Brief Report

Some people move it, move it... for pressure injury prevention

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Objective: To describe differences in in-seat behavior observed between individuals with a spinal cord injury (SCI) with and without a history of recurrent pressure injuries.

Design: Cross-sectional cohort study.

Setting: General community.

Participants: Twenty-nine adults more than 2 years post SCI, who used a wheelchair as their primary mobility device and had the ability to independently perform weight shift maneuvers. Participants were grouped according to whether or not they had a history of recurrent pressure injuries (PrIs), with 12 subjects having had two or more pressure injuries in the pelvic area (PrI Group).

Interventions: Not applicable.

Main Outcome Measures: Daily time in wheelchair, number of transfers, and frequency of pressure reliefs (full unloading), weight shifts (30% load reduction), and in-seat movements (transient center of pressure movements or unloading).

Results: The median participant spent 10.3 hours in his wheelchair and performed 16 transfers to or from the wheelchair daily. Pressure reliefs were performed less than once every 3 hours in both groups. Weight shifts were performed significantly more often by the No PrI Group (median (interquartile range) 2.5 (1.0–3.6) per hour) than the PrI Group (1.0 (0.4–1.9), with $P = 0.037$ and effect size $r = 0.39$). In-seat movements were performed 46.5 (28.7–76.7) times per hour by the No PrI group and 39.6 (24.3–49.7) times per hour for the PrI group ($P = 0.352$, effect size $r = 0.17$).

Conclusion: Weight shifts that can be produced by functional activities and that partially unload the buttocks should be considered as an important addition to individuals' PrI prevention regimen.

Keywords: Wheelchairs, Pressure ulcer, Pressure injury, Spinal cord injuries, Movement, Monitoring

Reduced mobility and impaired sensation combine to make pressure injuries (PrI) one of the most common and costly secondary medical complications in persons with spinal cord injury (SCI).¹ Preventing PrIs typically requires reducing the magnitude and duration of external loading.^{2,3} Pressure magnitude is managed by the selection of wheelchair cushions, other supports, and the seated posture, while duration of pressure is addressed via the frequency of weight shifting activities while seated. As a consequence, wheelchair users with SCI are frequently taught by clinicians to perform pressure reliefs designed to shift body weight off the buttocks.⁴

Previous studies have not found a relationship between pressure relief behavior and PrI prevalence in

SCI cohorts.^{1,5,6} However, each of the studies relied on self-report measures of pressure relief practices, yet self-reported behavior is known to be highly unreliable. Furthermore, protective weight shifting behaviors may include activities other than dedicated pressure reliefs. Indeed, many functional movements performed while seated in a wheelchair will also redistribute pressure off, and increase blood flow to PrI risk sites.⁷ For example, Sonenblum *et al.* demonstrated in participants with SCI that resting their elbows on their thighs resulted in a 95% increase in ischial blood flow compared to an upright posture, while leaning to the side caused a 300% increase in bloodflow.⁷

The purpose of this brief report is to describe differences in in-seat behavior observed between individuals with and without a history of recurrent PrIs. We hypothesized that people without a history of PrIs would be more active in their seats.

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Methods

Methods for data collection were reported in reference 8. Briefly, with IRB approval, we recruited a convenience sample of 29 adults with chronic SCI, defined as more than 2 years post injury. Participants used a wheelchair as their primary mobility device and had the ability to independently perform weight shift maneuvers. Individuals were classified as either having experienced no PrIs or only 1 PrI shortly following their SCI (No PrI Group), or had experienced recurrent (i.e. two or more) PrIs in the pelvic area (PrI Group). This approach is modeled after a risk analysis performed by Krause & Broderick¹ to study patterns of pressure ulcer recurrence. By looking at patterns of recurrence rather than a single incidence, it is more likely that behavioral measures may have contributed to pressure injury outcomes.

Participants were instrumented with a custom weight shift monitor (WSM) composed of 8 piezo-resistive force sensors beneath their wheelchair cushion, and a data logger to store the measured forces (Fig. 1). The instrumentation session commenced with a training protocol designed to relate the loads measured by the WSM beneath the cushion to pressures at the buttocks/cushion interface, measured simultaneously by an FSA interface pressure mat (Vista Medical, Ltd., Henlow Bay, Winnipeg, MB, Canada). Participants went home with the WSM and data logger and were instructed to go about their daily life as if the equipment was not present.

The following variables were defined by the investigators for analysis:⁸

- *Weight Shift*—either ischium is partially unloaded (> 30% pressure reduction) for > 15 seconds
- *Pressure Relief*—left and right ischium fully unloaded for > 15 seconds and < 2 minutes
- *Out of Chair*—fully unloaded for > 2 minutes

A fourth metric, *In-Seat Movement*, was defined to reflect higher frequency, shorter duration movements of the body's center of mass that would result in

changes to buttocks loading. In-Seat Movement was defined as the frequency with which: 1) Total body weight on the seat is reduced by 30%, and/or 2) Center of pressure on the buttocks travels at least 10 cm within a 5-second window.

For reference, a weight shift might occur when someone leans to their armrest or wheel, or when they rest their elbows on their thighs,⁷ while a pressure relief will occur when someone does a pushup or a full front lean. In-Seat Movements tend to result from reaching, leaning and adjusting posture with movements similar to weight shifts and pressure reliefs, but that are more transient, lasting less than 15 seconds.

All analysis was conducted with respect to the typical subject behavior, reported as the median (inter-quartile range) across subjects. Kruskal-Wallis tests compared subjects in the two groups, and the P-values and effect sizes of the differences in medians are reported. As opposed to the statistical analyses, Figure 2 presents all days of data across subjects to provide information about the range and variability of behavior.

Results

We recorded 225 complete days across 29 participants, 12 in the PrI group and 17 in the No PrI group. Participants were predominantly male, long-term wheelchair users of similar height and weight, although the No PrI group had more women than the PrI group (Table 1). Participants in the PrI group were a little older (mean (SD) 47 (11) years) compared with the no PrI group (37 (11)).

The median participant spent 10.3 hours in his wheelchair and transferred out of his wheelchair 8 times per day, or 16 total transfers daily. There was no difference in time in chair and number of transfers between the two groups (Table 2).

Participants in both groups performed few pressure reliefs and there was no difference between groups (Table 2). Weight shifts and in-seat movement, on the other hand, were performed more frequently than pressure reliefs. Weight shifts were performed significantly more often per hour by the No PrI Group (2.5 times per hour) than the PrI Group (1.0 times per hour). In-seat movements were performed 46.5 times per hour by the No PrI group and 39.6 times per hour for the PrI group.

Although typical subject behavior (represented by the median day) was not impacted by outliers, such as days with no wheelchair use, overall day-to-day variability in in-seat behavior was considerable. Figure 2, which presents all days of analysis, illustrates this variability within and across subjects. Although in-seat movement

Figure 1. Weight Shift Monitoring Instrumentation.
Reproduced from Sonenblum et al.⁸

Figure 2. Box plots illustrate the median and inter-quartile range of in-seat behavior across all complete days of data collection.

frequency did not differ significantly between groups, individuals with the highest in-seat movement frequencies were more likely to be in the No PrI group.

Discussion

This is the first study to objectively measure and compare the in-seat behavior between individuals with and without a history of recurrent PrIs. Despite subjective studies indicating that pressure relief behavior is unrelated to PrI outcomes,^{1,5,6} our results suggest that there is a difference in weight shifts between individuals with and without a history of PrI. Our study is unique in that it captured weight shifts that resulted from functional activities in addition to pressure reliefs intended solely to relieve pressure. That is, in our study, positions such as resting elbows on thighs or leaning onto an arm rest

or reaching sideways, which can reduce pressure by 30%, were counted as weight shifts when held for 15 seconds, or in-seat movement when more transient. These results, combined with evidence describing the physiological benefits of weight shifts,^{7,9,10} support the importance of seated movement in PrI prevention. However, the significant variation in daily behavior means that weight shifts and in-seat movements are not routine activities. Many individuals in the No PrI group performed few weight shifts on certain days (Fig. 2), yet this lack of activity did not lead to tissue breakdown.

Limitations

It is worth noting that while subjects in both groups spent a considerable amount of time in their wheelchairs daily, they also transferred out of their wheelchairs

Table 1 Characteristics of subjects with and without a PrI history were similar, except for age.

	PrI History (n = 12)	No PrI History (n = 17)	P-value
Age (years)	47 (11)	37 (11)	0.033
Height (inches)	71 (3)	69 (4)	0.141
Weight (lbs)	184 (50)	168 (36)	0.342
Years in wheelchair	17 (11)	13 (8)	0.190
Sex	11 M, 1 F	12 M, 5 F	
Complete injuries	8 (67%)	9 (53%)	0.373
Self-report buttocks sensation	4 (33%)	8 (47%)	0.460
Level of injury			
Cervical	1 (8%)	2 (12%)	
Thoracic	9 (75%)	14 (82%)	
Lumbar	2 (17%)	0 (0%)	
Unknown	0 (0%)	1 (6%)	

Table 2 Typical subject behavior, compared across PrI group (n = 29).

	Median (Inter-quartile Range)		P-value	Effect size
	No PrI	PrI		
Time in wheelchair	10.3 (7.6–12.5)	10.3 (8.3–11.4)	1.000	0.00
# Transfers out of wheelchair	7.5 (3.0–11.5)	8.5 (5.7–11.0)	0.535	0.11
Pressure relief frequency	0.2 (0.1–0.5)	0.3 (0.0–0.7)	0.658	0.08
Weight shift frequency	2.5 (1.0–3.6)	1.0 (0.4–1.9)	0.037	0.39
In-seat movement frequency	46.5 (28.7–76.7)	39.6 (24.3–49.7)	0.352	0.17

frequently throughout the day. The surfaces to which they transfer, and their weight shift behaviors on these other surfaces may also contribute to tissue health or breakdown.

As noted in the results, the two groups of participants were fairly similar in composition, with small differences in gender and age. While both factors could be associated with differences in behavior or PrI risk,¹¹ our study indicated no significant correlation between weight shift frequency and age, nor differences in weight shift frequency according to sex. Future work intended to better understand the relationship between in-seat movement, individual characteristics, and PrI outcomes should prospectively follow a larger population of wheelchair users for an extended duration.

Conclusion

Weight shifts and in-seat movements that can be produced by functional activities and that partially unload the buttocks should be considered as an important addition to individuals' PrI prevention regimen.

Declaration of interest

In accordance with Taylor & Francis policy and my ethical obligation as a researcher, I am reporting that I may submit a patent application for the sensors and analysis methods used in this study to measure in-seat movement.

Disclaimer statements

Contributors SES and SHS participated in study design, data collection and analysis, and manuscript preparation and revision.

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Conflict of Interest None.

Ethics approval This study was approved by the institutional review boards at Georgia Tech, Shepherd Center, and Duke University.

Disclosures None.

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