

Biomechanical Evaluation of Pressure Distribution during Extended Use of HoverMatt™ Technology

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Background:

Nursing personnel have one of the highest job-related injury rates of any occupation in the United States^{1,2}. The healthcare industry recognizes that the high risk of injury in nursing is caused by unsafe patient handling and movement. Lateral transfers have been identified as one such high risk patient handling task that is frequently performed by nursing staff and other health care professionals.

A lateral transfer is defined as movement of a patient in a supine position from one surface to another. Lateral patient transfers include transfers to and from bed, stretcher, prone cart, or bathing trolley. Lateral transfers necessitate use of the weaker muscles of the caregiver's arms and shoulders as primary lifting muscles, rather than the stronger muscles of the legs.

In an effort to reduce the risk of injury to caregivers, various products have been developed and are commercially available. Technology solutions rely on strategies to reduce friction as the patient is transferred from one surface to the other. Lateral transfer aids can be grouped into three categories: (1) friction reducing lateral sliding aids, (2) air assisted lateral sliding aids, and (3) mechanical lateral sliding aids.

The HoverMatt[®] is an air-assisted device frequently utilized for the lateral transfer of patients. This device may be best used for patients who can offer caregivers limited or no assistance during a lateral transfer. The technology is in two parts: a flexible mattress, which is placed under a patient and a portable air supply that is used to inflate the mattress. Air flows through perforations in the underside of the mattress and the patient is moved on a cushioned film of air allowing caregivers to perform lateral transfers with less effort.

As the HoverMatt technology is in two parts, it is possible for the flexible mattress to be deflated and portable air supply removed. This eliminates the need to repeatedly install / remove the air-mattress beneath the patient between transfers. However questions are raised as to whether leaving the deflated mattress beneath a patient / resident for an extended period of time might contribute to risk of developing pressure ulcers.

Objectives:

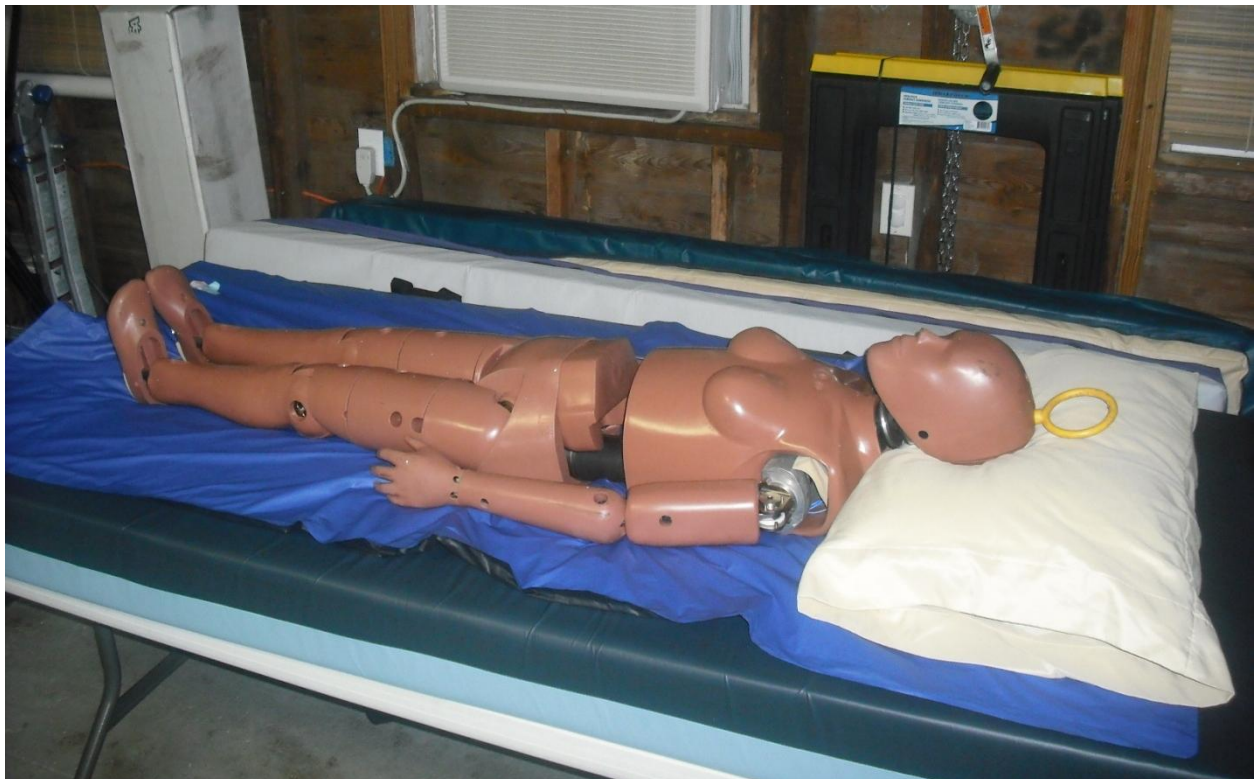
The purpose of this study was to objectively measure and evaluate the pressure distribution between patients of various sizes and the HoverMatt technology over extended durations. The following objectives were identified:

- 1: Quantify the pressure distributions created at the patient / mattress interface for a variety of institutional mattresses over extended durations.
- 2: Quantify the pressure distributions created at the patient / HoverMatt® interface for a variety of institutional mattresses over extended durations.
- 3: Compare results from objectives 1 and 2 above and determine whether leaving the deflated HoverMatt technology beneath a patient causes increased pressure over extended durations.

Methods:

Whole body pressure distributions were recorded using a FSA computer-based pressure measurement system (Vista Medical, Winnipeg, Canada). Prior to beginning the study, the FSA sensor array was calibrated using an automatic calibration system from Vista Medical. Sensor “drift”, a known characteristic of pressure mapping systems, was quantified by measuring unloaded sensor output for eight hours.

Figure 1: Hybrid III 5th percentile mannequin on FSA pressure sensing array



Data were acquired for four mannequins, representative of patient weights 115lb (small female), 175lb (average male), 265lb (large male), and 420lb (bariatric individual). Four institutional mattresses were utilized - AccuMax, HillRom, ProCair and TriLine. For each patient and mattress combination, data were acquired for the FSA pressure matt only, FSA + standard HoverMatt and FSA + disposable HoverMatt. Figure 1, above, illustrates data acquisition using the FSA pressure matt only, with the Hybrid III 5th percentile female anthropomorphic test mannequin.

Using the FSA technology, pressure for each of the 2096 sensors were recorded every 6 seconds for a minimum of 8 hours, producing at least 10,000,000 data points per trial. Files were reduced such that all data points beyond 4800 frames were deleted. In addition, based on preliminary analysis of sensor characteristics, the first hour of data (600 records) were also deleted across all files to minimize sensor instability.

Results:

Sensor creep (Figure 2) was mathematically subtracted from all trials. Even after removing this sensor characteristic, an effect of time was still observed, however, such effect is associated with the FSA sensor (Figure 3), rather than either the traditional HoverMatt (Figure 4) or disposable HoverMatt (Figure 5). Figure 6 illustrates the effect of pressure over time attributable to the HoverMatt technology (standard and disposable combined) after removing the effect of the FSA sensor.

Conclusions:

There is no significant difference between trials with and without the HoverMatt technology. That is, utilization of either the standard HoverMatt or the disposable HoverMatt did not cause increased pressure at the patient / matt interface. Furthermore, it was noted that pressure distributions over time for the disposable HoverMatt were favorable to the standard HoverMatt, though not statistically significant.

Table 1: Summary of Results

	115 lb patient			175 lb patient			265 lb patient			420 lb patient		
	FSA	HoverMatt	Disposable	FSA	HoverMatt	Disposable	FSA	HoverMatt	Disposable	FSA	HoverMatt	Disposable
AccuMax												
Average (mmHg)	2.7	2.7	2.8	5.5	4.7	4.8	8.2	6.7	7.3	12.6	13.8	14.1
Variance (mmHg ²)	108.3	124.6	107.3	226.5	206.2	187.6	367.0	317.0	344.9	587.3	672.6	681.7
Standard deviation (mmHg)	10.4	11.2	10.4	15.0	14.4	13.7	19.2	17.8	18.6	24.2	25.9	26.1
Coefficient of variation (%)	383.2	407.6	368.4	274.1	308.3	286.7	233.3	267.7	253.7	193.1	188.1	185.3
HillRom												
Average (mmHg)	2.9	2.8	2.9	4.5	4.6	4.6	6.3	7.0	6.4	11.2	11.4	11.1
Variance (mmHg ²)	146.0	152.2	157.8	214.1	224.5	228.6	310.4	387.4	330.0	569.6	596.7	542.1
Standard deviation (mmHg)	12.1	12.3	12.6	14.6	15.0	15.1	17.6	19.7	18.2	23.9	24.4	23.3
Coefficient of variation (%)	420.8	447.8	426.6	322.8	325.2	327.6	279.1	281.1	283.3	212.2	213.5	210.1
ProCair												
Average (mmHg)	3.0	2.8	2.9	4.9	5.3	4.9	8.4	7.6	7.2	14.8	14.7	13.8
Variance (mmHg ²)	109.4	126.5	118.2	186.4	235.6	208.6	409.2	395.8	326.4	788.9	787.3	731.9
Standard deviation (mmHg)	10.4	11.2	10.9	13.6	15.3	14.4	20.2	19.9	18.1	28.1	28.1	27.1
Coefficient of variation (%)	349.1	395.2	374.9	277.4	291.1	292.1	242.0	260.9	250.6	190.2	190.8	196.0
TriLine												
Average (mmHg)	3.6	3.0	3.2	5.4	5.2	5.5	7.5	7.6	7.5	15.1	15.1	13.0
Variance (mmHg ²)	181.9	171.4	183.5	254.9	246.5	226.6	379.5	402.5	382.3	823.9	858.7	686.2
Standard deviation (mmHg)	13.5	13.1	13.5	16.0	15.7	15.0	19.5	20.1	19.5	28.7	29.3	26.2
Coefficient of variation (%)	378.0	433.4	425.8	293.4	303.7	275.7	261.3	263.3	261.6	189.8	193.7	200.9

Figure 2: 'Creep' Associated with unloaded FSA pressure mapping system

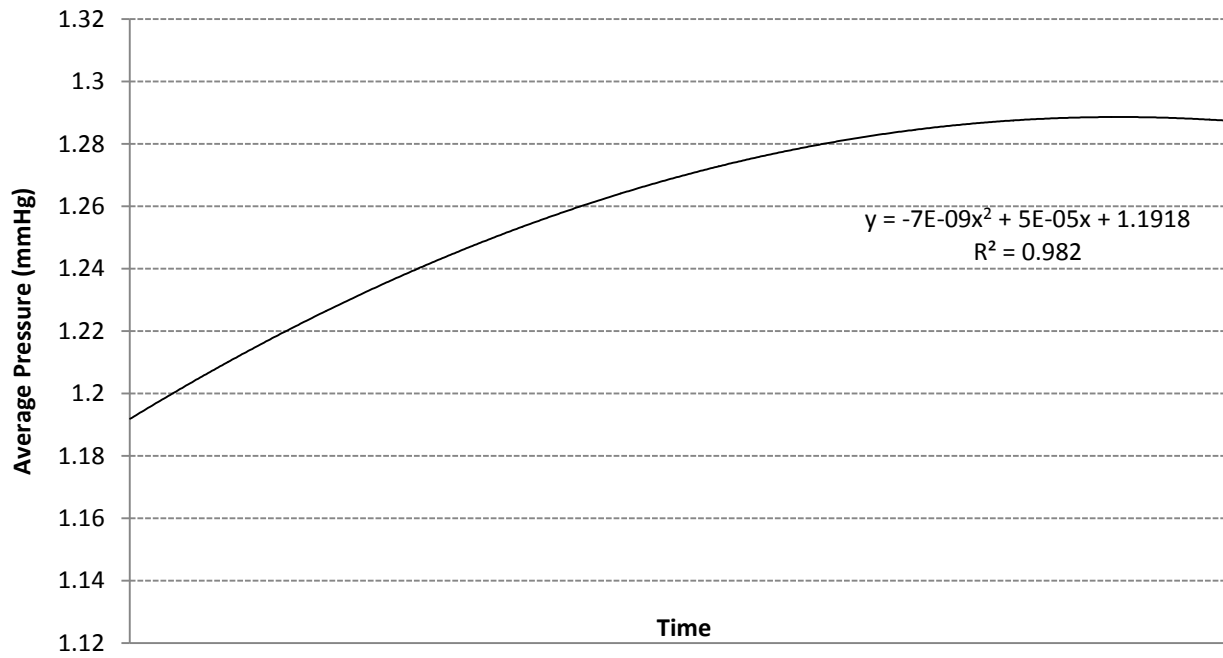


Figure 3: Effect of Pressure over Time for loaded FSA sensor only across patients and mattresses (adjusted for sensor creep)

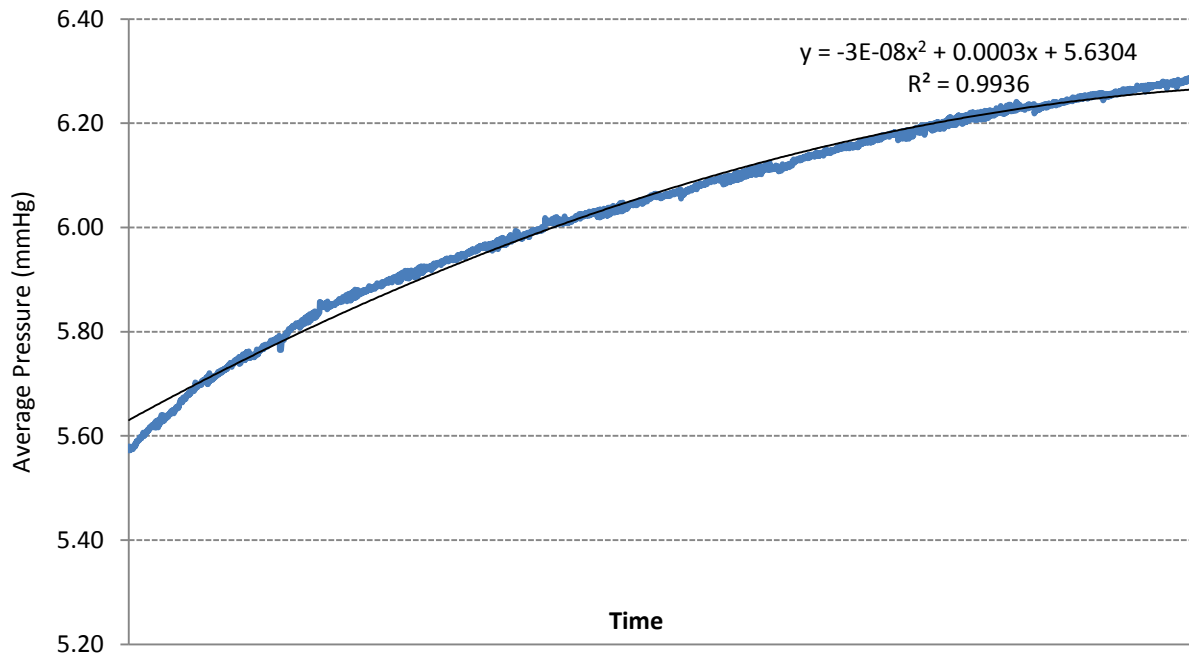


Figure 4: Effect of Pressure over Time for FSA plus HoverMatt across patients and mattresses (adjusted for sensor creep)

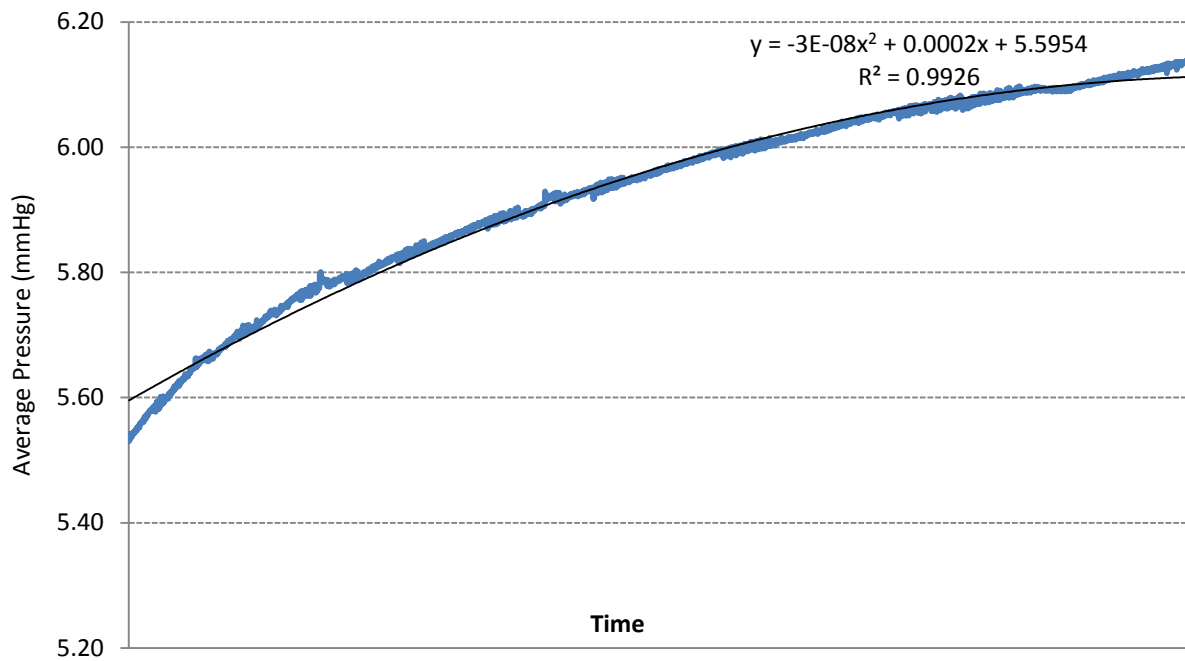


Figure 5: Effect of Pressure over Time for FSA plus Disposable Mat across patients and mattresses (adjusted for sensor creep)

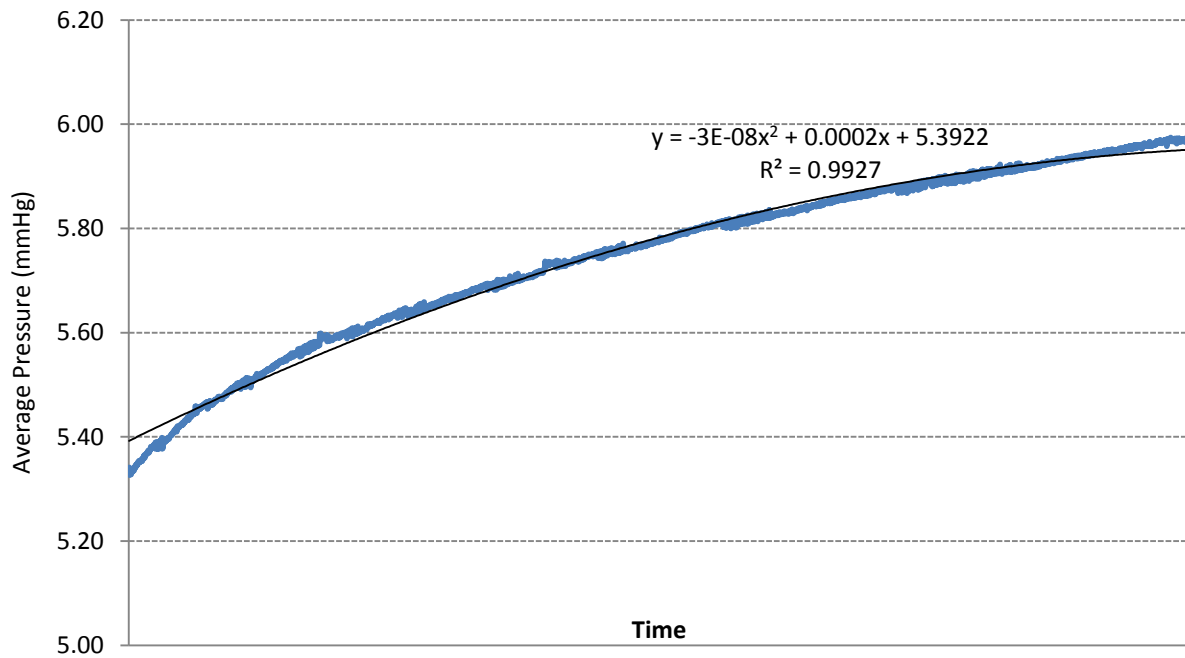
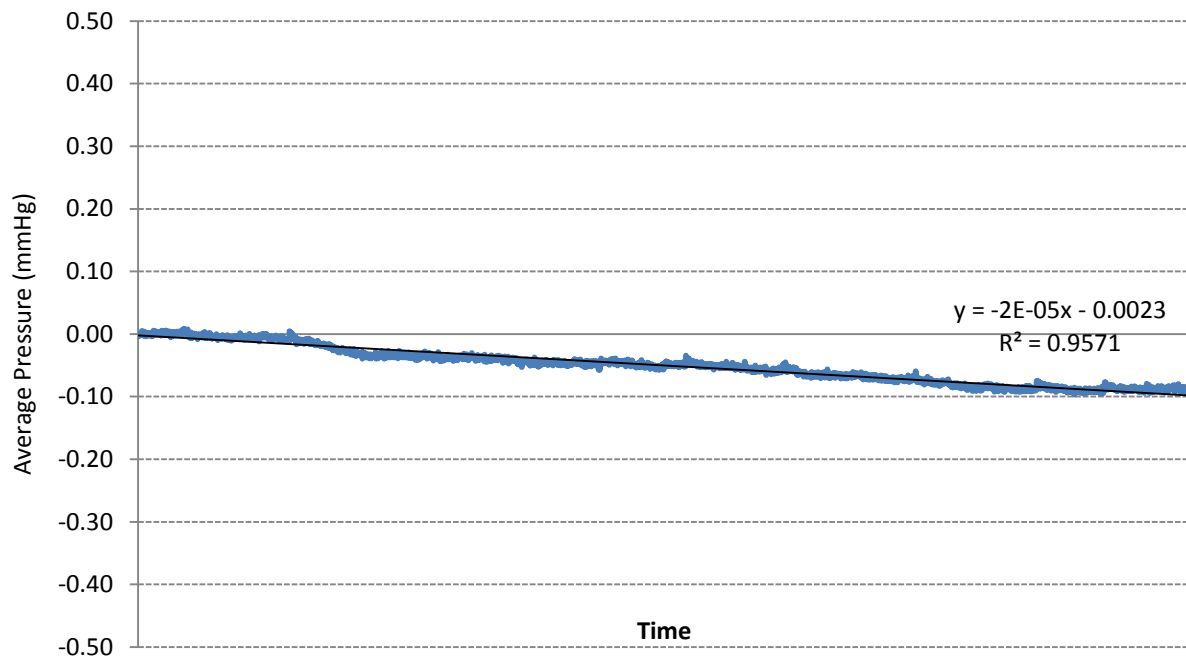


Figure 6: Effect of Pressure over Time on HoverMatt after removing effect of loaded FSA sensor



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.