

Dynamic Off-loading Cushion Interface Pressure Testing

Objectives

Interface pressure testing to assess

1. Off-loading of the primary ‘at-risk’ sites (IT’s and sacrum) during bladder deflation.
2. Changes in loading of other sites during bladder deflation
(e.g., loading of trochanters during IT off-loading)
3. Distribution of pressure while cushion is inactive

Clinical Utility to assess ability to:

1. Accommodate pelvic tilt and mild pelvic obliquity
2. Facilitate postural stability and control

SUBJECTS

14 adult wheelchair users with spinal cord injury, 11 male and 3 female. Age range: 22-59. Height range: 60 – 74”. Weight range: 131 – 215 pounds. Pelvic tilt: 7 neutral, 6 posterior pelvic tilt, 1 anterior pelvic tilt. Pelvic obliquity: 7 neutral, 7 with mild obliquity ($\leq \frac{1}{2}''$ to $1''$). Data from 13 subjects was used in analysis due to posture limitations of 1 subject.

METHODS

The Tekscan CONFORMat© IPM system was used to measure interface pressure. For infection control, a stretchy thin plastic sheet was used to cover the CONFORMat.

Subjects were positioned on the cushion in a test chair with 17” seat depth, height adjustable desk arms, 70° footrests, tension adjustable backrest, a 93° seat-to-back angle and 3° seat tilt. Each subject assumed a self-selected posture and the test chair was adjusted as needed.

Bladder inflation-deflation sequence was as follows:

| State & action | Time | Data taken |
|---|------------|-----------------------------------|
| Full Inflation | 0:00-1:00 | Inflation Pretest @ 1:00 |
| 1st ITs deflation: IT bladders deflate, hold & release | 1:00-2:10 | IT deflate 1 @ t=1:45 |
| Full Inflation | 2:10-2:55 | |
| 1st sacral deflation: Sacral bladder deflates, holds & releases | 2:55-4:05 | Sacral deflate 1 @ t= 3:40 |
| Full Inflation | 4:05-4:50 | |
| 2nd IT deflation: IT bladders deflate, hold & release | 4:50-6:00 | IT deflate 2 @ 5:35 |
| Full Inflation | 6:00:6:45 | |
| 2nd sacral deflation Sacral bladder deflates, holds & releases | 6:45-7:55 | Sacral deflate 2 @ 7:30 |
| Full Inflation: Cycling ceases; all bladders inflated. | 7:55-13:55 | Inflate Post 1 @ 8:55 |
| | | Inflate Post 2 @ 13:55 |

ANALYSIS

CONFORMat regions were defined to approximate IT and sacral bladder dimensions. Interface pressures within these regions were entered into analysis. The IT bladders used a 4 x 8 sensel area and for the sacral bladder, a 3 wide x 8 long sensel area was defined.

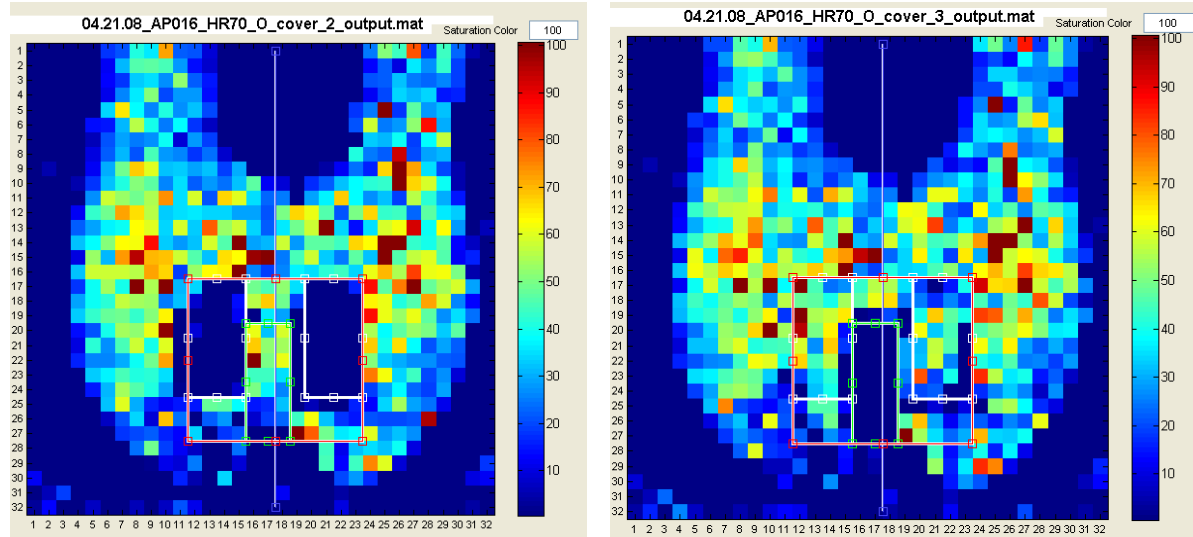


Figure 1: Example CONFORMat data. Red box circumscribed entire ischial-coccygeal region. While boxes indicate IT bladder region and green box defines the sacral bladder area.

RESULTS

Analysis of Interface Pressures

Variables: Mean pressure= avg of sensels in defined bladder region

Peak Pressure Index (PPI): the highest recorded average pressure of 4 values within the defined bladder region

Analysis: Within subject ANOVA and Tukey post-hoc analysis

ISCHIAL TUBEROSITY BLADDER RESULTS

| Variable | condition | N | Mean | SE Mean | StDev | Minimum | Maximum |
|--------------|--------------|----|-------|---------|-------|---------|---------|
| MeanPress_IT | IT Deflate 1 | 13 | 2.888 | 0.518 | 1.869 | 0.62 | 6.17 |
| | IT Deflate 2 | 13 | 3.312 | 0.679 | 2.449 | 0.83 | 8.24 |
| | Sac Defl 1 | 13 | 33.11 | 2 | 7.22 | 21.29 | 43.84 |
| | Sac Defl 2 | 13 | 33.22 | 2.13 | 7.67 | 22.22 | 46.41 |
| | Infl. Post 1 | 13 | 33.54 | 1.89 | 6.83 | 21.38 | 43.28 |
| | Infl. Post 2 | 13 | 35.74 | 1.62 | 5.85 | 25.28 | 43.97 |
| | Infl. Pre | 13 | 25.22 | 1.94 | 7.01 | 18.23 | 41.03 |
| PPI_IT | IT Deflate 1 | 13 | 9.96 | 1.26 | 4.54 | 3.67 | 15.54 |
| | IT Deflate 2 | 13 | 11.12 | 1.89 | 6.83 | 3.38 | 24.63 |
| | Sac Defl 1 | 13 | 62.16 | 5.8 | 20.9 | 42.42 | 124.5 |
| | Sac Defl 2 | 13 | 61.69 | 5.65 | 20.38 | 38.25 | 121.54 |
| | Infl. Post 1 | 13 | 63.09 | 5.21 | 18.78 | 47.25 | 121.79 |
| | Infl. Post 2 | 13 | 64.27 | 3.93 | 14.19 | 49.25 | 106.67 |
| | Infl. Pre | 13 | 52.79 | 5.17 | 18.65 | 36.46 | 103.5 |

Analysis of Inflated Conditions: Ischial Bladders

PRETEST values were lower than both POSTTEST values for both PPI_IT and MeanPress_IT ($p < 0.0001$). This increase in loading might be explained by creep of the sensor, cushion and/or tissue.

No differences exist between POST 1 and POST 2. ($p = 0.725$)

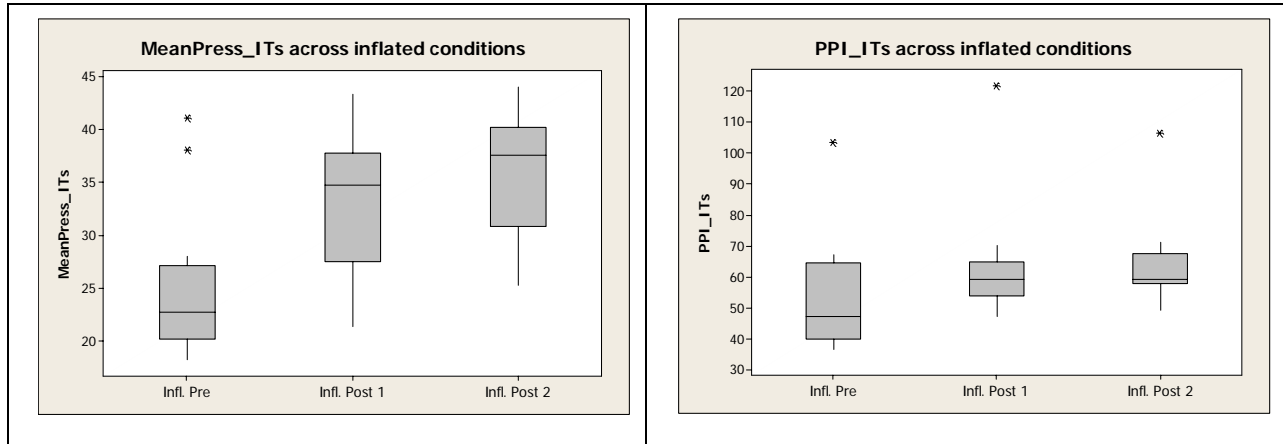


Figure 2. Box plots of interface pressures measured in the IT regions during full inflation states

Analysis of deflated states: Ischial Bladders

A large difference exists between deflated and inflated conditions (all $p < 0.0001$) and no differences existed between the deflated states ($p > 0.99$).

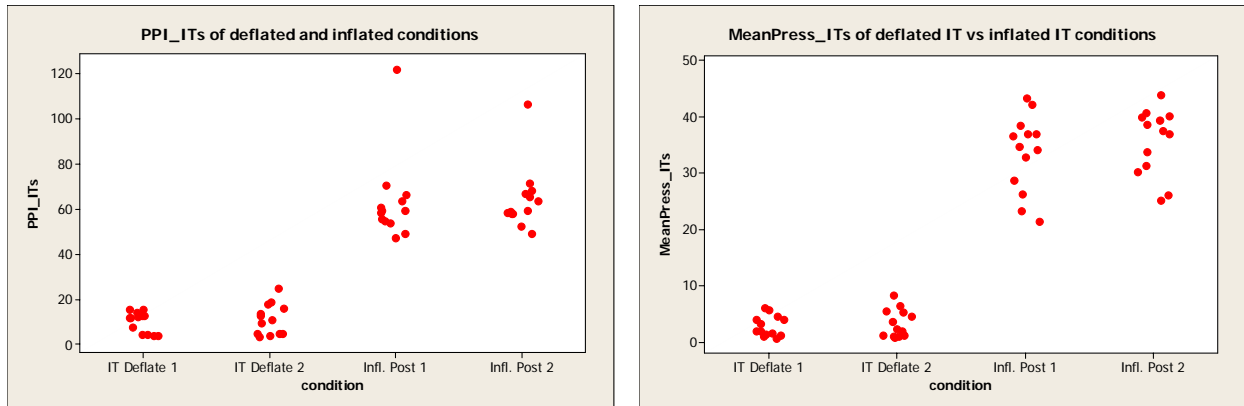


Figure 3. Individual value plots of interface pressures measured in the IT regions during deflated and inflated states.

SACRAL BLADDER RESULTS

| Variable | condition | N | Mean | SE Mean | StDev | Minimum | Maximum |
|---------------|--------------|----|-------|---------|-------|---------|---------|
| MeanPress_Sac | IT Deflate 1 | 13 | 40.09 | 3.43 | 12.35 | 9.42 | 58.15 |
| | IT Deflate 2 | 13 | 34.28 | 3.29 | 11.87 | 6.81 | 51.25 |
| Sac Defl | Sac Defl 1 | 13 | 2.14 | 0.9 | 3.246 | 0 | 10.06 |
| | Sac Defl 2 | 13 | 2.285 | 0.896 | 3.23 | 0 | 9.81 |
| Infl. Post | Infl. Post 1 | 13 | 26.8 | 2.8 | 10.09 | 4.42 | 42.17 |
| | Infl. Post 2 | 13 | 30.79 | 3.05 | 11.01 | 6.49 | 48.56 |
| Infl. Pre | Infl. Pre | 13 | 29.7 | 2.84 | 10.24 | 6.25 | 45.63 |

| | | | | | | | |
|---------|--------------|----|-------|------|-------|-------|-------|
| PPI_Sac | IT Deflate 1 | 13 | 68.29 | 5.12 | 18.44 | 31.83 | 90.5 |
| | IT Deflate 2 | 13 | 60.04 | 5.11 | 18.43 | 27.08 | 85.42 |
| | Sac Defl 1 | 13 | 5.67 | 2.4 | 8.66 | 0 | 28.67 |
| | Sac Defl 2 | 13 | 6.38 | 2.38 | 8.59 | 0 | 28.75 |
| | Infl. Post 1 | 13 | 43.17 | 4.12 | 14.87 | 10.75 | 65.42 |
| | Infl. Post 2 | 13 | 51.49 | 3.98 | 14.35 | 19.83 | 67.33 |
| | Infl. Pre | 13 | 47.39 | 4.45 | 16.03 | 17.67 | 69.25 |

Analysis of Sacral Bladders

Pressures at the sacral bladder were much lower in the deflated state compared to inflated conditions (all $p < 0.0001$). No differences existed within the deflated or inflated states ($p > 0.99$)

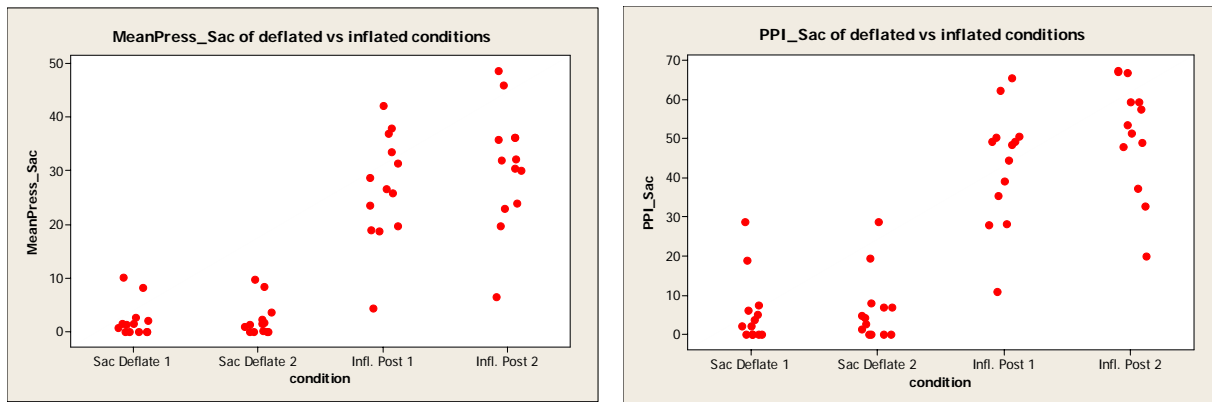


Figure 4. Individual value plots of interface pressures measured in the sacral region during deflated and inflated states.

Discussion

- IPM testing showed that bladder deflation effectively off-loaded the bony prominences.
- Bladder deflation did not result in concomitant pressure increases at other sites
- IP measured during the inflated states reflected effective pressure distribution over the entire buttock surface.
- The cushion was able to support pelvic posture across the range of subjects. Subjectively, the majority of the participants rated the AP Cushion as good or better with respect to general stability and comfort compared to their own cushions. Each subject transferred independently without difficulty on to and off of the cushion.
- About one-half of the subjects had mild obliquities ($\leq \frac{1}{2}$ to 1°); offloading was achieved for each on the low side. How well this design would address fixed obliquities, or those $> 1^\circ$ requires further testing.
- Lastly, this test series represented only a short term trial of the cushion. Each subject sat for 14 minute bouts. Thus, change in interface pressure during long duration sitting is not yet known. This requires further testing.

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