then moved back to her original position before the next staff check, then the short-duration self-initiated

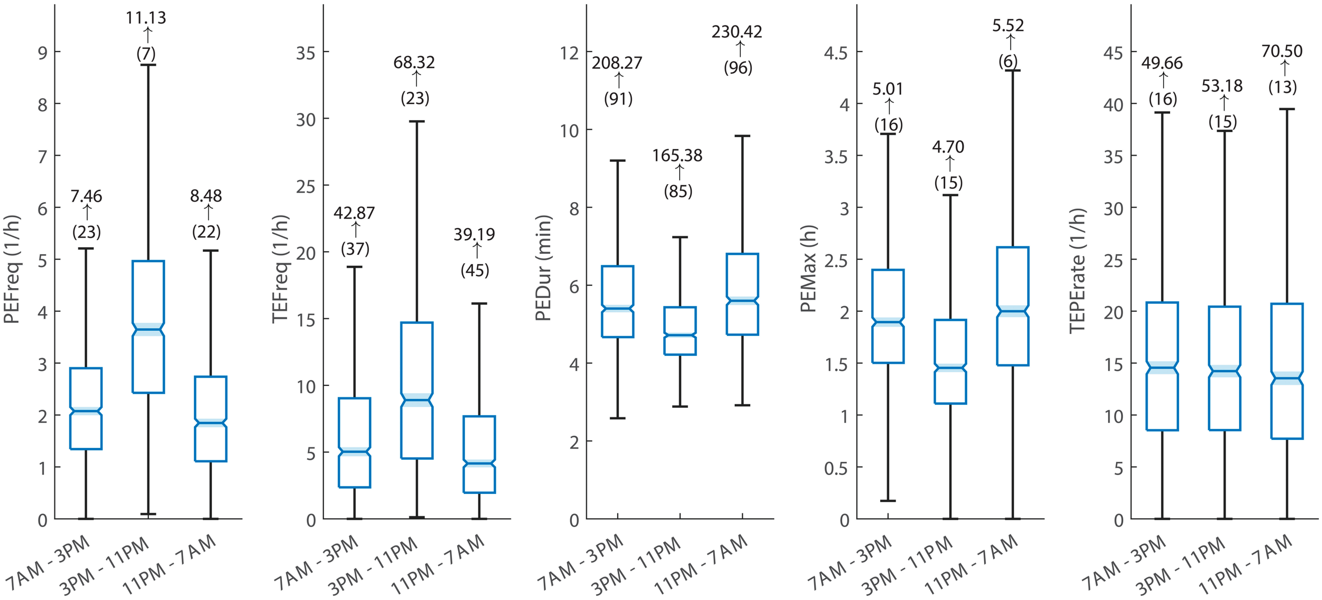
Table 3. PE AND TE MEASURES

Measure	Mean (95% CI)	Median (Interquartile Range)
PE rate, no. PEs/h	2.89 (2.81–2.97)	2.75 (1.87–3.70)
TE rate, no. TEs/h	7.99 (7.63–8.36)	6.61 (3.42–11.18)
PE dur, min	7.04 (6.63–7.45)	5.58 (4.77–6.93)
PE max, h	6.00 (5.90–6.11)	6.54 (4.76–7.48)
TE within PE rate, TEs/h	15.33 (14.84–15.82)	14.38 (8.79–20.58)

Abbreviations: CI, confidence interval; PE, prolonged event; TE, transient event.
Mean, 95% CI, median, and interquartile range of prolonged event (PE; 1–480 minutes) and transient event (TE; <60 seconds) measures of nursing home residents (n = 1,056).

Figure 2. SUMMARY BOXPLOTS

The boxplots illustrate significantly more movement between 3 and 11 PM (ie, during shift 2) than the rest of the day, specifically when represented by prolonged event (PE) rate, transient event (TE) rate, PE duration, and PE maximum duration. The rate of TEs within PEs was consistent throughout the day.



Numbers above whiskers indicate the number of outliers (between parentheses) and the maximum outlier value.

movement would not be captured as part of the prescribed repositioning protocol. Further, Kennerly and colleagues[14] have shown that TEAM-UP residents who spend the greater part of a day lying down also demonstrate very frequent position changes. The current study extends previous work by Padhye and colleagues[20] using accelerometers, reporting that PrI risk reduction was associated with the complexity of the speed and vibration of activities among NH residents. The current study underscores that movement activity while lying and sitting is more complex than previously detected and may cumulate in protection against PrI.

Duration and Maximum PEs

Although the average PE among residents ranged between about 5 and 7 minutes in duration, residents' longest PEs fell largely within a range of approximately 5 to 8 hours. Long-duration PEs of 6 or more hours may have occurred if residents refused repositioning or were sleeping with appropriate sleep protocols. Of note, the TEAM-UP intervention trial recorded no incident PrIs, which might typically be associated with maintaining a single position over such prolonged periods.[5] Because long PEs still have some TEs, residents were rarely without any movement.

However, not all residents demonstrated frequent or regular TEs. There were almost 700 people with a 4- to 5-hour PE in shift 3, which showed an intrashift mean of 1 TE per hour. Assuming a normal distribution of such residents, a quarter of them (175 people) are likely demonstrating very few TEs during the night. Further exploration of TEs in relation to the occurrence of PrI is indicated to understand the role TEs play in reducing the likelihood of skin breakdown. For example, many residents were observed to maintain

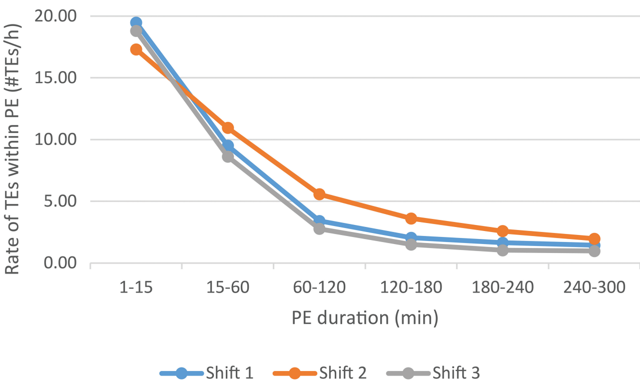
Table 4. RESIDENTS (n = 1,056) WITH PROLONGED EVENTS (n = 1,128,324) OF 1 TO 300 MINUTES BY BIN AND SHIFT

		PE Duration, min					
Shift	**Heading**	**1 to < 15**	**15 to < 60**	**60 to < 120**	**120 to < 180**	**180 to < 240**	**240 to 300**
	Residents, n	1,036	1,025	985	904	725	505
Shift 1 (7 AM to 3 PM)	PE, n (%), mean per resident	227,170 (20.13), 12.27	57,234 (5.07), 3.10	17,156 (1.52), 0.94	7,026 (0.62), 0.38	3,334 (0.30), 0.17	1,288 (0.11), 0.07
	Residents, n	1,054	1,051	998	819	605	413
Shift 2 (3 PM to 11 PM)	PE, n (%), mean per resident	411,971 (36.51), 23.55	84,529 (7.49), 4.56	16,612 (1.47), 0.96	5,156 (0.46), 0.30	2,333 (0.21), 0.13	971 (0.09), 0.05
	Residents, n	1,039	1,024	987	905	835	692
Shift 3 (11 PM to 7 AM)	PE, n (%), mean per resident	207,725 (18.41), 11.82	50,742 (4.50), 2.89	15,577 (1.38), 0.89	7,199 (0.64), 0.39	5,610 (0.50), 0.29	2,363 (0.21), 0.13
Total	Residents PE count, n (%)	846,866 (75.05)	192,505 (17.06)	49,345 (4.37)	19,381 (1.72)	11,277 (0.99)	4,622 (0.41)

Abbreviations: PE, prolonged event; TE, transient event.

Figure 3. RATE OF TRANSIENT EVENTS (TEs) WITHIN PROLONGED EVENTS (PEs) BY PE DURATION

The average value of TE within PE rate across residents is shown. Note that the number of residents who contribute to the average rate varies in each bin (see Table 4).



tissue integrity with frequent or regularly occurring TEs, whereas others maintain a single position for 5 to 8 hours and engaged in few transient movements. Advancing knowledge about the dynamic interactions between variability of individual residents' perception of discomfort that often triggers self-repositioning and tissue tolerance to pressure loading can lead to new insights about their influence on PrI development and PrI prevention.

Nursing Care Shifts and Implications for Behavior

This is the first time that objective measurements have documented the movement pattern of NH residents across nursing shifts. Shift 2 had the highest rates of PEs and TEs as well as the shortest PEs, all indicating that most movements occurred during this time of day. Additional analyses of movement by hour showed that the greatest number of TEs occurred at the same times of day: 1 PM, 5 PM, and 10 PM (untabled); 1 PM and 5 PM are most closely aligned with mealtimes, and 10 PM is more closely aligned with shift change or preparation for sleep, which involves several mobility-related activities of daily living. The time of day when movements occurred least was 11 PM to 7 AM.

These findings advance the understanding of the pattern of movement within the context of nursing care schedules and offer the potential to rethink the timing for activities and therapies in caring for older adults, as well as highlight when nursing staff need to be aware of repositioning. For example, are there activities routinely scheduled during the 3 PM to 11 PM shift that could be performed at a less active time of day, thus intentionally reducing the length of PEs and perhaps increasing the number of TEs to support PrI prevention? In addition, there may be opportunities to better tailor care delivery and special events to resident activity and sleep preferences and even disperse staff duties and improve workflow.

A desired overall nursing goal may be to increase the frequency of resident movement among less active residents who have movement capacity. These results can be used to inform such an effort. The findings indicate that most residents have the ability to perform short-duration movements regardless of overall PrI risk level. Residents who have selectively chosen to remain in the same position, producing an elongated PE, could be encouraged to engage in structured activities with other residents and have the additional benefit of socialization.

Strengths

The concept of PEs versus TEs is unique. This study was innovative in its organization of these individual movements into identifiable patterns. The level of granularity that was possible in examining residents' movements revealed for the first time that people previously thought to be sedentary or "immobile" are truly moving. It is acknowledged that some people are completely immobile. But overwhelmingly, human behavior produces the slight changes in position discovered in this study.

In addition, TEAM-UP is the first study to measure movement objectively over 24-hour periods in a large population. Doing so enables better understanding of how NH residents are naturally moving in real-world conditions. Finally, the measures used in this study, particularly the identification of TEs within PEs, provide a new set of metrics from which to develop new/modified PrI prevention strategies.

Limitations

This study was constrained by the nature of secondary analyses of data collected during the TEAM-UP trial. Therefore, care was taken to evaluate data distributions thoroughly and select appropriate cutoff points to maximize meaningfulness while minimizing potential bias.

Second, all residents participating in the TEAM-UP trial were eligible for inclusion in this secondary analysis if their movement data comprised at least 8 hours of sensor data. During data evaluation, subgroup analyses were conducted to test whether different cutoff points would alter conclusions; differences were minimal except where otherwise presented above. Nevertheless, it is possible that the establishment of these cutoffs limited discovery of alternative movement patterns.

Third, predetermined angle thresholds used to define the boundaries for detection of position changes are consistent with the international guidelines that specify a preferred 30° head-of-bed angle but no preferred tilt or roll angles; however, the actual angle achieved upon each position detection was not investigated in this study and could be explored in future research.

Fourth, because all participants in this study were NH residents, generalizations are limited to that setting. In particular, the study cannot distinguish between nurse- and self-initiated movements.

Finally, all residents included in the analyses were assessed via the Braden Scale as having an overall low, mild, moderate, or high PrI risk.[18] Residents at severe PrI risk (total Braden Scale scores <10) were not studied because the exclusion criteria of the TEAM-UP trial did not include these residents because of the individualized PrI prevention care this population requires. Therefore, little is known about the level of mobility and independence of these residents, and this study's conclusions may not be generalizable for those who are at severe PrI risk.

Implications for Research

The findings that emerged from this descriptive, exploratory study suggest several lines of inquiry to inform and improve nursing care of NH residents. First, given that residents move independently, and changes of position are often for less than 15 minutes, what damage to skin integrity is prevented? Small studies of relatively independent NH residents who have linked mobility subscale scores to scan-detected tissue breakdown require follow-up studies of actual movement patterns in larger samples of NH residents with a greater range of mobility impairment.[21]

Second, given that prolonged positioning does occur with and without intermittent short-term movements, what measure of tissue pressure relief and what degree of effectiveness in off-loading pressure are associated with various patterns of PE and TE?

Finally, a study that maps PE and TE movement patterns with care delivery/activities/event schedules could identify opportunities to tailor care schedules to residents' movement patterns and impact nursing staff workflow in beneficial ways.

CONCLUSIONS

A large sample of NH residents at varying risks of PrIs demonstrated complex patterns of movements of both short and prolonged duration. Movement occurring while lying and sitting was more complex than that associated with repositioning protocols and other nursing functions that support residents' activities of daily living. Patterns varied based on time of occurrence: the time of day with most movement was 3 PM to 11 PM, and the least movement was observed from 11 PM to 7 AM. Findings represent new evidence for how NH residents naturally move in real-world conditions and provide a new set of metrics for examining tissue off-loading and its role in PrI prevention strategies. ●

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