Ergonomic Evaluation of the LiftSeat® Patient Handling Technology to Facilitate Toileting Tasks

By: John Lloyd, PhD, CPE

August 2008

Introduction

Nursing personnel have one of the highest job-related injury rates of any occupation in the United States[1,2]. Numerous researchers have studied patient handling and consider it to be a high risk for developing musculoskeletal injuries [3,4,5,6,7,8,9,10]. The healthcare industry recognizes that the high risk of injury in nursing is attributable to patient handling and movement.

New approaches need to be adopted to achieve a safer process for the handling of movement of patients and this concept needs to be embedded into the culture of healthcare delivery. One particular patient handling task requiring improvement is toilet transfers. The standard technique used to transfer partially-dependent patients on and off a toilet requires manual assistance. To date, there is little or no evidence in the literature that quantifies the risk of injury to the caregiver specific to this manual task. As the patient population cared for presents with more comorbidities, is more obese, and more dependent, safer techniques and assistive technologies are particularly critical for the performance of patient handling tasks.

Methodology and Results

An evaluation is presented to quantify the biomechanical demands acting on a caregiver during toilet transfers of partially-dependent patients. One commercially-available powered toilet transfer technology, LiftSeat®, was compared against the manual technique of assisting patients on and off a toilet.

<u>Step 1: Mannequin™ software</u> was used to determine joint angles and floor-relative distances for both the LiftSeat® and standard toilet using computer-generated patient representatives, ranging from 5th percentile (small) US adult female to 95th percentile (large) US adult male (Figures 1 & 2). Results are presented in Tables 1 & 2, below.

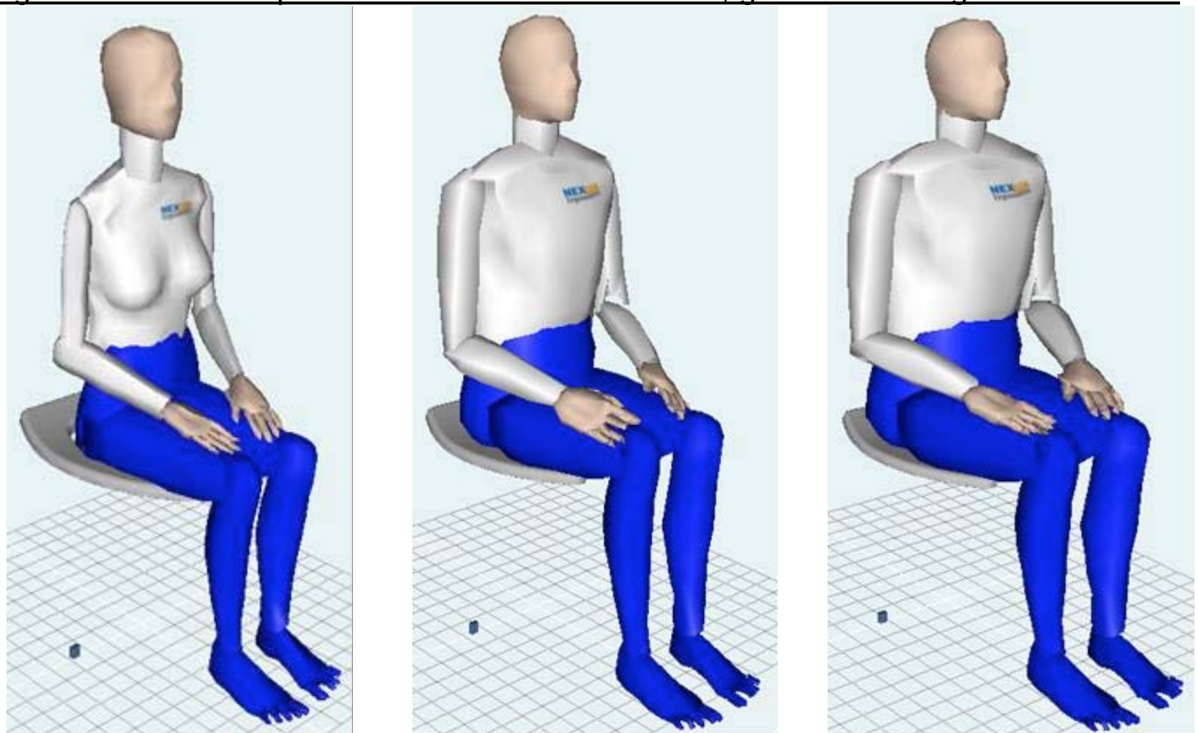
<u>Table 1: Anthropometry of Patient Representatives</u>

	stature (in)	weight (lb)
5th percentile female	60.2	109.4
50th percentile male	69.1	171.3
95th percentile male	73.5	216.2

<u>Table 2: Vertical Distance from Floor to Axilla (inches)</u>

	Toilet	LiftSeat
5th percentile female	33.4	39.6
50th percentile male	35.0	40.4
95th percentile male	37.3	44.5

Figure 1 – Patient representatives on standard toilet, generated using HumanCAD™

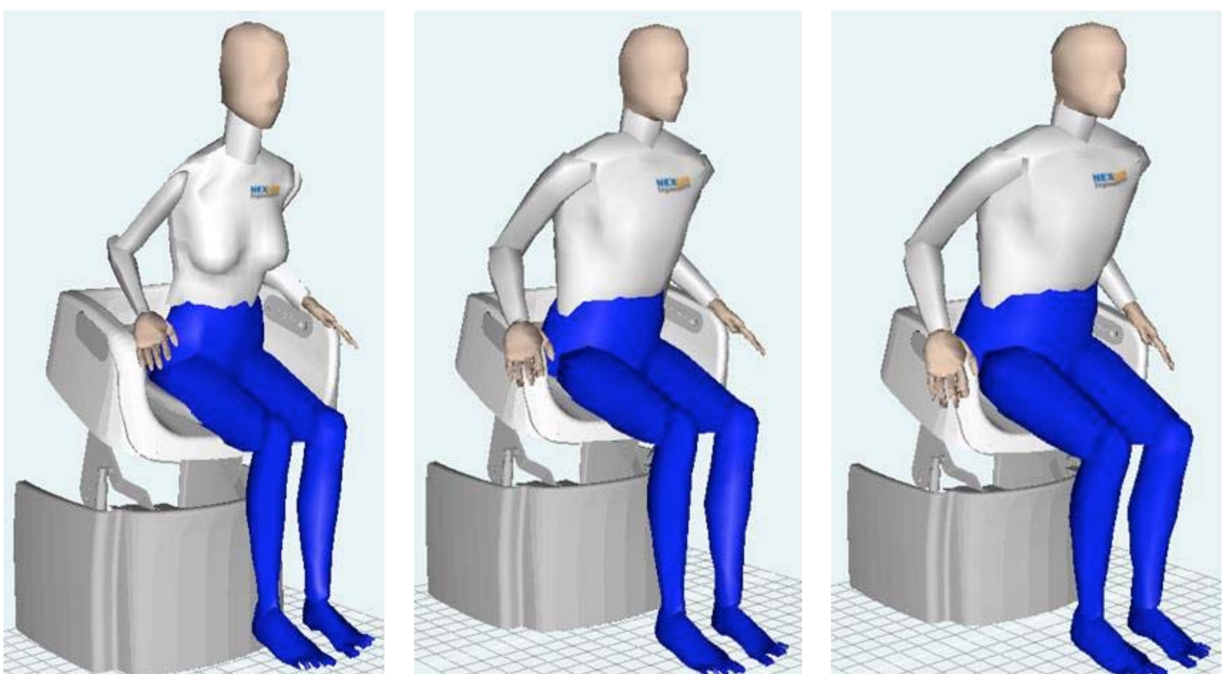


5th percentile US adult female

50th percentile US adult male

95th percentile US adult male

Figure 2 – Patient representatives on LiftSeat® in Egress Position, using HumanCAD™



5th percentile US adult female – isometric view

50th percentile US adult male – front view

95th percentile US adult male – right view

Computer simulated patients range in weight from 109.4 lbs (small 5th percentile US adult female) to 216.2 lbs (large 95th percentile US adult mal). Using Mannequin™ software the height from the floor to axilla ranged from 33.4 to 37.3 inches for the standard toilet and between 39.6 and 44.5 inches for the LiftSeat®.

Step 2: Lab Testing. Five subjects representatives were asked to simulate assisted egress from a standard toilet and LiftSeat® in a laboratory, where the level of patient assistance was constant between tasks (see Figure 3). The force that a caregiver would need to provide to assist the patient in this task was measured using a Chatillon gauge. Five repeated measures were collected for each subject, with both the standard toilet and LiftSeat®, for a total of 50 measures. Mean forces are presented in Table 3, below.

Figure 3 – Lab Testing

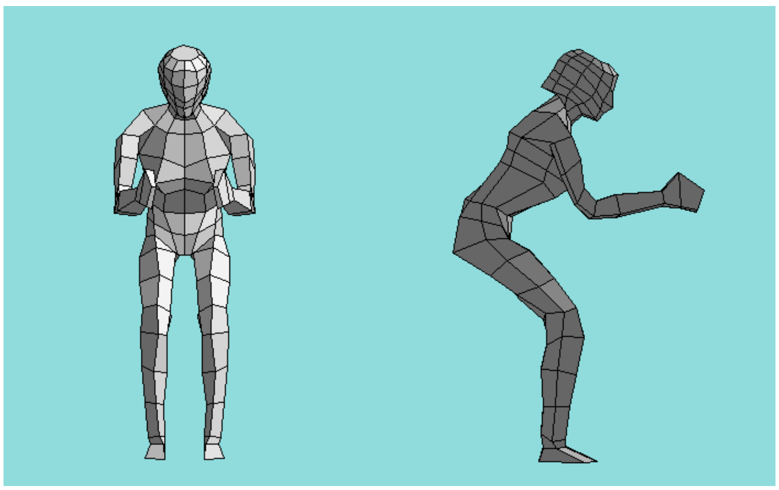
Table 3: Vertical Distance from Floor to Axilla (inches)

Subject	Weight (lb)	Std Toilet (lbF)	LiftSeat (lbF)
1	195	59.1	45.4
2	210	38.9	32.6
3	277	54.2	40.0
4	165	24.3	21.4
5	197	53.1	32.1
Average	208.8	45.9	34.3
%bw		22.0	16.4

Results of lab testing show that, on average, a caregiver provides approximately 46 lb force when assisting patients on and off a standard toilet, compared with 34 lb force when assisting patients on and off a LiftSeat®. Presented as a percentage of patient weight, this force equals 22% and 16.4% respectively. Therefore, considerably less force is required to assist patients with toileting transfer tasks using the LiftSeat®.

Step 3: UM3DSSPP. Findings from the Mannequin modeling and lab testing were used to perform further analysis using the University of Michigan 3D Static Strength Prediction Program (UM3DSSPP). UM3DSSPP is based on 30+ years of research at the University of Michigan and was used to compute biomechanical demands acting on a caregiver during utilization of the LiftSeat® for patient toileting tasks. Biomechanical models were also generated for standard toilets to be used as a comparative task (Figure 4).

Figure 4 – UM3DSSPP Modeling



Biomechanical measures computed using UM3DSSPP include lumbar spine forces, shoulder forces, determination of percent population capable (calculated as a function of caregiver strength), and calculation of risk of lumbar spine injury. These measures were calculated for 1 and 2 caregiver toileting scenarios across patient representatives from small female to large male for comparison between the LiftSeat® and standard toilet patient transfer tasks. Results of the UM3DSSPP analysis are presented in Table 4, below.

Table 4: UM3DSSPP Results for Standard Toilet and LiftSeat®

		Standard Toilet						LiftSeat					
Patient representative		5th %ile female		50th %ile male		95th %ile male		5th %ile female		50th %ile male		95th %ile male	
# caregivers		1	2	1	2	1	2	1	2	1	2	1	2
lift height (in)		33.4	33.4	35	35	37.3	37.3	39.6	39.6	40.4	40.4	44.5	44.5
% bw		22	22	22	22	22	22	16.4	16.4	16.4	16.4	16.4	16.4
left force (lbF)		12.0	18.1	18.8	28.3	23.8	35.7	9.0	13.5	14.0	21.1	17.7	26.6
right force (lbF)		12.0	6.0	18.8	9.4	23.8	11.9	9.0	4.5	14.0	7.0	17.7	8.9
% Capable	Elbow	97	89	80	44	37	7	97	70	88	77	66	53
	Shoulder	99	87	99	35	99	12	100	85	100	75	99	41
	Torso	99	94	99	76	97	61	99	94	99	89	96	74
	Hip	99	95	99	98	99	99	99	99	99	98	99	99
	Knee	91	71	81	36	66	18	86	46	77	27	71	33
	Ankle	90	74	52	12	16	0	84	41	54	10	40	14
Spine Force (lb)	Comp	186	262	78	438	162	543	92	246	92	359	205	436
	A/P Shear	11	23	-4	13	10	-21	12	11	3	0	-1	-23
	Lateral shear	0	27	0	42	0	56	0	21	0	33	0	44

The difference between results for standard toilet vs LiftSeat® egress were calculated and presented in Table 5, below. Mean values across tasks were calculated. Highlighted values indicate biomechanical improvement of the LiftSeat®.

Table 5: Comparison of Biomechanical Results for Standard Toilet and LiftSeat®

Patient representative		5th %ile female		50th %ile male		95th %ile male		Mean
# caregivers		1	2	1	2	1	2	
% Capable	Elbow	0	-19	8	33	29	46	16.2
	Shoulder	1	-2	1	40	0	29	11.5
	Torso	0	0	0	13	-1	13	4.2
	Hip	0	4	0	0	0	0	0.7
	Knee	-5	-25	-4	-9	5	15	-3.8
	Ankle	-6	-33	2	-2	24	14	-0.2
Spine Forces (lb)	Compression	94	16	-14	79	-43	107	39.8
	A/P Shear	-1	12	-7	13	11	2	5.0
	Lateral shear	0	6	0	9	0	12	4.5

Conclusions and Future Work

Results of this biomechanical analysis aid us in better understanding the physical demands placed on caregivers during manual transfer of partially-dependent patients on and off a toilet. Clearly, the LiftSeat presents a considerable biomechanical benefit for caregiver-assisted toilet transfer tasks over a standard toilet. It is anticipated that this information will promote the utilization of powered technologies for this stressful task across the healthcare industry, thereby reducing the risk of caregiver injury.

It is proposed that further research may be warranted to investigate the muscular efficacy of the LiftSeat® over a standard toilet for unassisted toileting transfers in home-based independent patients.

References

[1] U.S. Department of Labor, Occupational Safety and Health Administration. (1999) Ergonomics program; Proposed rule. Fed. Reg., November 23.

[2] U.S. Department of Labor, Occupational Safety and Health Administration. (2000). 29 CFR Part 1910. Ergonomics program: Final rule. Fed. Reg., November 14.

[3] Garg, A. & Owen, B. (1992) Reducing back stress to nursing personnel: An ergonomic intervention in a nursing home. Ergonomics, 35(11), 1353-75.

[4] Garg, A., Owen, B.D. and Carlson, B., (1992) An Ergonomic evaluation of nursing assistants' job in a nursing home. Ergonomics, 35, pp.979-995.

[5] Smedley, J., Egger, P., Cooper, C. and Coggon, D. (1995) Manual handling activities and risk of low back pain in nurses. Occupational and Environmental Medicine, 52, pp. 160-163.

[6] Yassi, A., Ostry, A. S., Spiegel, J., Walsh, G. and De Boer, H. M. (2002) A collaborative evidence based approach to making healthcare a healthier place to work. Hospital Quarterly, 5, pp. 70-78.

[7] Marras, W.S., Davis, K.G., Kirking, B.C. and Bertsche, P.K. (1999) A comprehensive analysis of low back disorder risk and spinal loading during the transferring and repositioning of patients using different techniques. Ergonomics, 42, pp. 904-926.

[8] Zhuang, Z., Strobbe, T.J., Hsiao, H., Collins, J. W. and Hobbs, G. R. (1999) Biomechanical evaluation of assistive devices for transferring residents. Applied Ergonomics, 30, pp. 285-294.

[9] Goldman, R. H., Jarrad, M. R., Kim, R., Loomis, S. and Atkins, E.H. (2000) Prioritizing back injury risk in hospital employees: application and comparison of different injury rates. Journal of Occupational and Environmental Medicine, 42, pp.645-652.

[10] Nelson, A.L., Fragala, G., & Menzel, N. (2003) Myths and facts about back injuries in nursing. American Journal of Nursing, 103(2), 32-40.

[11] Nippon Engineering College. (2002) Comparison meeting of motion analysis systems. Tokyo, Japan