Investigating the pressure redistribution of a range of seat cushions offered by REPOSE in both upright seated and semi-reclined position in the Multi-C air chair.

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BRIEF

An independent report was commissioned by Repose and completed by Jo Webb of The OT Service to identify differences in pressure redistribution of seven internal cushions available in the Repose range to help advise, guide, and prescribe the most appropriate cushion for comfort and pressure redistribution for customers with a variety of needs.

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1. INTRODUCTION

A pressure ulcer is defined as a localised injury to the skin or underlying tissue, occurring as a result of pressure, or pressure in combination with shear and usually over a bony prominence (European Pressure Ulcer Advisory Panel and National Pressure Ulcer Advisory Panel, 2009). Pressure ulcers are a common, costly, and physically debilitating health complication, affecting people in both acute care and the community affecting approximately one in seven hospitals and 1 in 20 community patients (Kaltenthaler et al,2001, McGinnis et al, 2001). Any patient can develop a pressure ulcer; however, they are more likely to occur in people who are seriously ill, have a neurological condition, reduced sensation, limited mobility, nutritional deficiency, the inability to reposition themselves or significant cognitive impairment (NICE, 2014). Common sites for pressure ulcers are bony prominences, such as the sacrum and ischial tuberosities in a seated position. The development of a pressure ulcer can impact an individual's rehabilitation process, leading to extended hospital stays with the annual cost of treating pressure ulcers in the U.K. estimated to be between £1.4 and £2.5 billion annually (Dealey et al., 2012).

Evidence based guidelines for the treatment and prevention of pressure ulcers give detailed guidance when caring for people in bed (EPUAP and National Pressure Ulcer Advisory Panel 2009) (EPUAP and NPUAP 2009). This focuses on regular posture change and pressure reducing mattresses and overlays. The evidence suggests that high pressures for a short time are just as damaging as low pressures over a long time. Guidance from the National Institute for Health and Care Excellence (NICE, 2014) is similar encouraging regular risk assessment, positional changes and use of pressure reducing mattresses and overlays. Guidance for prolonged sitting is less detailed and less well-established (Stockton & Rithalia 2007). Guidance from NICE (2005) is limited to four sentences focusing on assessment, position, posture and support for the feet, similar minimal guidance is evident in the Cochrane Collaboration Review (McInnes et al, 2009) and the Institute for Clinical Systems Improvement (2010) Pressure Ulcer Prevention and treatment Protocol.

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There are over 200 pressure redistributing devices on the market for people with reduced mobility who are often confined to their chairs or beds (Ousey, 2005). “Low tech” devices are commonly mattresses, cushions or overlays and can be gel-filled or contain air pockets, memory foam, or flotation type cells or indeed, a combination of these (Stockton and Rithalia, 2008). “High tech” devices are available for the at-risk patient and include dynamic systems of alternating pressure, low pressure or rolling systems to constantly redistribute the patients’ weight, therefore reducing peak pressure areas (NICE, 2014). Provision of this specialist equipment within health and social care is costly with some equipment lacking in an evidence base regarding impact on interface pressure, ease of use and comfort. Research is therefore needed to evaluate the effect that any innovations in pressure relieving systems may have on redistribution of pressure, comfort, and positioning to provide a robust evidence base prior to provision. This study aims to evaluate the pressure redistribution features of a range of 7 cushions currently available as an integrated seating system by Repose Seating Limited to identify impact on interface pressure, comfort and to identify a grading system to help prescribe the most appropriate foam to be recommended for a range of at-risk clients.

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2. AIMS OF THE STUDY:

- To investigate the impact of using different seat cushions on interface pressure in upright sitting and semi-reclined seating.

- To compare the differences in interface pressure and patterns of redistribution to identify any differences in:

i) Surface area (cm2)
ii) Average pressure (mmHg)
iii) Peak Pressure Index (PPI) at sacral region (mmHg)
iv) Peak Pressure Index (PPI) at left and right ischial tuberosities (mmHg)

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3. RESEARCH METHODOLOGY

Method:

Quasi - experimental study to investigate the interface pressures exhibited on volunteers whilst seated on a range of 7 pressure management cushions within the Multi C-Air chair, using a within subjects' comparative design.

Participants

3 participants taken from volunteers from the staff team at Repose Furniture:

2 females: 1 male

Age: Range 25 - 48 years (Mean 40, SD 13)

Height: Range 159cm - 173cm (Mean 168.33, SD 8.08)

Weight: Range 73.3kg – 108.7kg (Mean 90.97, SD 17.7)

BMI: Range 24.49 – 42.99 (Mean 32.62, SD 9.45)

Procedure:

Each participant attended data collection sessions at Repose Furniture HQ, West Midlands. Total time for data collection on the seven different cushions in 2 different seated positions (see Figure 3 below) was approximately 4.5 hours for each participant. Interface pressure readings were collected at the key pressure points of ischial tuberosities and sacrum on each cushion surface and recorded in the Xsensor software (http://www.sumed.co.uk).

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Figure 2 – Inserting cushion samples and fitting X-sensor mat.

Cushion sample inserted

Covered with memory foam chaise

Xsensor mat in situ

Figure 3 – Seated positions for data collection:

i) Seated upright

ii) Semi-reclined position

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Outcome Measures

X-Sensor Pressure measurement system:

The X-sensor PX100 pressure sensor from SUMED International provides highly accurate analyses of the pressure and was used to measure:

- Surface area of the gluteal area in contact with the chair surface (in cm^2)
- Mean interface pressure across total gluteal contact area (in mmHg)
- Pressure hotspot "regions of interest" were identified at the ischial tuberosities and sacral region (in mmHg).

This system comprises of two grids of parallel conductive strips that are set perpendicular in orientation within a sensor mat. The mat is approximately 1mm thick with a measurement grid of 450mm X 450mm containing 1,296 sensing points.

The materials used and the method of assembly creates a robust, pliable, and conformable sensor pad which minimises any distortion of the true interface pressure. The sensor mat is linked to X-sensor PRO v6.0 software from SUMED International, has excellent calibration stability leading to consistent data collection with high reliability particularly where high repeatability and minimal creep characteristics are important. Fader et al. (2004) argued that Xsensor appears to be a gold standard technology for pressure mapping in humans. Manufacturer product literature outlines performance characteristics, including precision and reliability. Manufacturer calibration and quality control data, prior to sales, confirm a high level of precision and reliability. 10-200mmHg pressure ranges (Sumed UK, 2014), and has an accuracy rate of ±10 percent of the calibrated values (Peterson et al. 2013). The materials used and the method of assembly creates a robust, pliable, and conformable sensor pad which minimises any distortion of the true interface pressure. The sensor mat is linked to X-sensor PRO v6.0 software from SUMED International, has excellent calibration stability leading to consistent data collection with high reliability particularly where high repeatability and minimal creep characteristics are important (Trewartha and Stiller, 2011).

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Data are recorded as colour coded maps of pressure distribution as well as specific peak pressure and mean pressure readings given at specific timed stages, recorded in mmHg (See Figure 4).

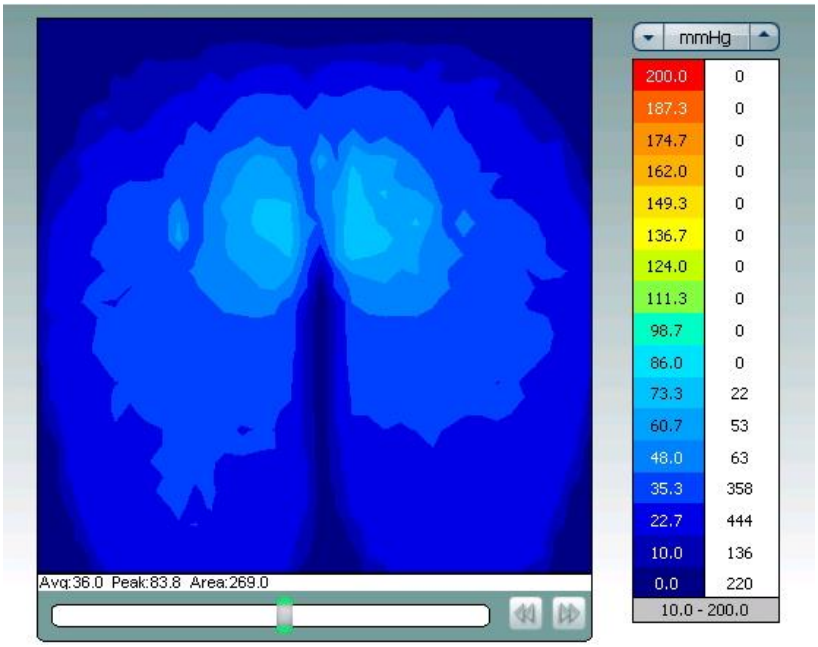

Figure 4 Example of X-sensor colour coded map with colour display in mmHg.

Data collection in each condition was 14 minutes in total, allowing for a 4 minute "settling time" (Davis and Call, 2013). All data was collected using a quiet room at Repose HQ. Data collection processes and analysis methodology followed International Best Practice Guidelines (ICPWM BPG2,2014)

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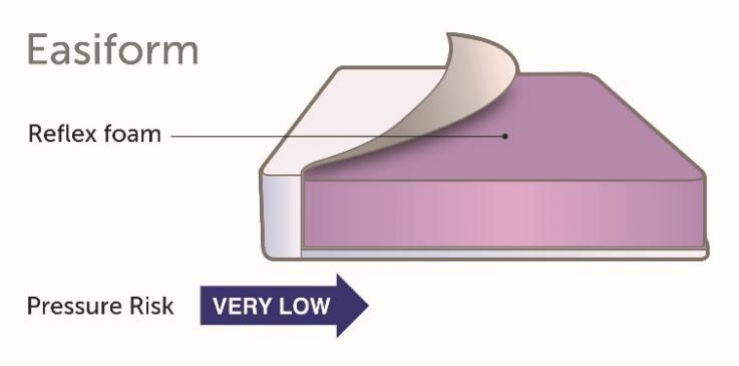
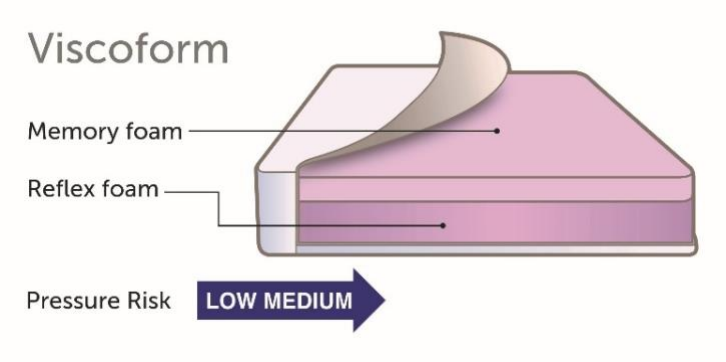
Data was collected on each of the following surfaces:

Surface 1: Easiform:



For standard seating, our softest foam cushion with high quality Reflex foam filler for gentle comfort.

Surface 2: Viscoform:



For those who have good posture and mobility but are seated for greater than one hour at a time and require pressure relief and supported comfort. This cushion has a high-density foam base which offers a supportive and firm seat base with a top layer of memory foam to allow immersion into the cushion, giving stability and a large surface area to reduce pressure levels.

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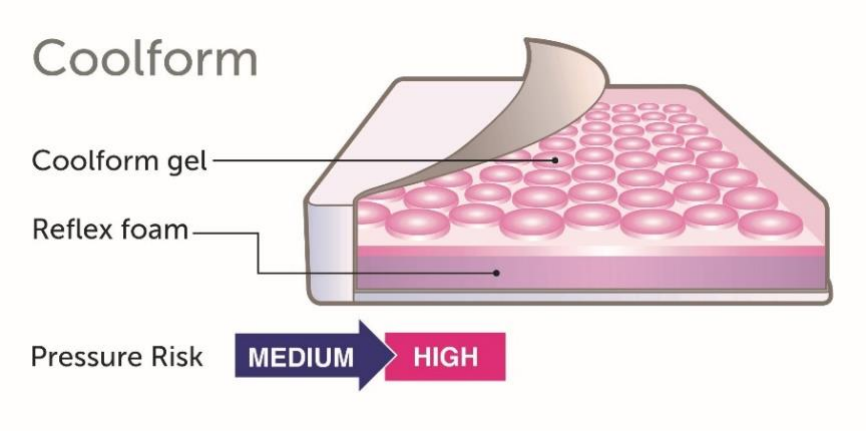
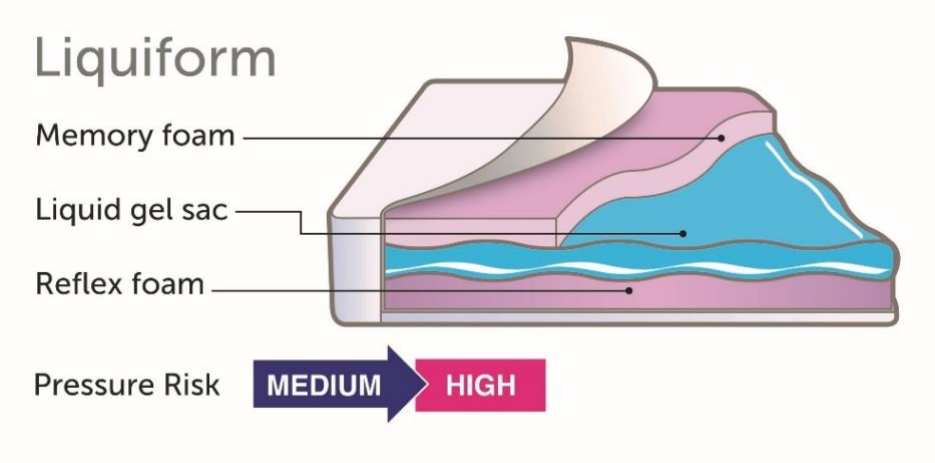
Surface 3: Cool form:



For those sitting for long periods with specific comfort issues such as a high risk of pressure sores. This cushion uses the latest medical grade silicone gel technology allowing pressure to be evenly distributed. The gel conforms to the shape of the body and equalises to body temperature. The gel cells allow air to flow easily and Coolform is totally odourless and hypoallergenic.

Surface 4: Liquiform:



For those who have good posture and mobility but sit for long periods of time and require pressure relief and supported comfort. Recommended for people with limited muscle bulk or at risk of excessive weight loss. This cushion has a high-density foam which offers a supportive and firm seat base. The foam is topped with a fluid liquid gel in a soft silicone cover which provides a high level of pressure relief. The liquid gel helps to dissipate heat and constantly adapts to the user's movement.

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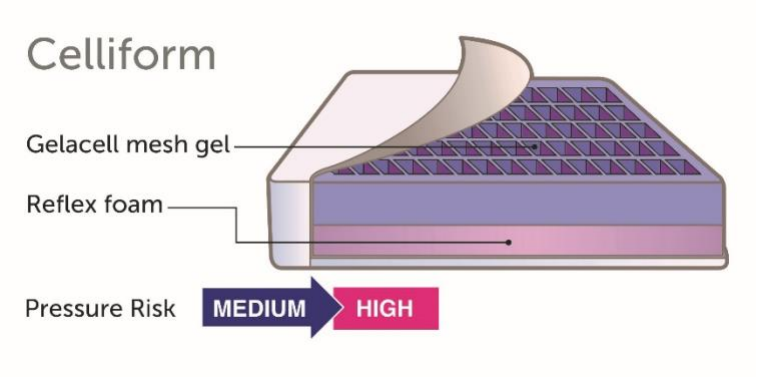
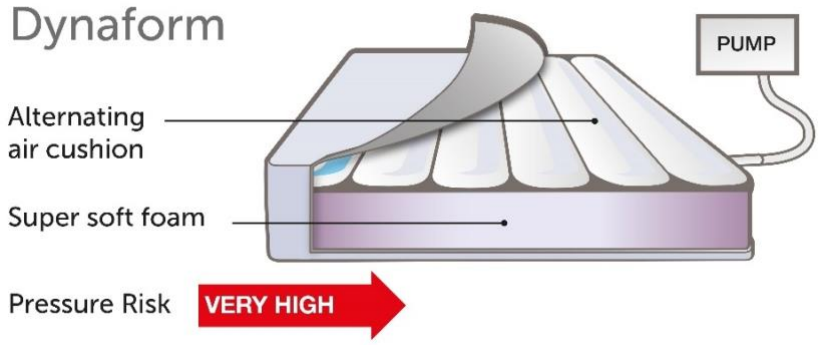
Surface 5: Celliform:



For those sitting for long periods with specific comfort issues such as a high risk of pressure sores. Gelacell has a unique cell matrix that distributes pressure across the contact area, as it contours and yields in response to weight redistribution. Gelacell absorbs body heat, reducing the risk of creating an environment that could increase pressure risks, the grid design also encourages air circulation. Gelacell is clinically tested and passes all dermatological tests for skin contact.

Surface 6: Dynaform :



For those at very high risk of developing pressure sores or a history of sores where the highest priority is to prevent further pressure damage. The Dynaform cushion is a dynamic alternating air cushion, which constantly changes the air levels within its air cells to recreate the effect of normal body movements, which provides constant pressure redistribution to prevent pressure build up.

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Surface 7: Levitex

Levitex foam is an innovative foam technology that helps reduce back and neck pain, as well as improving sleep posture.

(Results will be presented in tabular format and surfaces will be labelled using the above surface numbers, this will be consistent throughout analysis and presentation of results)
Data was collected over a period of 2 days on 20th and 21st January 2022.

Statistical Analysis

Pressure data recorded in mmHg stored in the X-sensor pressure system and transferred to secure laptops to allow analysis using the X-sensor advanced software technology. Data was merged using the average peak pressures for all 600 frames, then regions of interest were placed around the ischial tuberosities and sacral region to calculate peak pressure index (PPI) of each region. The entire activated area was also compared to explore impact of the cushions on overall contact surface area.

Results analysed using:

a) SPSS v 26 to i) summarise the mean / standard deviation for the demographic data and peak and mean pressures ii) compare peak and mean pressures using analysis of variance (ANOVA) for multiple comparison between the cushions.

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4. RESULTS

Section 1 – Exploration of interface pressure data.

Table 1 summarises all data collected from the pressure mapping of the seven cushions in the form of means and standard deviations, each area of interest was analysed separately to identify differences between each cushion surface using repeated measures ANOVA for multiple comparisons and further investigation of any significant relationship was explored using paired t-tests.

Table 1: Means and standard deviations (SD) for surface area and peak pressure index (PPI)s at the ischial tuberosities (IT's) and sacrum and peak pressure across the whole surface for seven different cushion surfaces in mmHg (n=3)

Rankings of performance in red (1 – 7, where 1 = best performance, 7 = worst)

Surface / position	Surface Area (cm2)	Mean pressure (mmHg)	PPI Sacrum (mmHg)	PPI Left IT (mmHg)	PPI Right IT (mmHg)	Peak pressure (mmHg)
1 seated	1574.73 (7) (296.89)	27.1 (1) (3.58)	43.23 (3) (11.57)	49.33 (1) (8.37)	44.63 (1) (3.87)	62.4 (1) (17.24)
1 reclined	1495.16 (7) (280.87)	28.77 (1) (3.95)	51.03 (1) (18.82)	55.97 (1) (12.5)	51.9 (1) (8.87)	65.6 (1) (17.24)
2 seated	1653.76 (3) (145.81)	29.27 (2) (1.72)	41.83 (2) (11.56)	59.47 (2) (5.50)	57.57 (2) (5.09)	71.5 (2) (5.72)
2 reclined	1614.52 (2) (107.56)	31.03 (2) (2.54)	53.17 (4) (22.01)	65.27 (2) (19.52)	67.6 (4) (2.91)	85.1 (3) (15.26)
3 seated	1643.01 (4) (154.12)	33.6 (5) (2.62)	58.87 (5) (14.35)	76.2 (4) (12.68)	65.27 (4) (9.45)	84.67 (3) (11.07)
3 reclined	1555.38 (5) (149.44)	31.93 (3) (2.27)	53.5 (5) (14.04)	68.47 (3) (8.23)	65.8 (3) (3.18)	84.93 (2) (9.27)
4 seated	1615.05 (6) (194.38)	31.00 (3) (2.82)	41.07 (1) (5.86)	72.13 (3) (14.31)	61.3 (3) (5.93)	89.8 (4) (19.19)
4 reclined	1551.07 (6) (154.62)	32.43 (4) (3.21)	52.83 (2) (21.88)	74.53 (4) (11.44)	64.03 (2) (11.99)	88.97 (4) (10.21)

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5 seated	1626.35 (5) (165.19)	34.63 (6) (3.37)	64.33 (6) (13.46)	91.63 (7) (18.22)	75.23 (5) (12.16)	107.2 (7) (22.67)
5 reclined	1556.45 (4) (170.85)	34.63 (6) (3.45)	66.87 (6) (14.90)	85.47 (7) (17.66)	78.17 (6) (11.77)	107.53 (6) (16.26)
6 seated	1648.39 (2) (185.98)	35.7 (7) (4.68)	72.93 (7) (32.01)	87.37 (6) (15.23)	87.37 (7) (10.87)	105.53 (6) (14.23)
6 reclined	1557.53 (3) (176.14)	35.7 (7) (4.45)	79.37 (7) (19.07)	85.4 (6) (11.79)	84.07 (7) (6.07)	116.83 (7) (26.91)
7 seated	1732.79 (1) (141.61)	32.93 (4) (2.49)	52.07 (4) (20.43)	82.67 (5) (7.43)	83.4 (6) (14.05)	100.27 (5) (8.5)
7 reclined	1660.75 (1) (188.69)	32.8 (5) (5.02)	53.00 (3) (17.98)	77.63 (5) (24.49)	72.07 (5) (25.35)	91 (5) (19.89)

Surface Area

Initial exploration of differences in surface area using repeated measures ANOVA identified significant differences between surface 5 and surface 7 ($p<0.05$). Further exploration using paired t-tests identified the following:

Surface area is significantly increased with Levitex cushion ($p=0.017$ in seated upright position and $p=0.019$ in semi reclined position). The images below demonstrate with examples of participant 1 showing a significant increase in surface area when changing from cushion 5 to cushion 7.

Surface area is increased by 145.16 cm2 with participant 1, demonstrating increased pressure redistribution and reduction in average pressure across the seat surface from 32.3mmHg to 30.2mmHg (See Figure 5)

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Figure 5 Example “screenshots” of Participant 1 on surfaces 5 + 7 to demonstrate visual impact of the identified significant difference in surface area between celliform and Levitex cushions.

Image 1 Celliform with surface area of 1453.23 cm2.

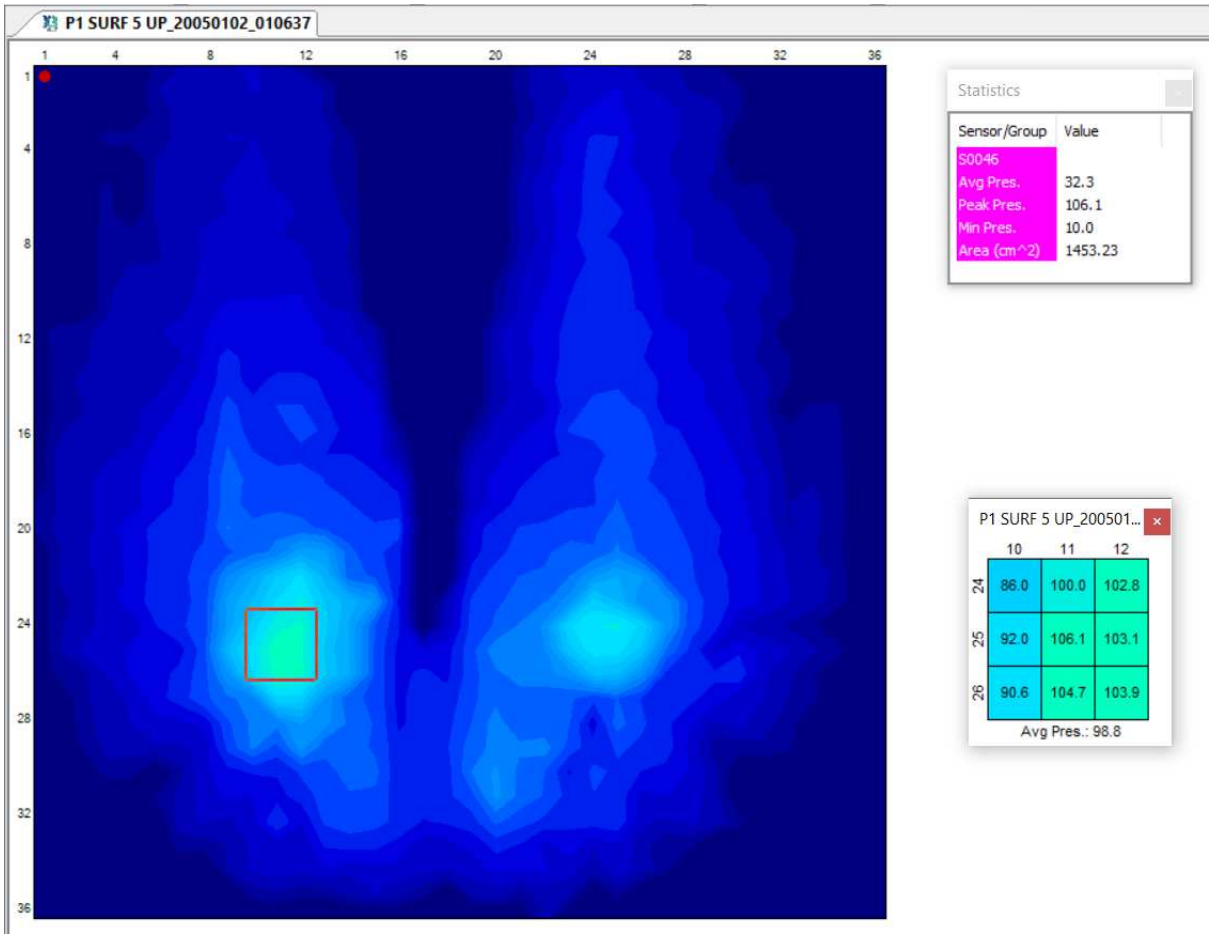

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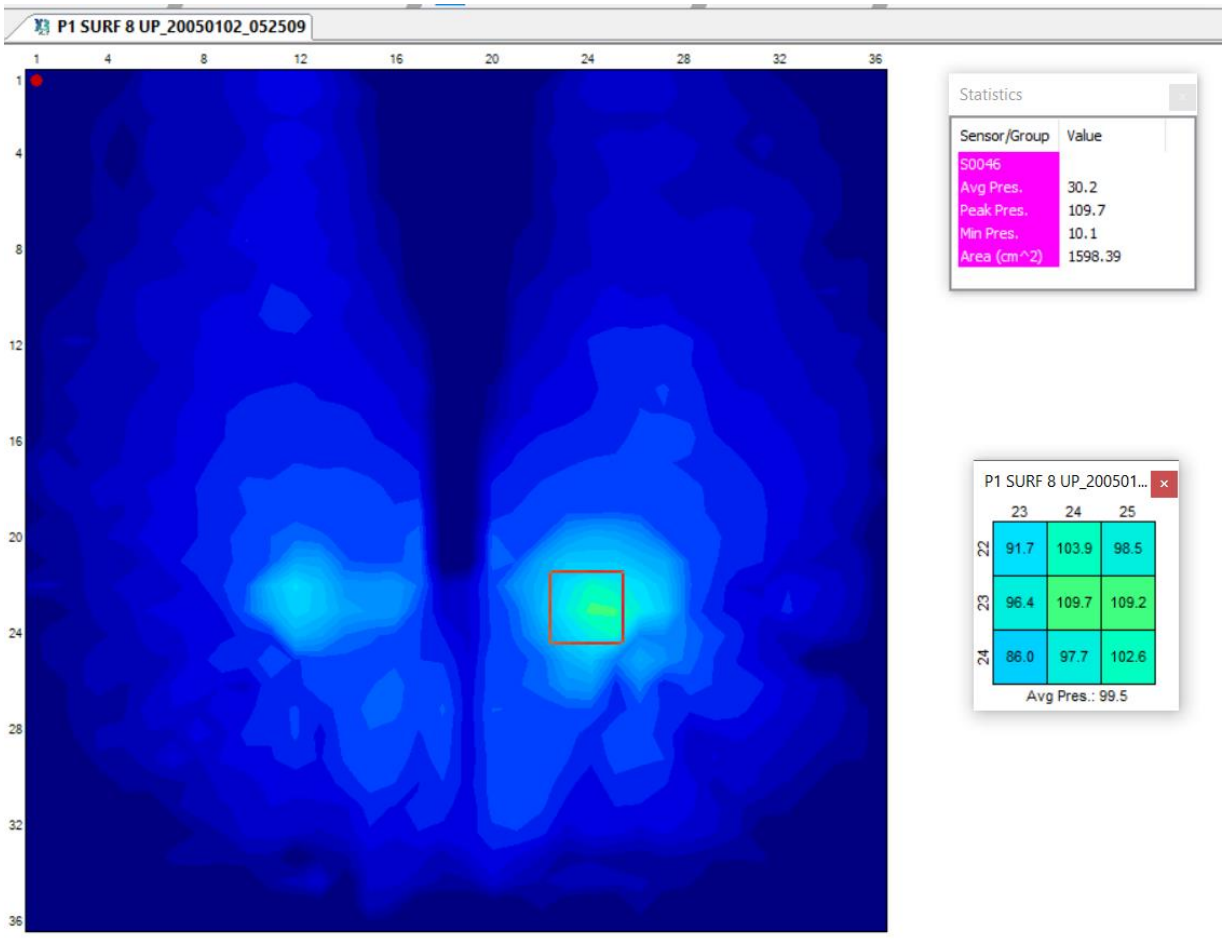
Image 2 Levitex with surface area of 1598.39 cm2.



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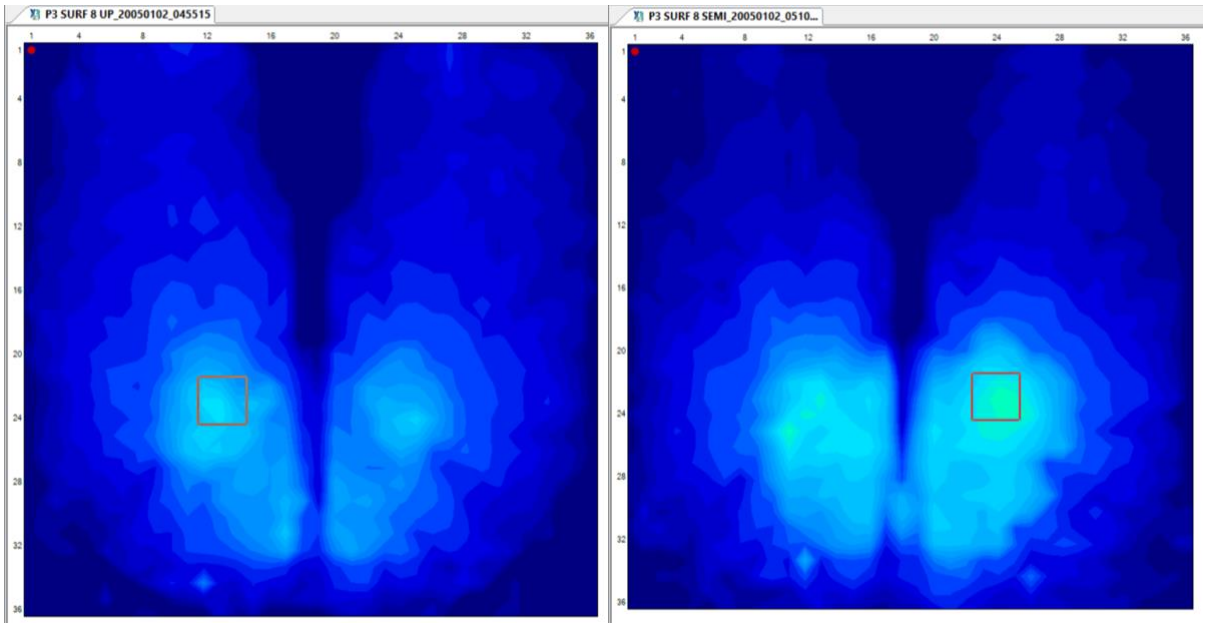
Screenshots of Participant 3 on surface 5 + 7 to demonstrate increase in surface area when comparing Celliform and Levitex cushions.

Celliform **Levitex**



Surface area = 1643.55cm2
Overall mean pressure = 38.5mmHg

Surface area = 1719.35cm2
Overall mean pressure = 33.5mmHg

Demonstrates a reduction in overall mean interface pressure and increased surface area.

Mean pressure in seated upright position

Descriptive Statistics

	Mean	Std. Deviation	N
S1_AP_Seated	27.1000	3.57911	3
S2_AP_Seated	29.2667	1.72434	3
S3_AP_Seated	33.6000	2.61534	3
S4_AP_Seated	31.0000	2.81603	3
S5_AP_Seated	34.6333	3.37244	3
S6_AP_Seated	35.7000	4.67654	3
S7_AP_Seated	32.9333	2.49867	3

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Initial indications from repeated measures ANOVA identified significant differences in mean pressure across a range of the cushions, identifying surfaces 5 + 6 as recording the highest mean interface pressures, an interesting observation as these 2 surfaces have previously been described as being suitable for “medium to high risk” and “very high risk” client. Cushion 6 is the “high tech”, Dynaform cushion, a dynamic alternating air cushion, which constantly changes the air levels within its air cells to recreate the effect of normal body movements, which provides constant pressure redistribution to prevent pressure build up. Similar type wheelchair cushions and mattresses are often a first choice for patients considered at high risk of pressure ulcer development.

Main effects identified differences between surface 1 and 3 (0.01), 1 and 5 (0.04) and 1 and 6 (0.007), reflecting lower mean pressures from surface 1 than the other 3 surfaces.

Significant differences were identified between surface 2 and 3 (0.018), 2 and 6 (0.07) and 2 and 7 (0.015) with surface 2 reflecting lower mean pressures.
Significant differences identified between surface 4 and 5 (0.009) with surface 4 being lower than surface 5.

Further exploration compared these differences using paired t-tests.
In the seated position, surface 1 demonstrated a significantly lower mean pressure than surface 3,5 and 6 (p=0.006, 0.02 and 0.003 respectively.) Surface 2 demonstrated significantly lower mean pressure than surface 3,6 and 7 (p=0.009,0.04 and 0.007 respectively). Surface 4 was significantly lower mean pressure when compared to surface 5 (p=0.004).

When comparing the three best performing surfaces (1,2 and 4) there was only a significant difference identified between 1 and 4 with 1 being significantly lower mean pressure (p=0.05). Surfaces 2 and 4 perform in a similar way.

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Mean pressure in semi-reclined position

Similar findings were noted for mean pressure in the reclined position with no significant difference between seated and semi-reclined:

Descriptive Statistics

	Mean	Std. Deviation	N
S1_AP_Reclined	28.7667	3.95137	3
S2_AP_Reclined	31.0333	2.54034	3
S3_AP_Reclined	31.9333	2.77909	3
S4_AP_Reclined	32.4333	3.21299	3
S5_AP_Reclined	33.9667	3.45012	3
S6_AP_Reclined	36.4333	4.44672	3
S7_AP_Reclined	32.8000	5.02096	3

Initial indications from repeated measures ANOVA identified significant differences in mean pressure across a range of the cushions, again identifying surfaces 5 + 6 as recording the highest mean interface pressures.

Main effects identified differences between surface 1 and 3 (0.05), 1 and 4 (0.02), 1 and 5 (0.0007) and 1 and 6 (0.01), reflecting lower mean pressures from surface 1 than the other 4 surfaces.

Significant differences were identified between surface 2 and 6 (0.04), and 3 and 6 (0.05) with surface 2 reflecting lower mean pressures.
Significant differences identified between surface 4 and 6 (0.0.04) and 6 and 7 (0.04) with surface 7 being lower than surface 6.

Further exploration compared these differences using paired t-tests.
In the reclined position, surface 1 demonstrated a significantly lower mean pressure than surface 3,4,5,6 and 7 (p=0.02, 0.01, 0.003, 0.006 and 0.001 respectively.)

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Demonstrating Easiform to significantly reduce average pressure across the gluteal area when in a reclined position more effectively than all other cushions apart from surface 2 (Viscoform) where there was no significant difference. Surface 6 (Dynaform) performed least well with significantly higher average pressures when compared with all other surfaces.

To help demonstrate the difference in mean pressure between the lowest (Dynaform) and highest (Easiform) performing cushions, please see the following screen shots from participant 2. Image 1 (Easiform) records an average seated pressure of 28.7mmHg, with a peak pressure “hotspot” PPI of 46.2mmHg and an average reclined pressure of 29.5 with a peak pressure “hotpot” of 55.4mmHg. Compare this with image 2 (Dynaform) recording an average seated pressure of 38.4mmHg, with a peak pressure “hotspot” PPI of 76.4mmHg and an average reclined pressure of 38.9mmHg with a peak pressure “hotspot” PPI of 86.3mmHg.This is reflected in the t-test results identifying significant differences of p=0.003 (seated) and p=0.006 (reclined). The increase in pressure in the sacral region in a reclined position is of particular interest when combined with the additional risk factor of shear when an at-risk individual is left seated in the position for any length of time.

Image 1 Easiform seated Easiform recline

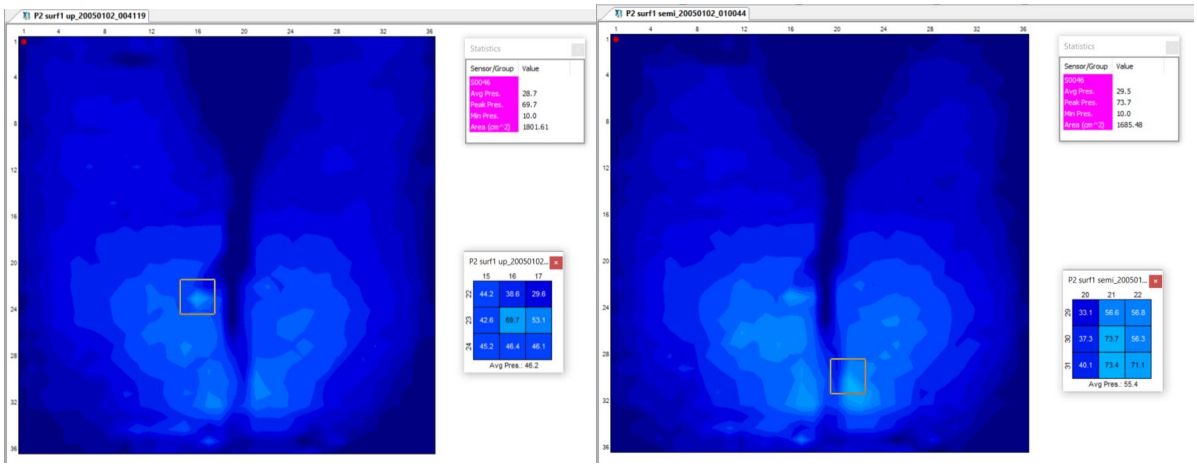

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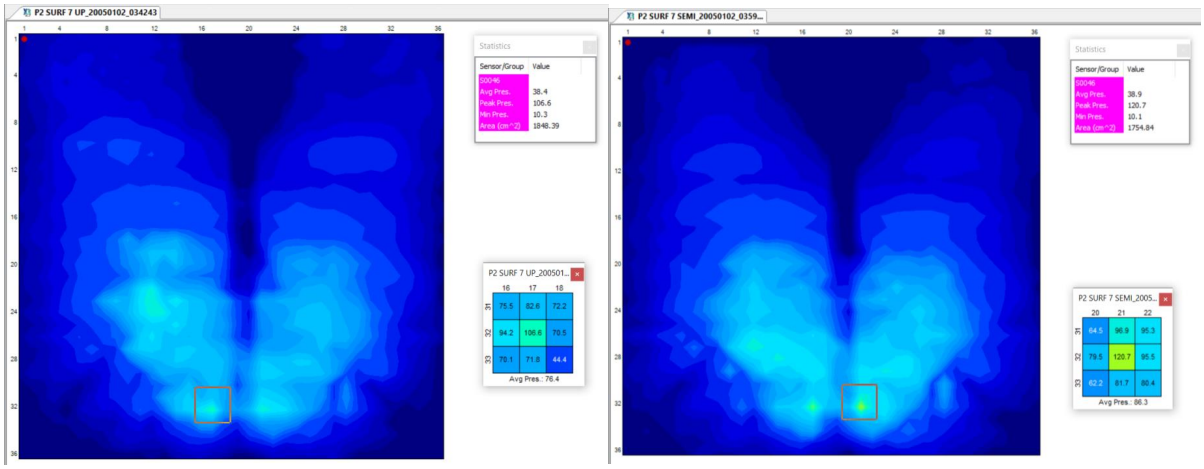
Image 2 Dynaform seated

Dynaform recline



Peak Pressure Index at Sacrum in seated position.

Initial indications using repeated measures ANOVA identified significant differences in sacral pressure between surfaces 1,2,4 and 5 (0.01, 0.02 and 0.04 respectively) with surface 5 (Celliform) demonstrating higher pressures when compared to Easiform, Viscoform and Liquiform. Further analysis using t-tests reinforced these findings ($p<0.02$) at interface between surfaces 2, 4 and 5, yet increased significance when comparing surface 1 (Easiform) with surface 5 (Celliform) where $p = 0.005$.

The sacral region is a very common site for the development of pressure ulcers for the less mobile person who spends a lot of time seated or in bed, particularly in a reclined position where the interface pressure shifts to this sacral region.

This is reflected in the recorded PPI's in the reclined position with significant main effects demonstrating 1 and 2 out performing surfaces 5 and 6. Further exploration using t-tests to compare the latter identifies that surface 5 has a significantly lower PPI at the sacrum compared with surface 6 ($p=0.02$), but the highest significance in the best performance at the sacrum identifies that Dynaform has a highly significant raised PPI at this high risk area when compared to surface 1 (Easiform) , $p=0.000002$. This would suggest that the high-tech alternating air cushion is not delivering a reduction in

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PPI at the sacrum, particularly in a reclined position, when it is needed most due to the added risk factor of shear in this position.

Descriptive Statistics

	Mean	Std. Deviation	N
S1_PPIS_Seated	43.2333	17.16285	3
S2_PPIS_Seated	41.8333	11.55783	3
S3_PPIS_Seated	58.8667	17.56967	3
S4_PPIS_Seated	41.0667	5.86032	3
S5_PPIS_Seated	64.3333	13.45821	3
S6_PPIS_Seated	72.9333	32.00505	3
S7_PPIS_Seated	52.0667	20.43388	3

Descriptive Statistics

	Mean	Std. Deviation	N
S1_PPIS_Reclined	51.0333	18.82268	3
S2_PPIS_Reclined	53.1667	22.01280	3
S3_PPIS_Reclined	53.5000	17.20581	3
S4_PPIS_Reclined	52.8333	21.87563	3
S5_PPIS_Reclined	66.8667	14.90179	3
S6_PPIS_Reclined	79.3667	19.06996	3
S7_PPIS_Reclined	53.0000	17.98527	3

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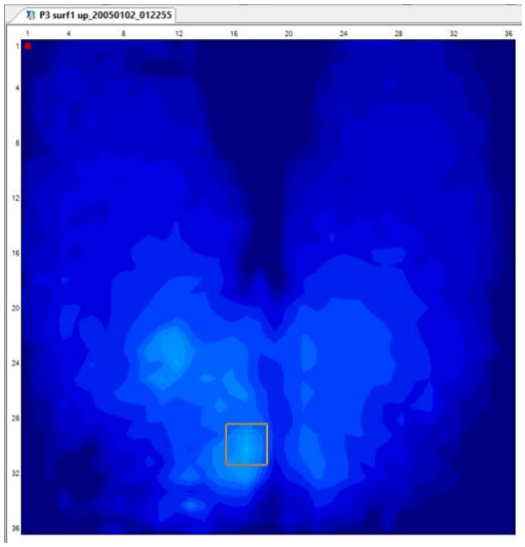
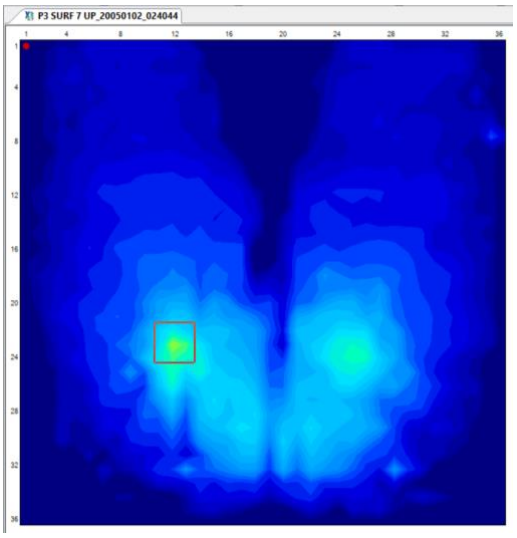
Images to compare PPI Sacrum in Participant 3 Easiform vs Dynaform (p=0.000002)

Easiform seated upright



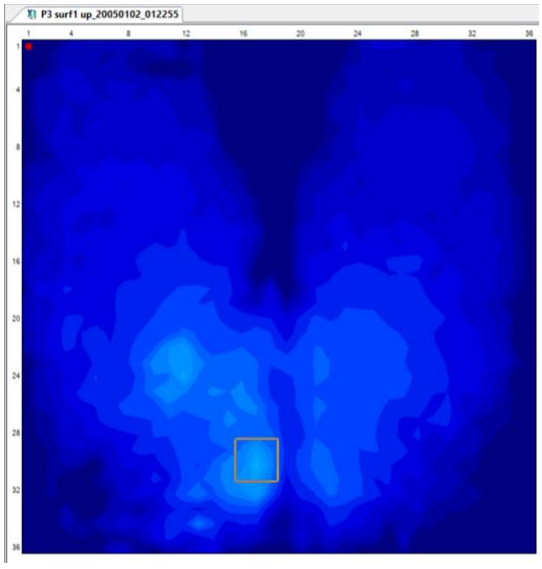
Mean Sacral PPI (n=3) = 43.23

Dynaform seated upright



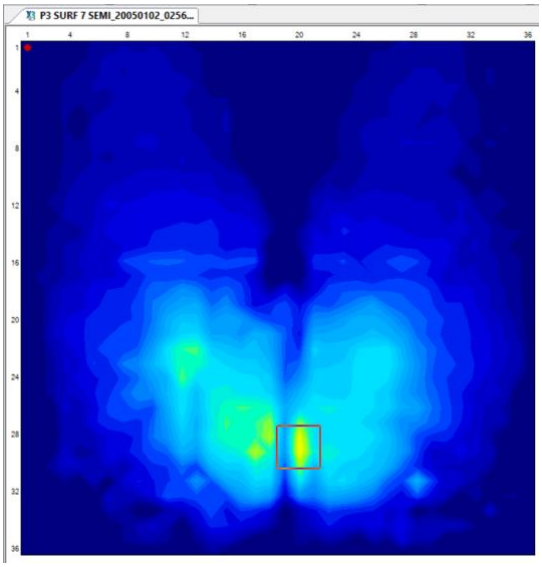
Mean Sacral PPI (n=3) = 72.93

Easiform reclined



Mean Sacral PPI (n=3) = 51.03

Dynaform reclined



Mean Sacral PPI (n=3) = 79.37

Although the above images are taken from participant 3, they highlight the trend in changes in PPI at the sacrum when shifting from a seated position to a reclined

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position and reflect the increase in risk of pressure ulcer development in an individual who remains seated for prolonged periods.

The Easiform shows a more efficient redistribution of pressure and significantly lower mean sacral pressure across all participants (p=0.000002), this combined with an overall lower mean pressure reported earlier, makes the Easiform a first choice for individuals at higher risk of developing a pressure ulcer. In addition to this, all 3 participants commented on the feeling of discomfort with the Dynaform cushion.

Peak pressure index at ischial tuberosities (IT's).

Repeated measures ANOVA identified significant differences across PPI's recorded at both ischial tuberosities or "sitting bones", a very common site for the development of pressure ulcers in patients with poor mobility who are seated for extended periods of time. Trends in significance were identified with surface 1 (Easiform) recording consistently lower PPI's at both IT's and surface 5 + 6 (Celliform and Dynaform) recording the highest PPI's in the group consistently. See descriptive statistic tables below where highest PPI's are highlighted in yellow (Surfaces 5 + 6) and lowest PPI's in green.

Descriptive Statistics – PPI at Left IT seated

	Mean	Std. Deviation	N
S1_PPILIT_Seated	49.3333	8.37218	3
S2_PPILIT_Seated	59.4667	5.50485	3
S3_PPILIT_Seated	76.2000	12.68345	3
S4_PPILIT_Seated	72.1333	14.30746	3
S5_PPILIT_Seated	91.6333	18.22123	3
S6_PPILIT_Seated	87.3667	15.22673	3
S7_PPILIT_Seated	82.6667	7.42989	3

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Descriptive Statistics – PPI at Left IT recline

	Mean	Std. Deviation	N
S1_PPILIT_Reclined	55.9667	12.50013	3
S2_PPILIT_Reclined	65.2667	19.52187	3
S3_PPILIT_Reclined	68.4667	8.22760	3
S4_PPILIT_Reclined	74.5333	11.43780	3
S5_PPILIT_Reclined	85.4667	17.65625	3
S6_PPILIT_Reclined	85.4000	11.79873	3
S7_PPILIT_Reclined	77.6333	24.48802	3

Descriptive Statistics – PPI at Right IT seated

	Mean	Std. Deviation	N
S1_PPIRIT_Seated	44.6333	3.86566	3
S2_PPIRIT_Seated	57.5667	5.09542	3
S3_PPIRIT_Seated	65.2667	9.45216	3
S4_PPIRIT_Seated	61.3000	5.92537	3
S5_PPIRIT_Seated	75.2333	12.16320	3
S6_PPIRIT_Seated	87.3667	10.87398	3
S7_PPIRIT_Seated	83.4000	14.05240	3

Descriptive Statistics – PPI at Right IT reclined

	Mean	Std. Deviation	N
S1_PPIRIT_Reclined	51.9000	8.87074	3
S2_PPIRIT_Reclined	67.6000	2.90517	3
S3_PPIRIT_Reclined	65.8000	3.17962	3
S4_PPIRIT_Reclined	64.0333	11.98847	3
S5_PPIRIT_Reclined	78.1667	11.76704	3
S6 PPIRIT_Reclined	84.0667	7.43797	3
S7_PPIRIT_Reclined	72.0667	25.34607	3

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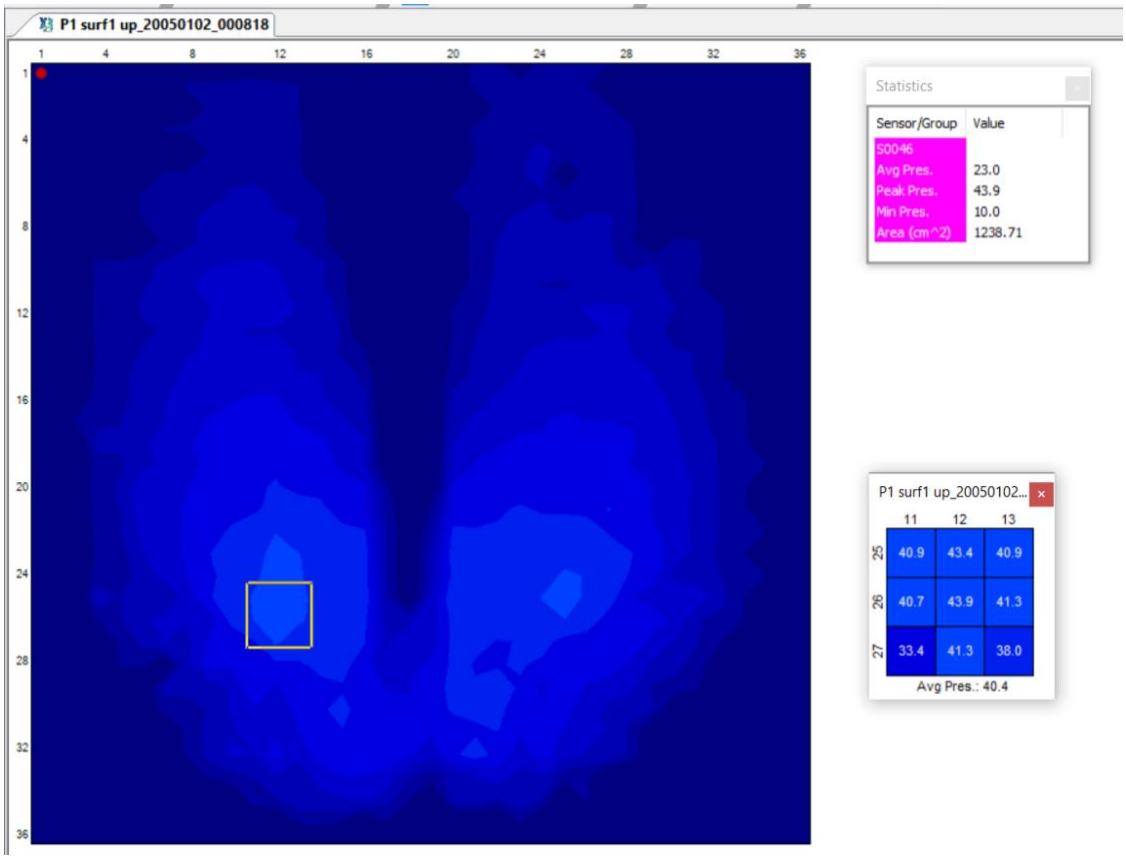
Further analysis using t-tests identified significant differences which can be seen in the images that follow:

Surface 1 vs Surface 6 (Participant 1 seated) p = 0.005

Surface 1 – Easiform



PPI at Left IT = 40.4mmHg, with an average pressure across the gluteal area of 23mmHg.

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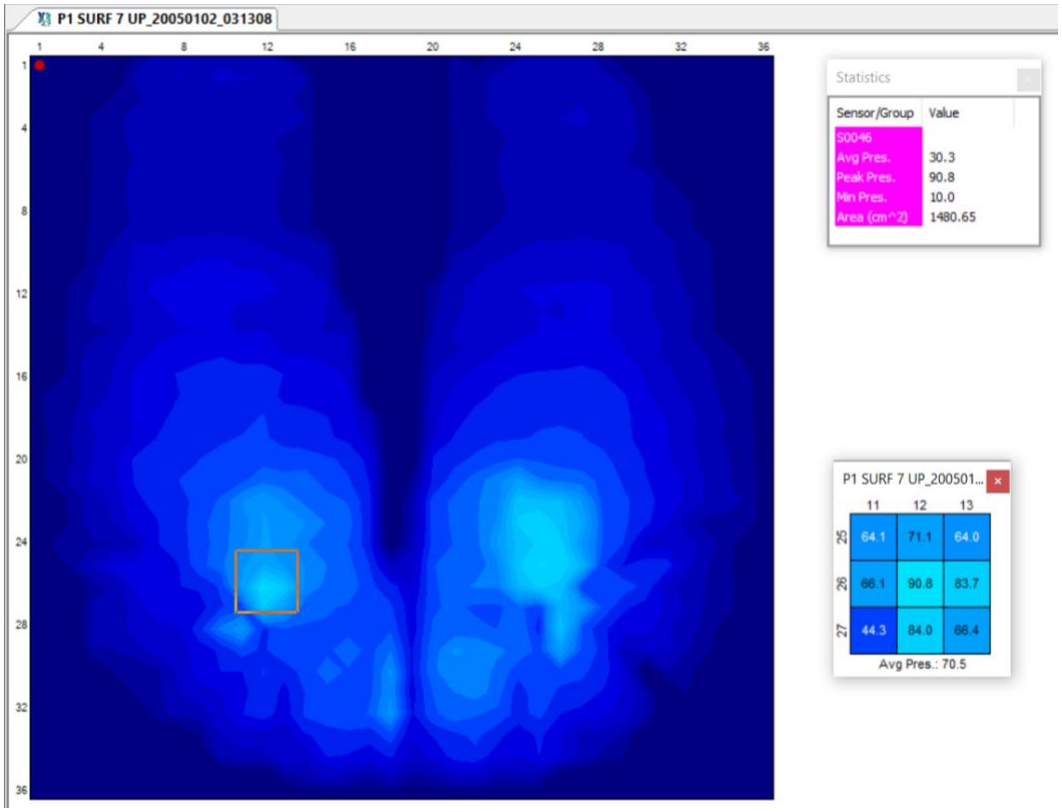
Surface 6 – Dynaform



PPI at Left IT increases to 70.5mmHg with an increase in average pressure across the gluteal area to 30.3mmHg, reflected in the lighter colours. Although the increase in average pressure is still within safe limits (i.e., < 65mmHg), the increased peak pressure at the centre of the PPI left It is significantly higher at 90.8.
Qualitative feedback from this participant was “Quite firm, weird, don’t like it, wouldn’t choose it”

Similar trends in an increase in average pressure are recorded with all participants (See Appendix for more images) with participant 2 commenting: “Uncomfortable – not getting any relief” and Participant 3 adding: “Not comfortable on deflate mode of cycle – numb bottom” (Comments were made separately and without prompting).

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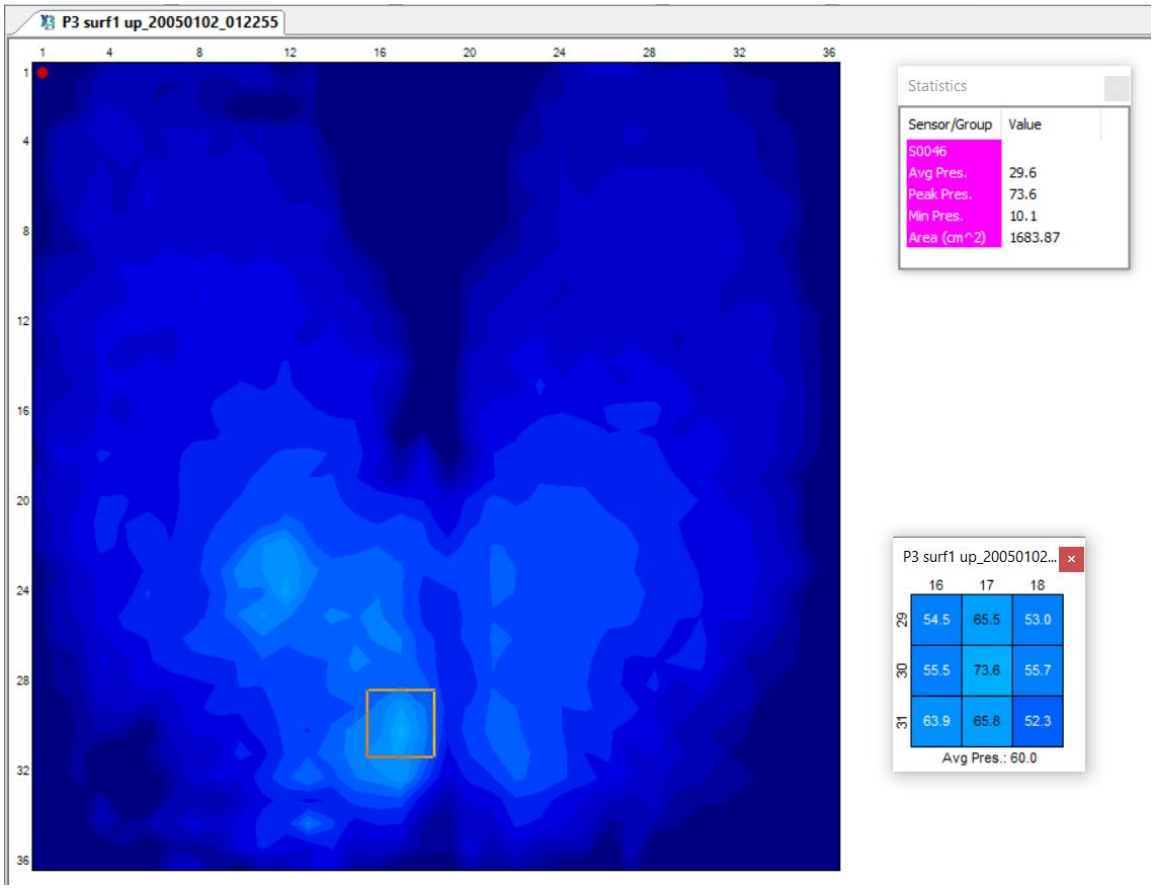
Surface 1 vs Surface 6 (Participant 3 seated) p = 0.005

Surface 1 – Easiform



PPI at Left IT = 60mmHg, with an average pressure across the gluteal area of 29.6mmHg.

The following image demonstrates the increase in PPI at Left IT to 100.1mmHg with the peak pressure at the centre point of the PPI reaching 119.2mmHg. Average pressure across the scaral region remains within safe limits at 38.4mmHg, however the high risk areas of the IT's in a prolonged seated position with an individual unable to reposition themselves would constiute significant risk of pressure ulcer development.

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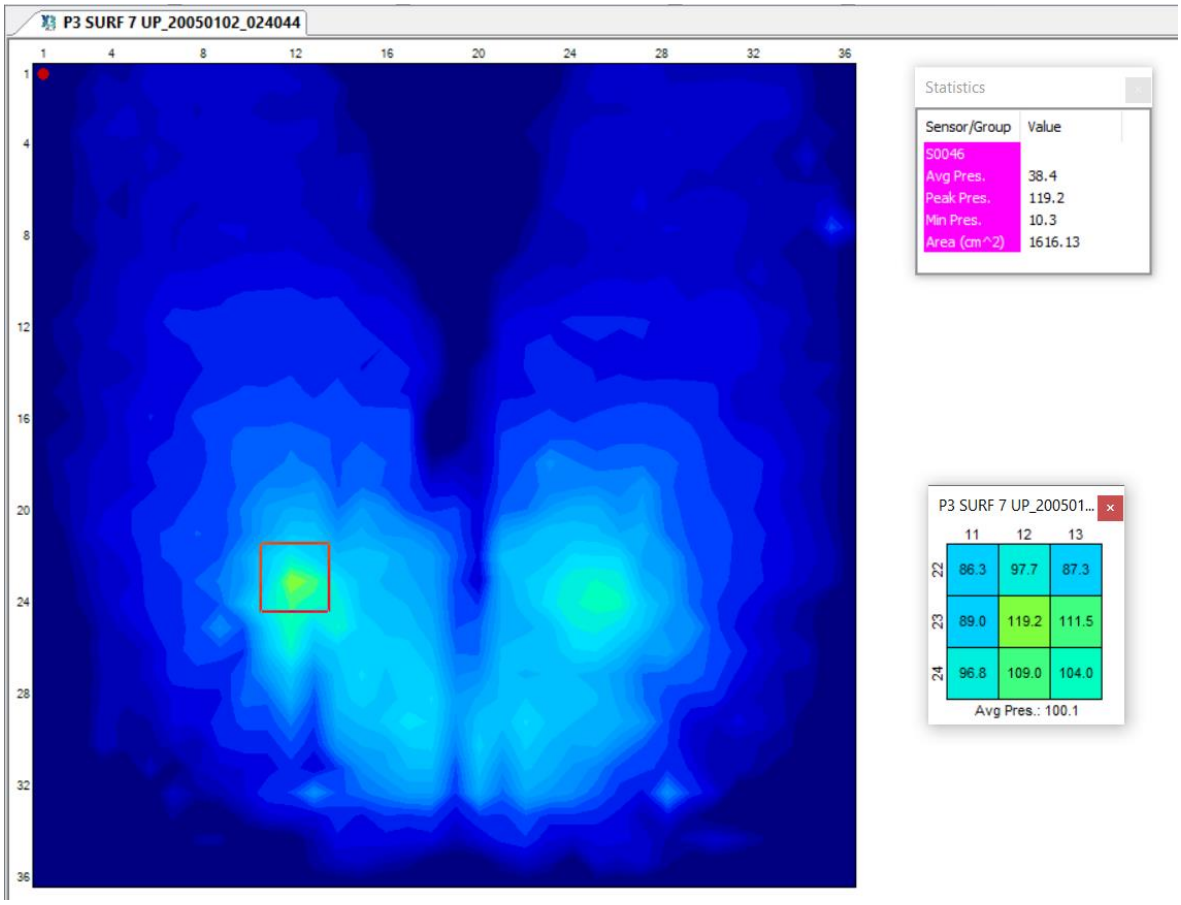
Surface 6 Dynaform



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5. CONCLUSIONS

Pressure redistribution

Exploration and comparison of mean pressures across the seated contact areas identifies that the “low tech” cushions – Easiform, Viscoform, Coolform liquiform and Levitex perform in a similar way to redistribute pressure across the contact area. All 7 cushions record very good “average pressures” across the contact area, with even the highest mean pressures falling well within recommended guidelines for extended periods of sitting.

Lowest mean pressures were recorded with Easiform, whilst highest mean pressures recorded with the high tech Dynaform cushion. However, mean pressure across the whole contact area can be misinterpreted if peak pressure areas and “pressure hotspots” are not identified and considered when recommending a seated or lying surface to an individual deemed “at risk”.

Peak pressures at sacrum and ischial tuberosities

Reduced mobility and extended periods of static sitting concentrate interface pressure on the ischial tuberosities in an upright position, shifting to the sacral region when in a reclined or “slumped” position when the pelvis tilts anteriorly. This shift in interface pressure adds the additional risk of shear to the sacral region and with the addition of moisture (Excessive sweating or incontinence) to the microclimate, risk factors continue to rise, making the choice of correct surface vital, particularly to the at-risk individual.

Results on p19 + 20 identify statistically significant differences in PPI at the sacrum when comparing the low tech Easiform, Viscoform and Liquiform with celliform which recorded higher PPI sacral pressures in both seated and reclined positions. The most statistically significant difference is identified between Easiform and Dynaform ($p=0.000002$) in the reclined position, suggesting that this may not be a recommended choice for an individual at high risk of pressure ulcer development, as suggested in the original marketing information:

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Dynaform : “ For those at very high risk of developing pressure sores or a history of sores where the highest priority is to prevent further pressure damage.”

When comparing the rankings of cushion performance, Easiform ranks in first place for average pressure and PPI at both IT’s in both the seated and reclined position, ranking first for PPI sacrum when reclined (with Liquiform and Viscoform raking first and second respectively for seated PPI sacrum lowest pressures).

Viscoform is consistently ranked in second place for average pressure, PPI sacrum and in both positions and has a consistently high performance. There are no statistically significant differences noted between Viscoform, Coolform and Liquiform, all performing equally well to redistribute pressure at all hotspots and across the surface (average pressure).

Levitex records the highest surface area across all cushions which reflects an increased envelopment, this is also reflected in consistent 3rd / 4th ranked positions across other data sets. There is no statistically significant difference noted between Viscoform, Coolform, Liquiform or Levitex, this would suggest that prescription of these low tech cushions should be based on personal preference for the individual based on comfort and could be offered to individuals with medium to high risk as the interface pressure data collected is within recommended limits and is lower than the recorded data from their higher tech alternatives, previously recommended for the ”high risk” individual.

Rankings of surface 5 + 6 (Celliform and Dynaform) consistently fall into the 6th and 7th lowest ranks for all recorded pressure, with consistently higher pressures recorded and some negative qualitative feedback regarding comfort:

“Uncomfortable – not getting any relief” and Participant 3 adding: “Not comfortable on deflate mode of cycle – numb bottom” (Comments were made separately and without prompting) (See images page 22/23).

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The most statistically significant differences mirror the low rankings of Celliform and Dynaform and provide evidence to support careful recommendation of these 2 cushions to the “High risk” individual, with seated pressures at the sacrum exceeding recommendations (>60mmHg) with some peak pressures recorded significantly higher than this.

Overall Ranking in order of best performance i.e., lowest interface pressure recorded (average pressure, peak pressure hotspots at sacrum, IT’s, and peak pressure) in both positions:

1 – EASIFORM – OVERALL BEST PERFORMANCE – significant lower risk.
2 – VISCOFORM
3 – LIQUIFORM
4 – COOL FORM
5 – LEVITEX

No statistical difference

6 – CELLIFORM
7 - DYNAFORM

PPI sacrum Celliform significantly lower than Dynaform (p=0.02)

Limitations

These findings are limited due to the small sample size (n=3) and require further investigation over longer periods of time and with a larger sample size including a range of range of people with varying abilities to allow them to reposition throughout an extended period of data collection. It would be useful to monitor long term usage of the different surfaces and collect qualitative feedback regarding comfort ratings in addition to recording pressure ulcer development or healing rates. Findings from this study with regard to the recommendation of “high tech” cushions including alternating air systems support recent findings from Nixon et al (2018) who investigated the use of alternating air mattresses for high-risk patients in the hospital environment. These findings also supported the fact that a high spec foam is as effective at redistribution

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of interface pressure and in some cases more effective at reducing the risk of pressure ulcer development when compared with the alternating air mattresses.

Nixon et al (2018) advocate that decisions regarding mattress choice should take into account skin status, patient preferences (movement ability and rehabilitation needs) and the presence of factors that may be potentially modifiable through alternating pressure mattresses, including being completely immobile, having nutritional deficits, lacking capacity and/or having altered skin/category 1 PU – this is sound advice when also considering the seated surface for individuals with restricted mobility and extended periods of static sitting. This is of increased importance when the individual is transferred out of the hospital environment into community where they may be at increased risk due to reduced level of monitoring.

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7. AUTHOR

Jo-Anne Webb has been a Senior Lecturer in Occupational Therapy within the School of Health and Social Care at The University of Salford for 25 years and is now a Specialist Occupational Therapist with Rehabilitation for Independence. Jo's research interests focus on safe moving and handling of people whilst minimising the risk of pressure ulcer development and exploration of the impact of surfaces on interface pressure and pressure ulcer development risk.

Jo has presented and published Nationally and Internationally on this subject, was an active member of the Pressure Ulcer Workstream of the National Wound Care Strategy Programme, developing training to increase awareness of pressure ulcer risks across a range of Heath Care Professionals and is currently on the Stryker Advisory panel.

Previous publications :

- Mellson,J., Richardson, N., James J (2013) Slings: Should they stay, or should they go? The Column, 25.3 National Back Exchange publication. September p16-21

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8. APPENDIX of IMAGES

Images taken from X-sensor data – all merged frames showing peak pressures across 600 frames for each image

The highlighted yellow square on eah image shows the peak pressure “Hotspot” and calculation of Peak Pressure Index (PPI) used as areas of interest for sstaistical comparison. PPI’s were identified for each ischial tuberosity and scaral region for each surface with each participant. Mean / SD’s generated from this raw data for analysis (See Table 1)

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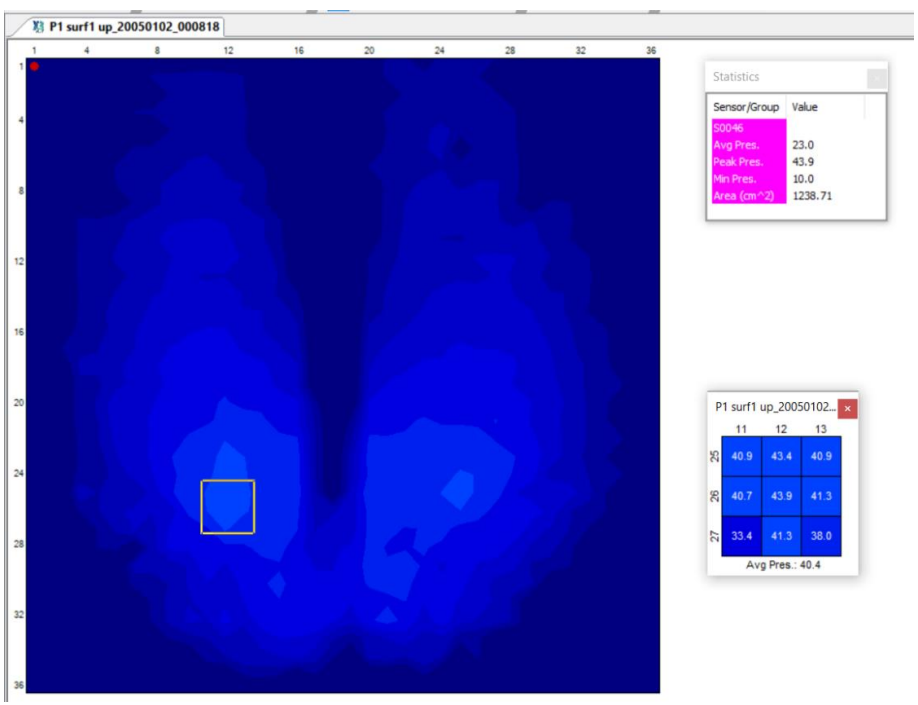
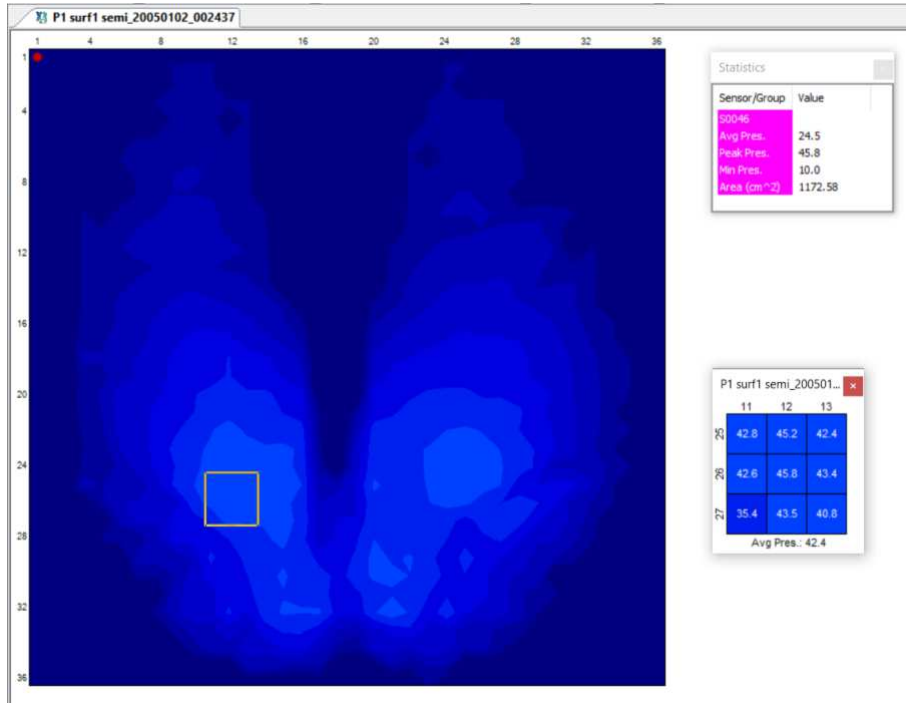
Surface 1 – Easiform

Participant 1 seated



Participant 1 semi reclined



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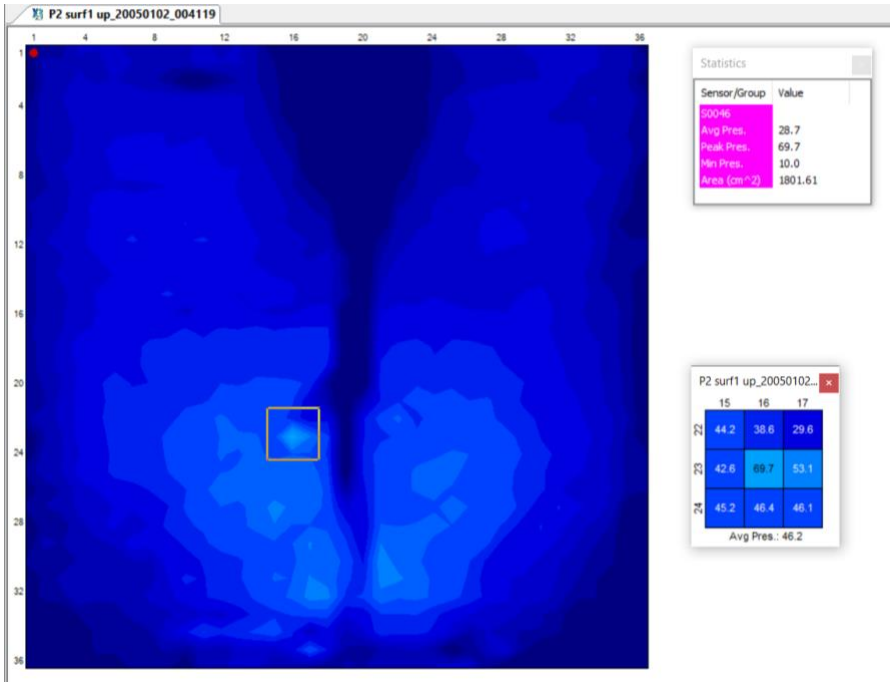
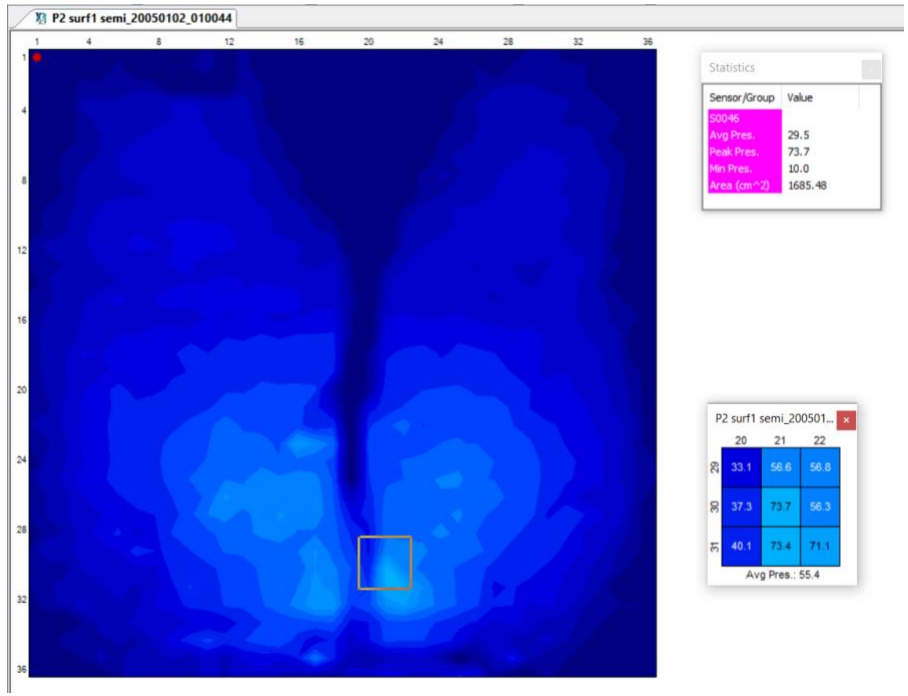
Surface 1 Easiform

Participant 2 – seated upright



Participant 2 semi reclined



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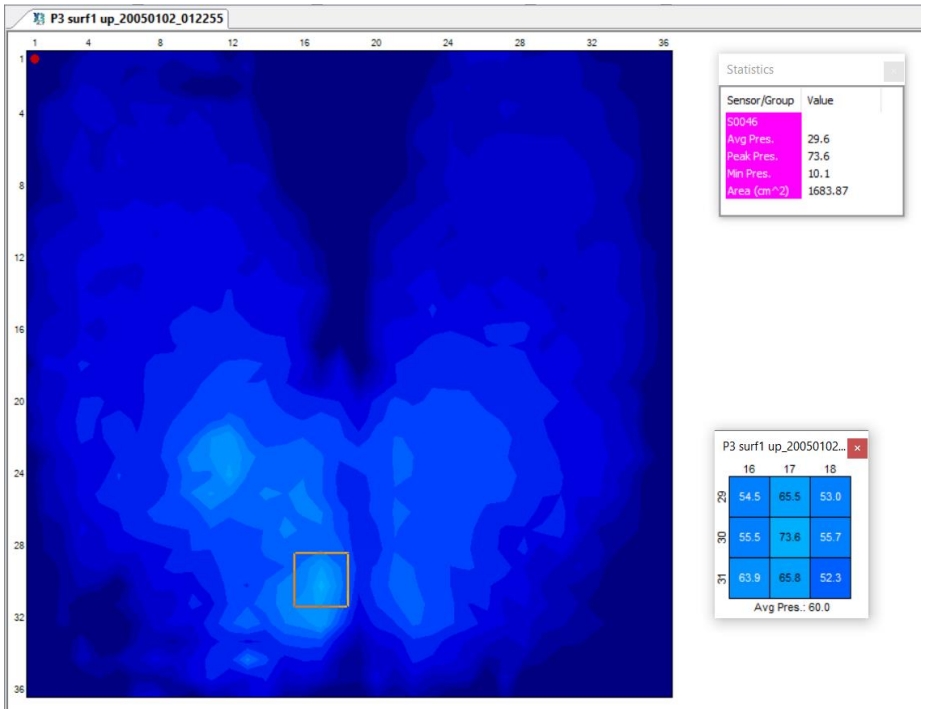
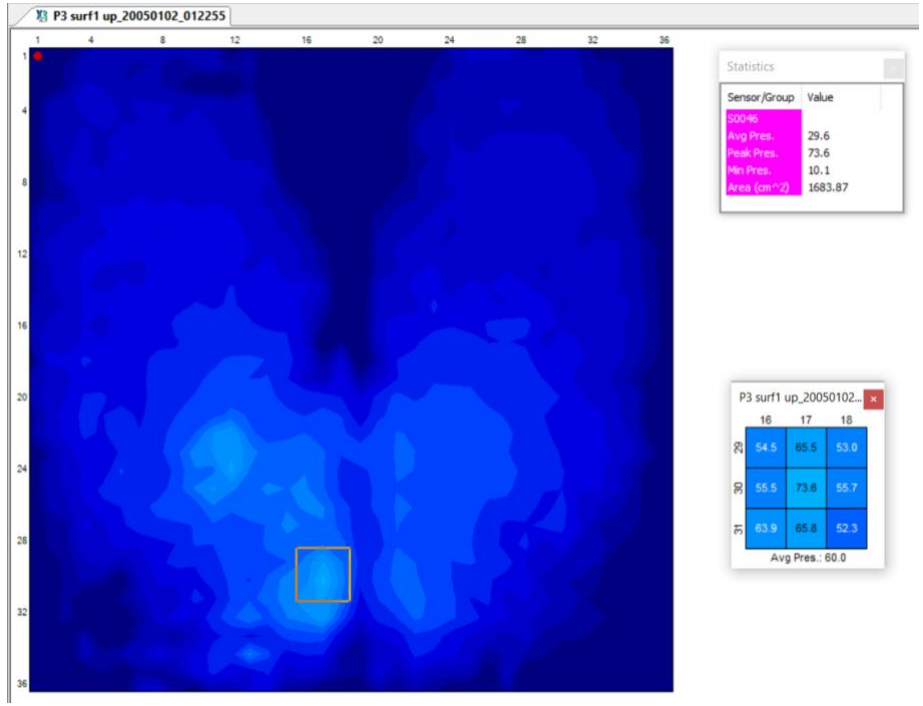
Surface 1 Easiform

Participant 3 seated upright



Participant 3 semi reclined



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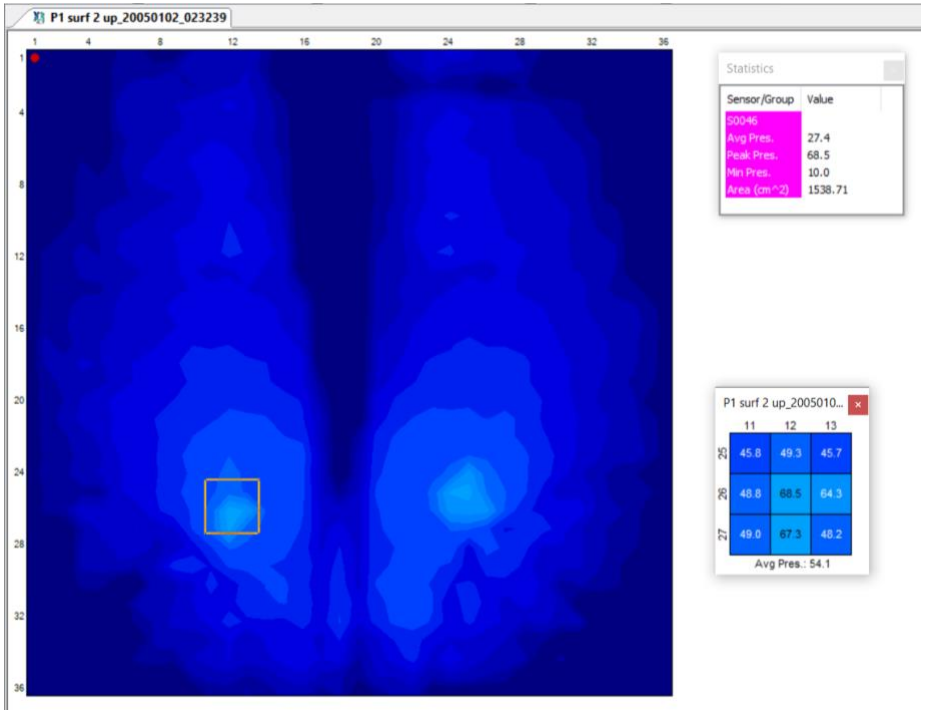
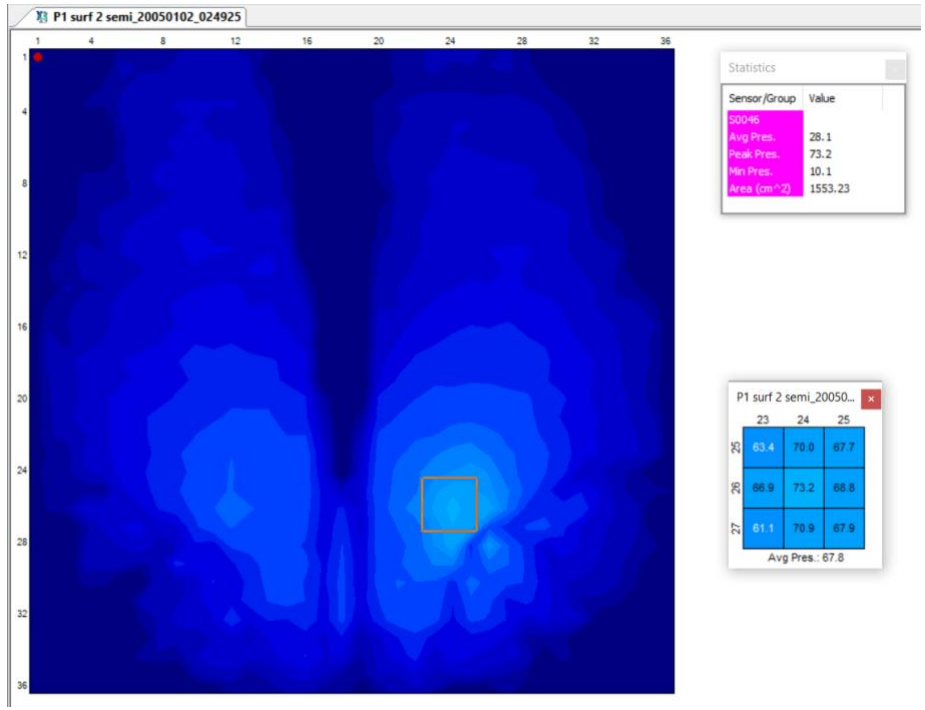
Surface 2 – Viscoform

Participant 1 seated upright



Participant 1 semi reclined



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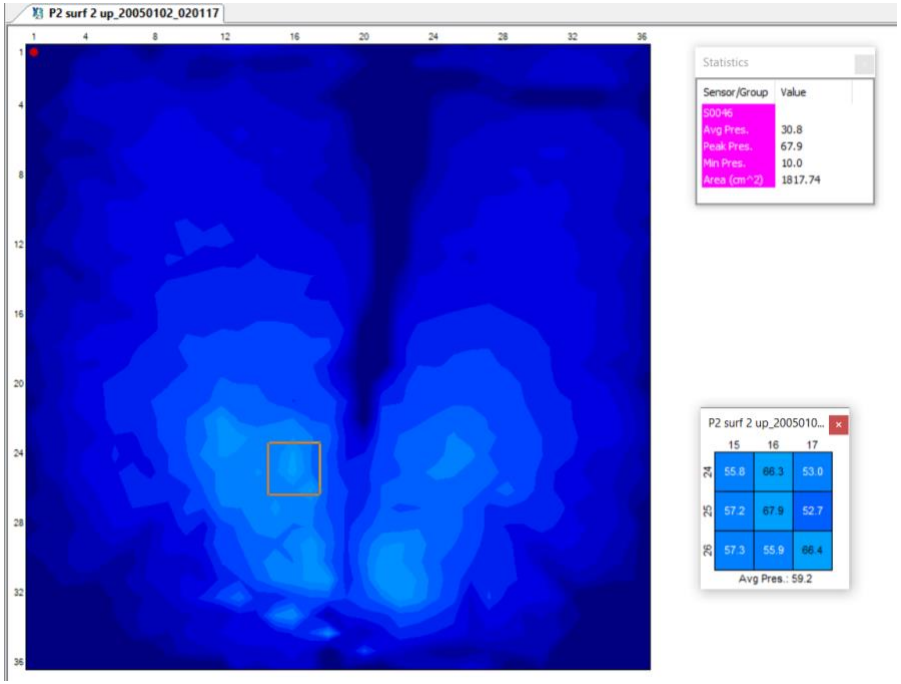
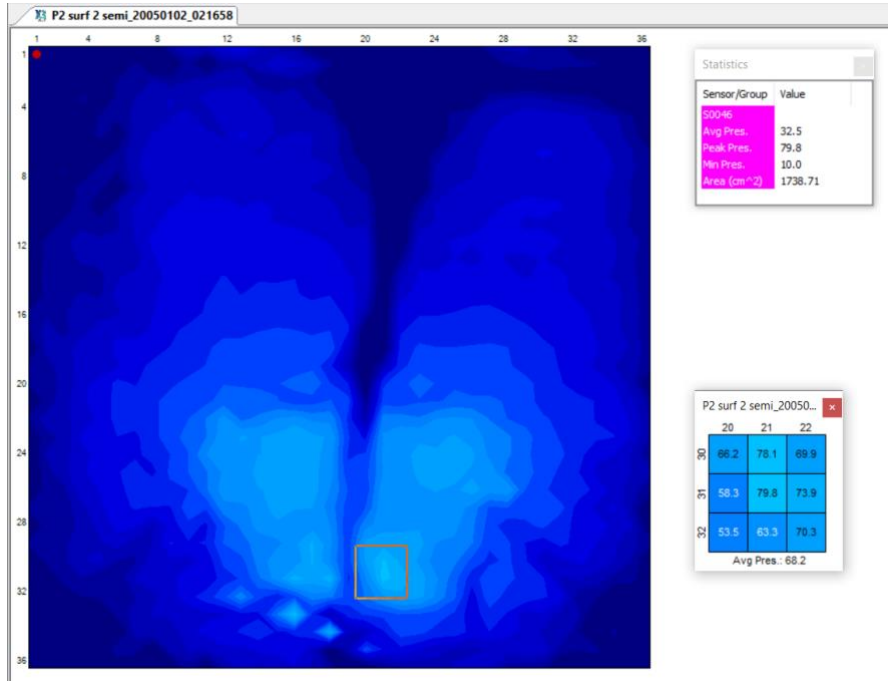
Surface 2 Viscoform

Participant 2 seated upright



Participant 2 semi reclined



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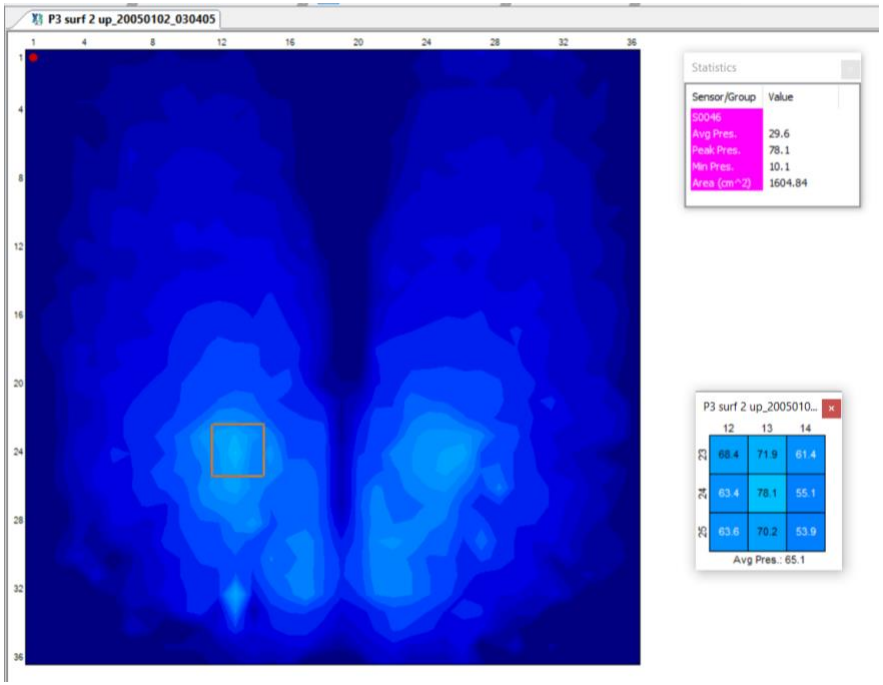
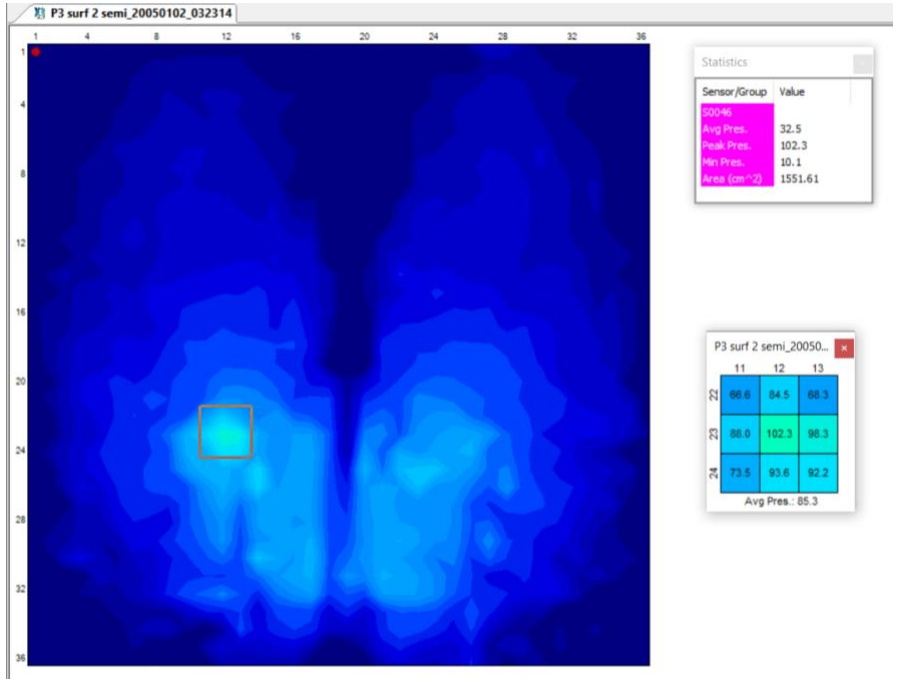
Surface 2 Viscoform

Participant 3 seated upright



Participant 3 – semi reclined



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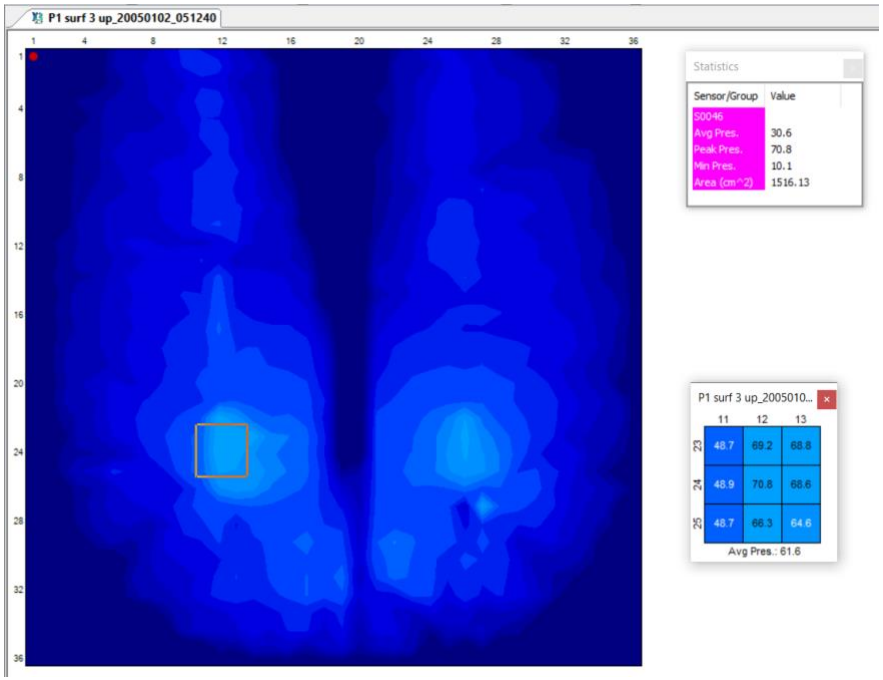
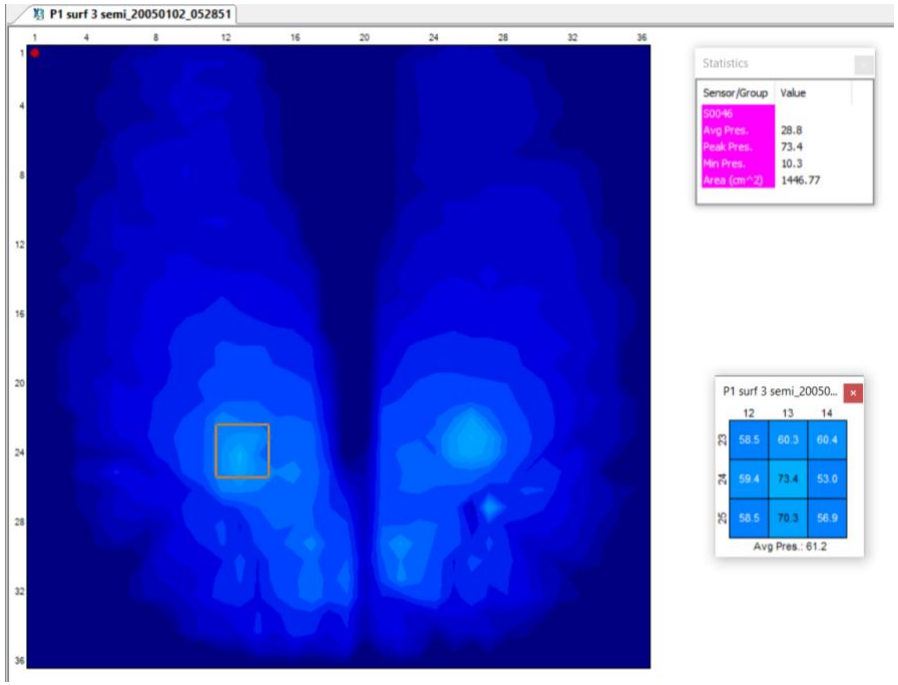
Surface 3 seated upright - Cool form

Participant 1 seated upright



Participant 1 semi reclined



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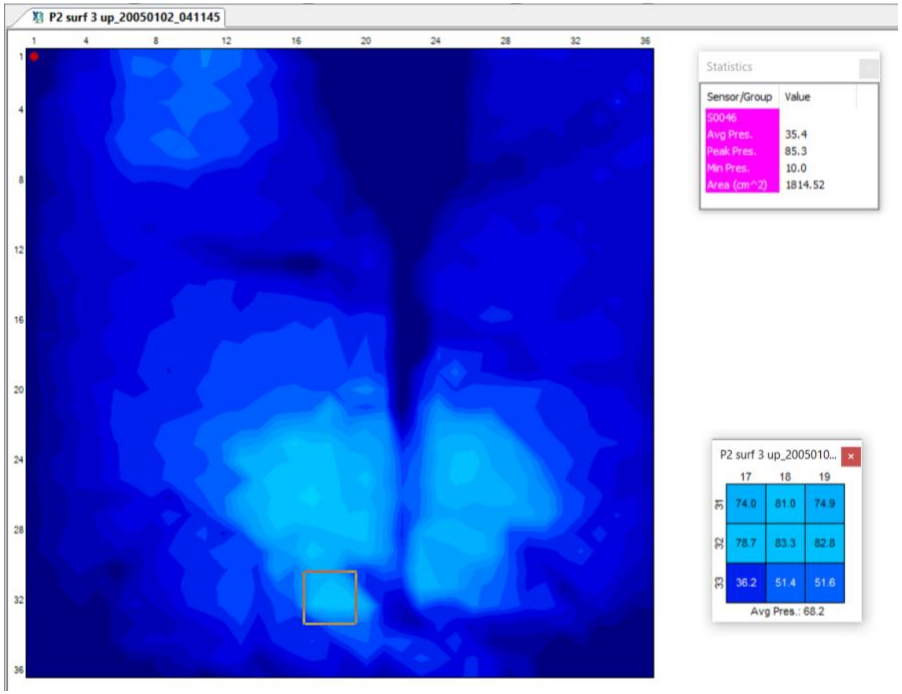
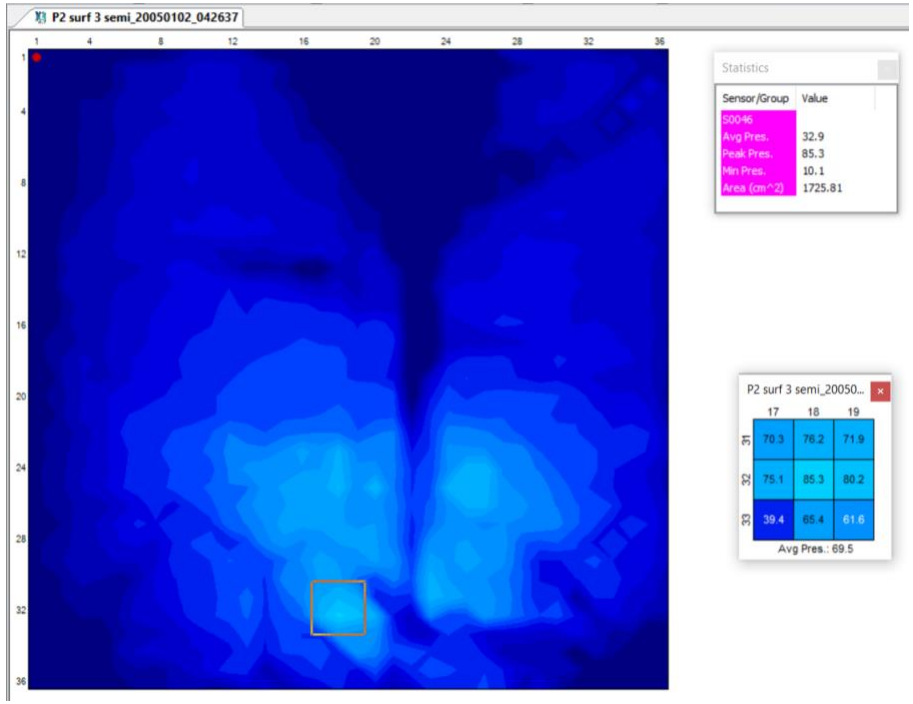
Surface 3 Cool form

Participant 2 seated upright



Participant 2 semi reclined



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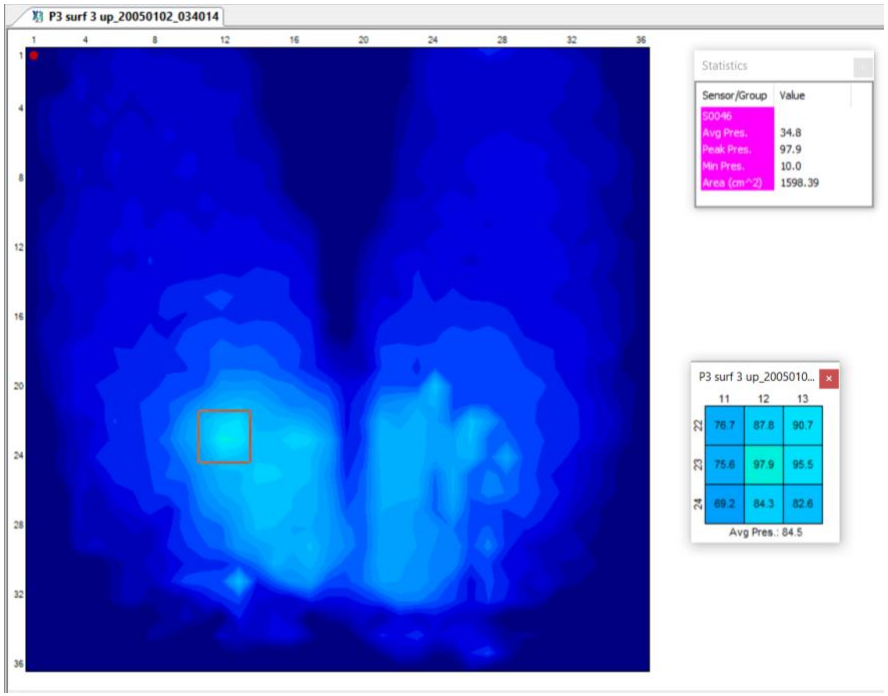
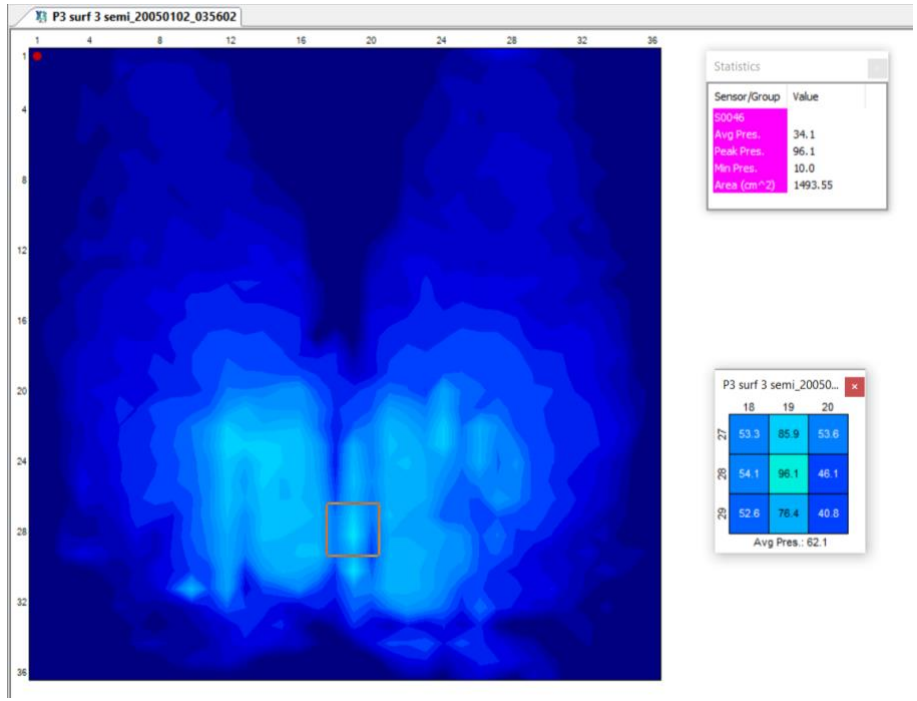
Surface 3 Coolform

Participant 3 - seated upright

Participant 3 – semi reclined

“Feels slippy and “bum feels numb” – better on recline





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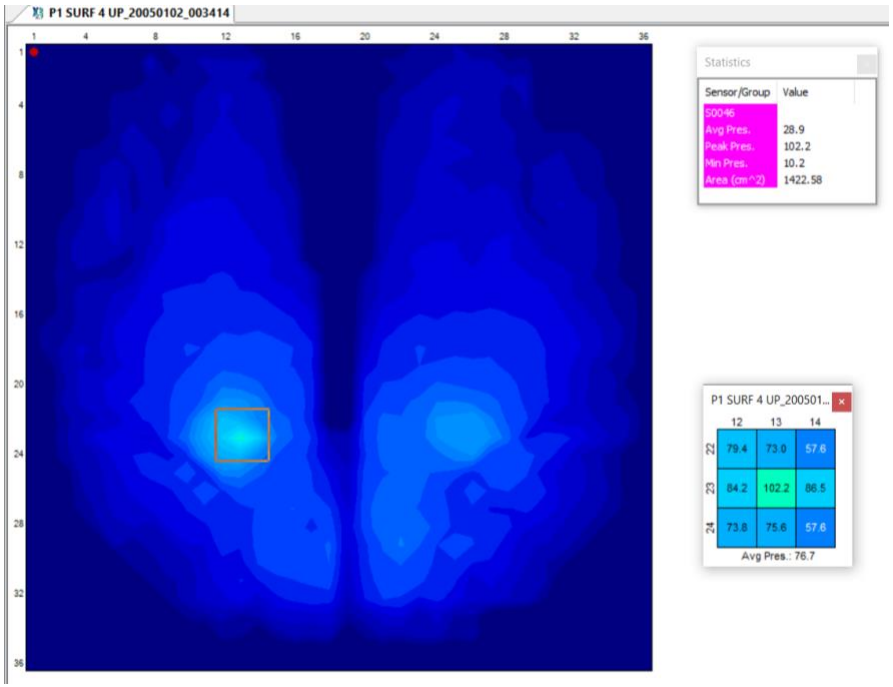
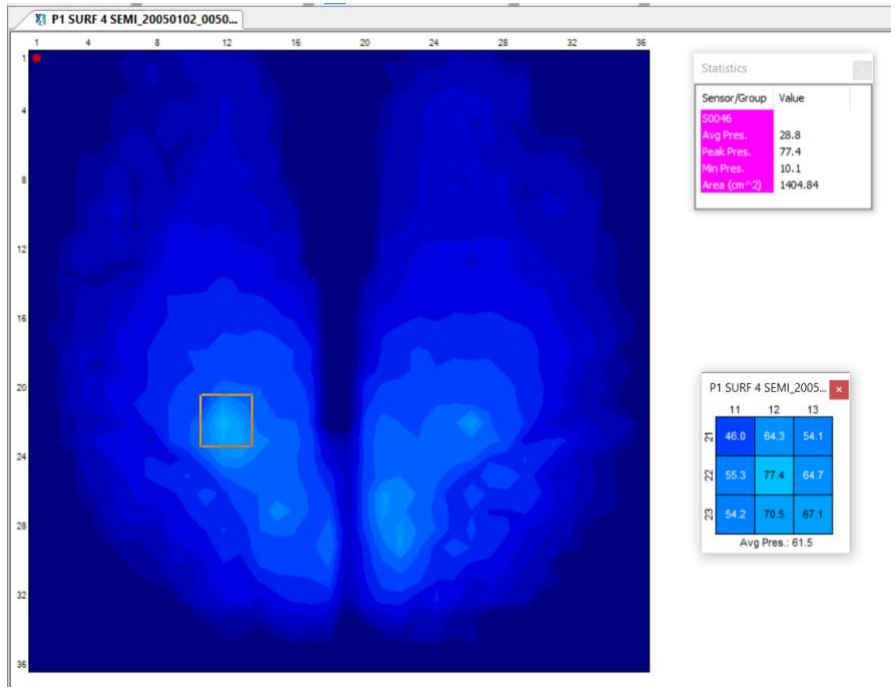
Surface 4 – Liquiform

Participant 1 seated upright



Participant 1 semi reclined



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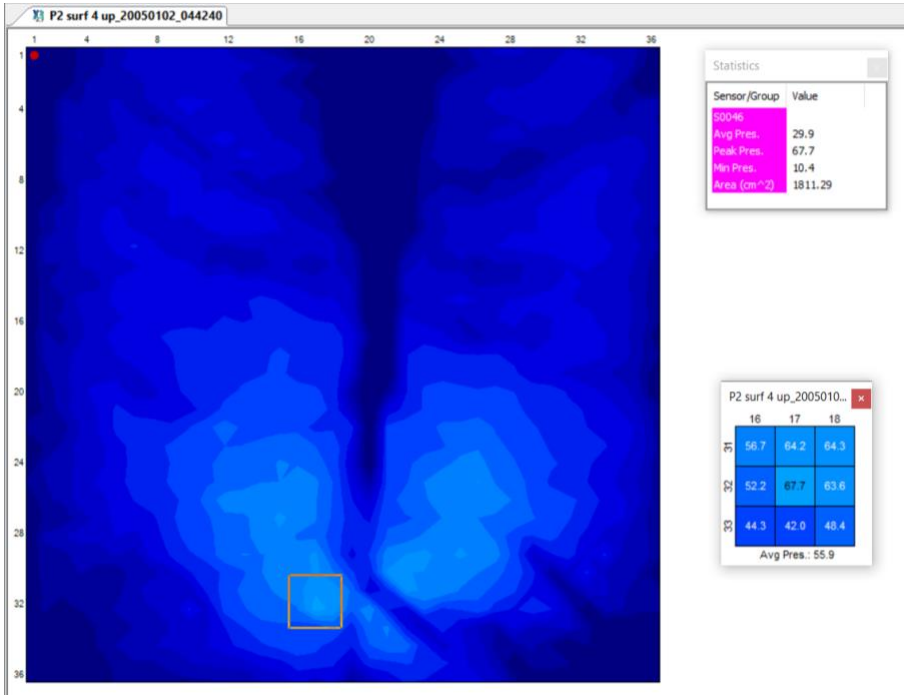
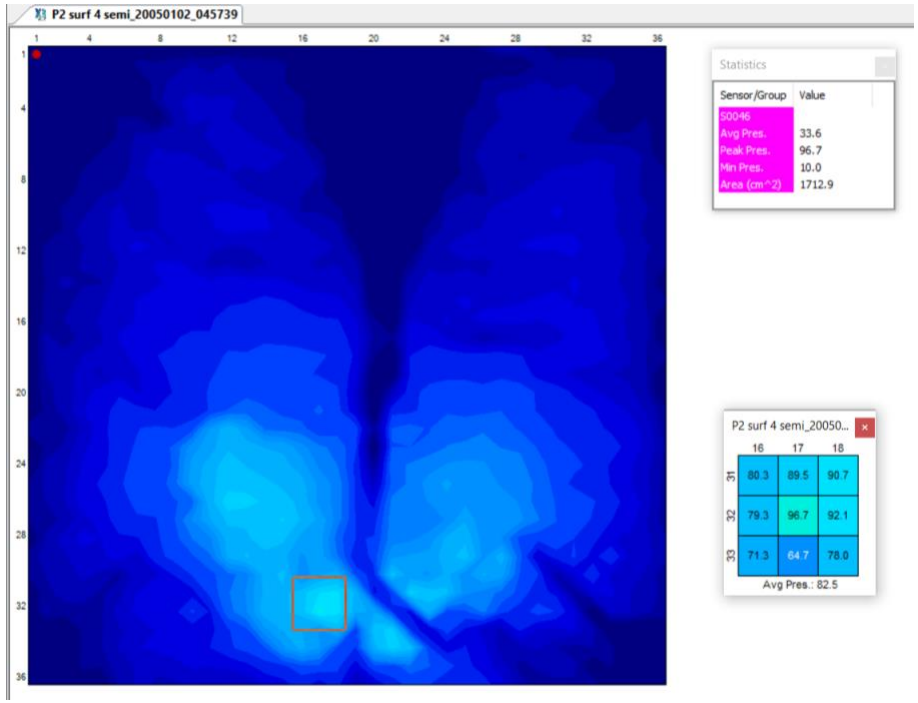
Surface 4 Liquiform

Participant 2 seated upright “favourite”



Participant 2 semi reclined



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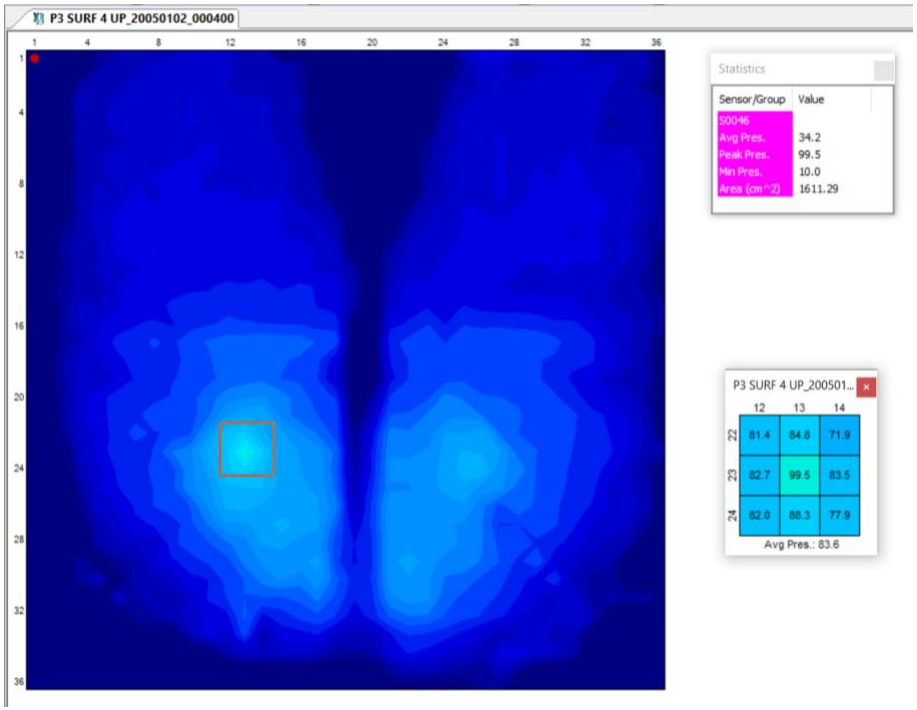
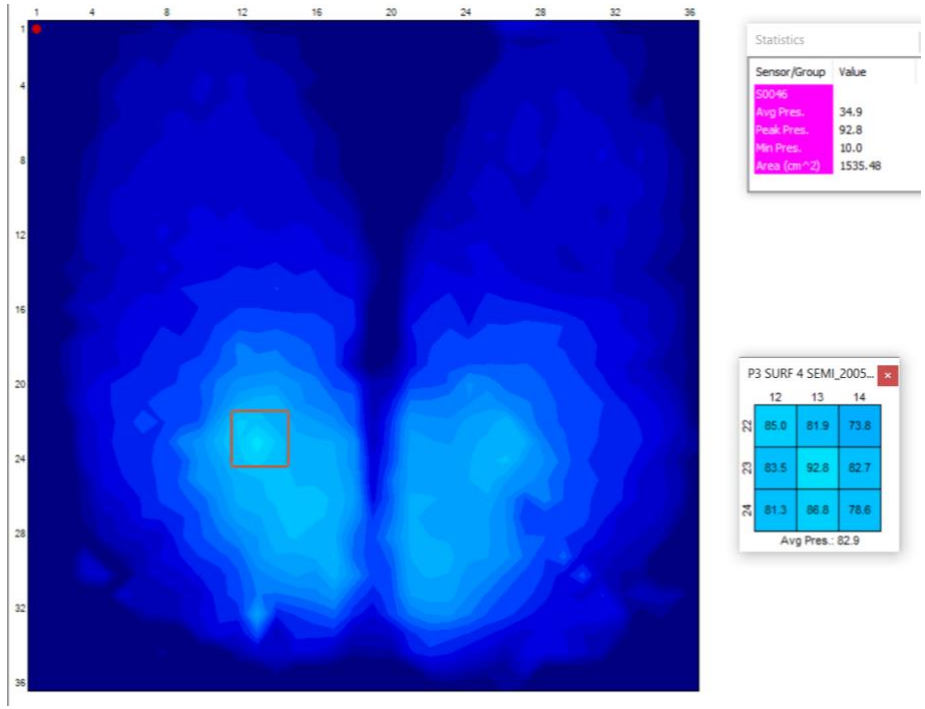
Surface 4 Liquiform

Participant 3 seated upright



Participant 3 semi reclined



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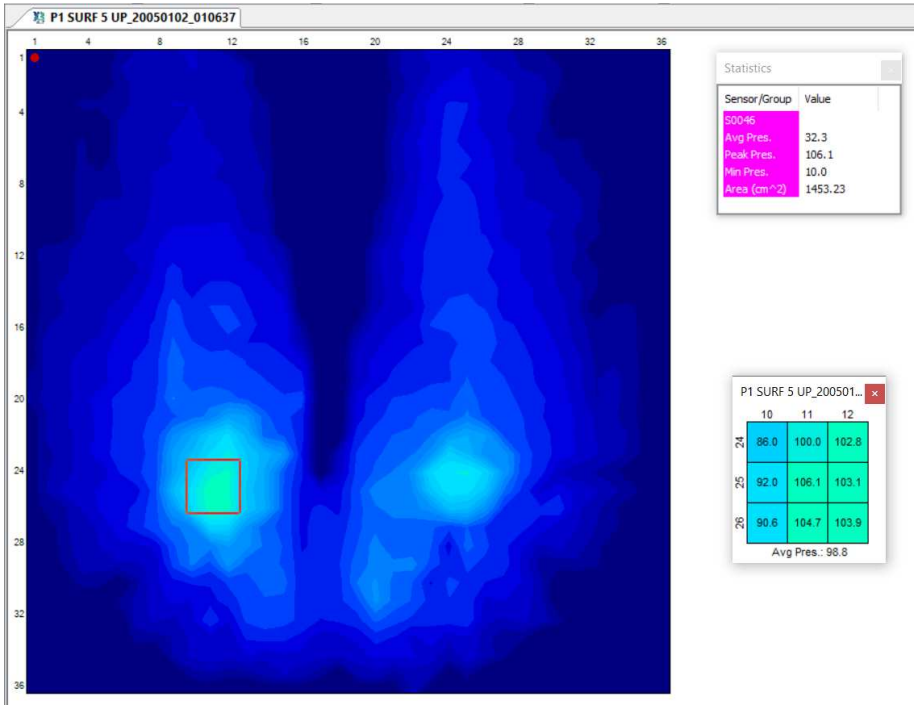
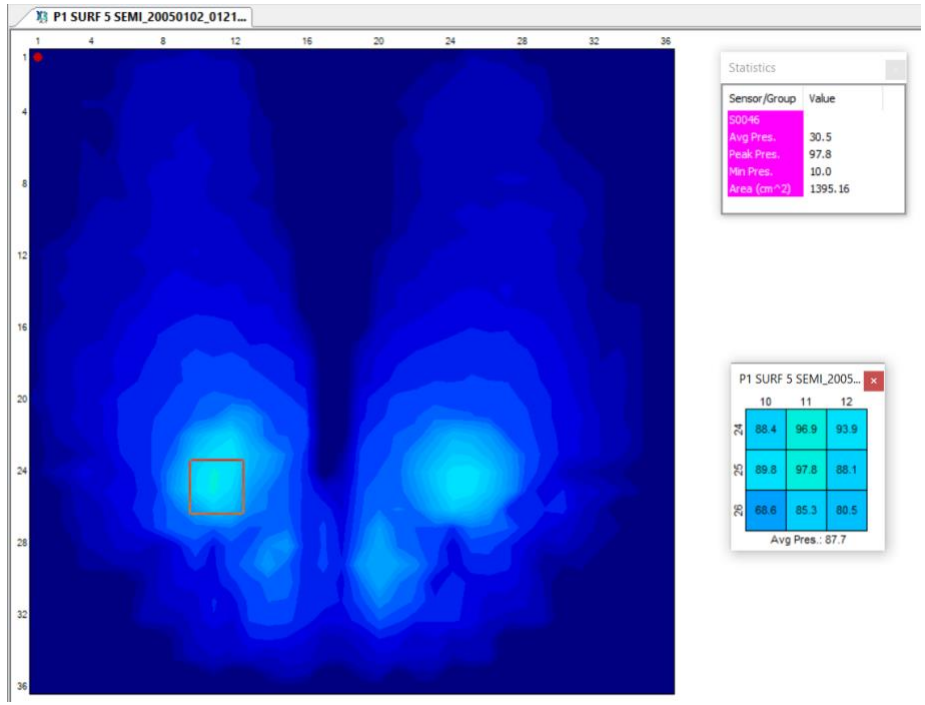
Surface 5 – Celliform

Participant 1 seated upright

Participant 1 semi reclined

“Feels firmer compared with surface 4 “in a good way”





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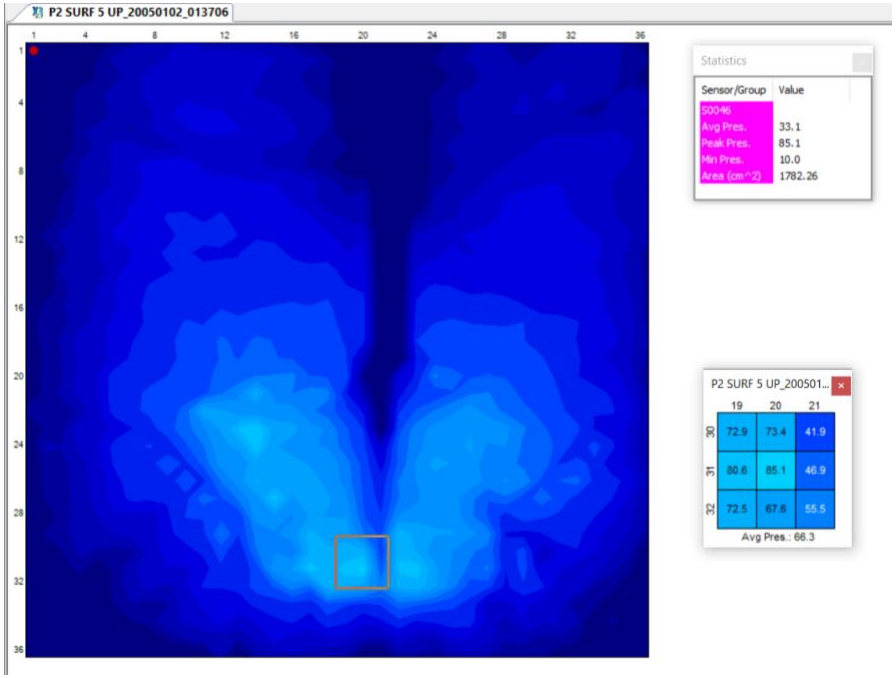
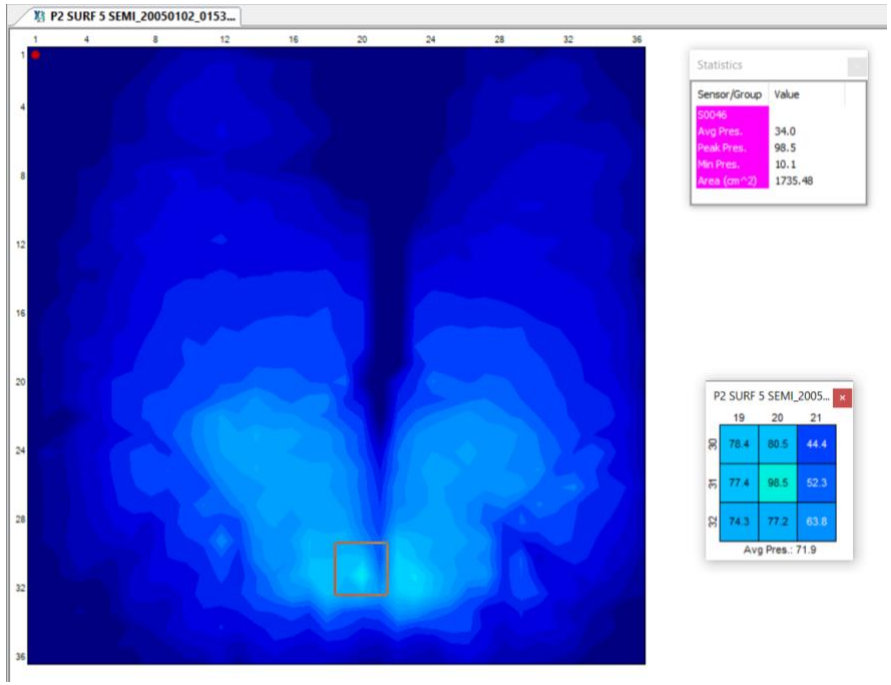
Surface 5 Celliform

Participant 2 seated upright



Participant 2 semi reclined



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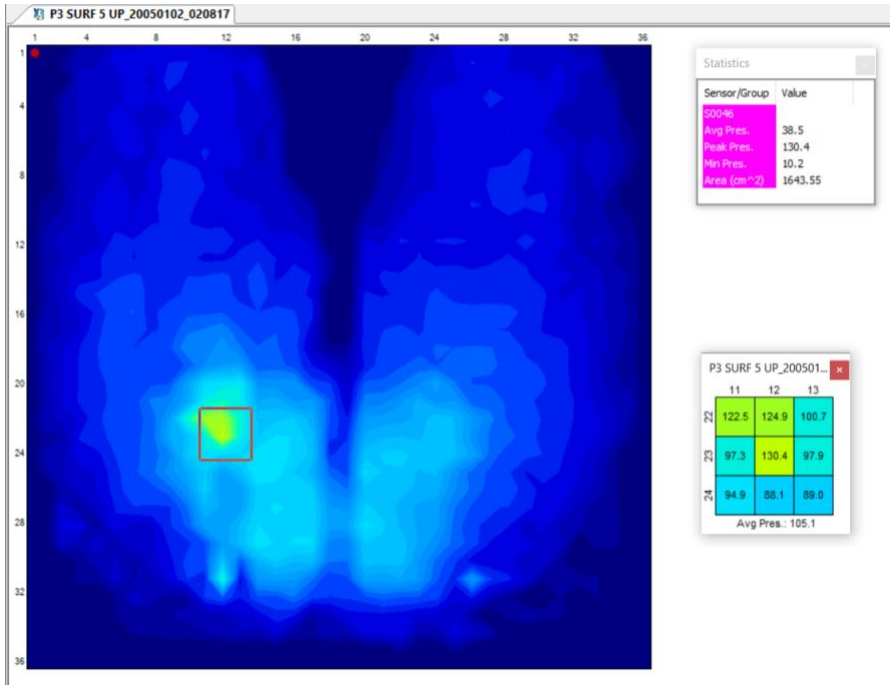
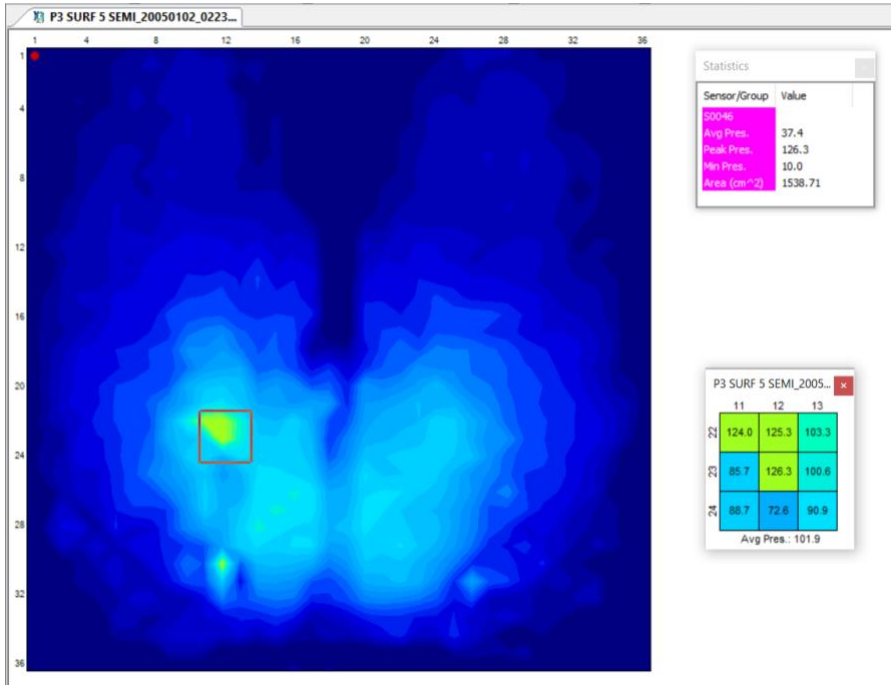
Surface 5 Celliform

Participant 3 seated upright



Participant 3 semi reclined



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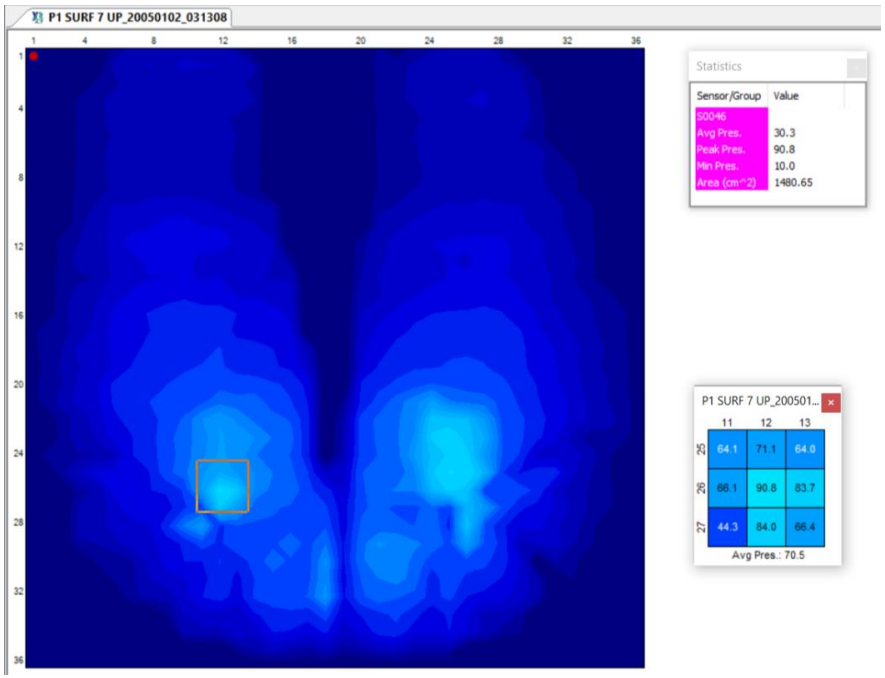
NB: Following removal of the original “surface 6 (Airform) from the study the next 2 cushions are renamed surface 6 + 7 although in screen shots appears as SURF 7 + 8)

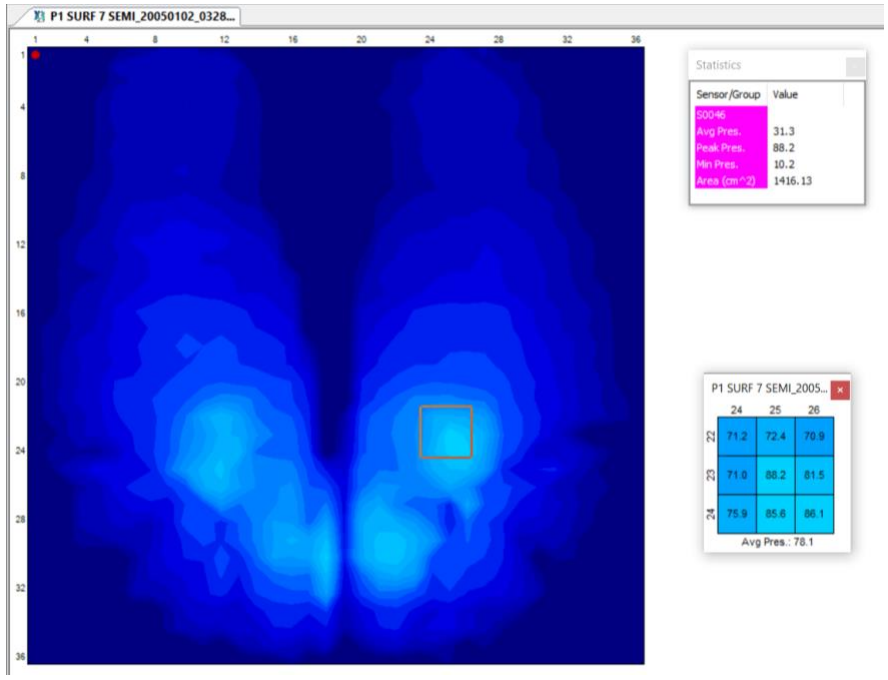
Surface 6 Dynaform (Alternating air cushion) Negative feedback from all 3 participants

Participant 1 seated upright

“Quite firm, weird, don’t like it, wouldn’t choose it”



Participant 1 semi recline



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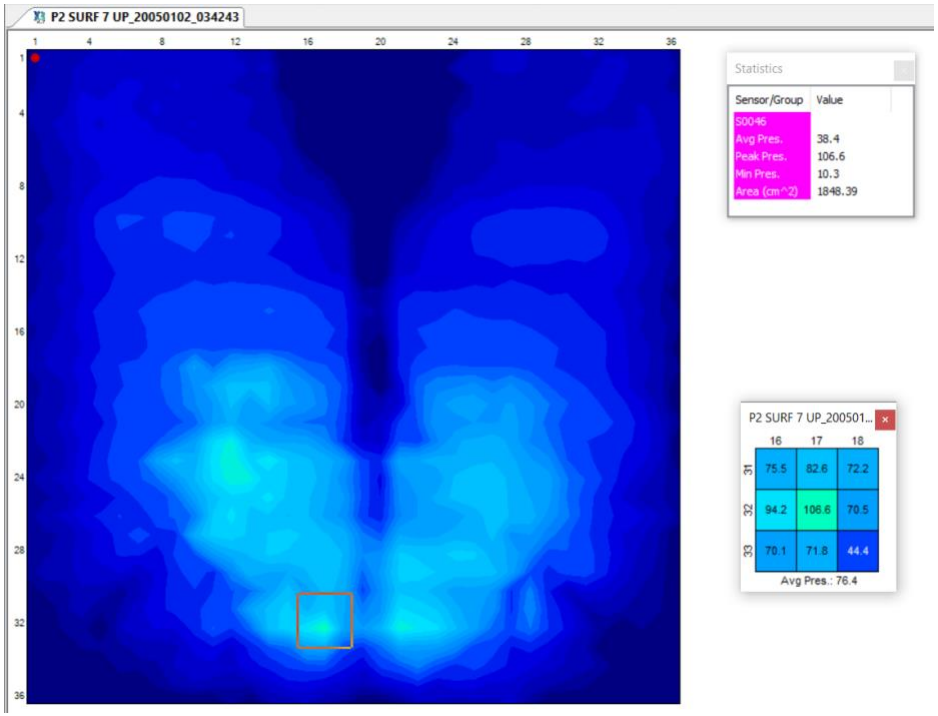
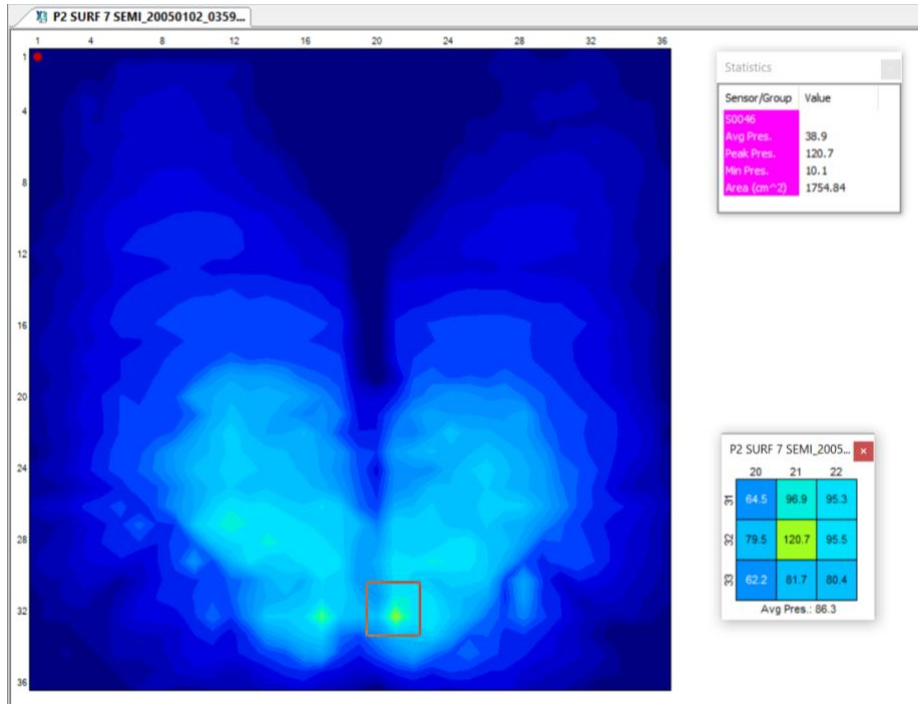
Surface 6 Dynaform

Participant 2 seated upright

Participant 2 semi reclined

“Uncomfortable – not getting any relief”





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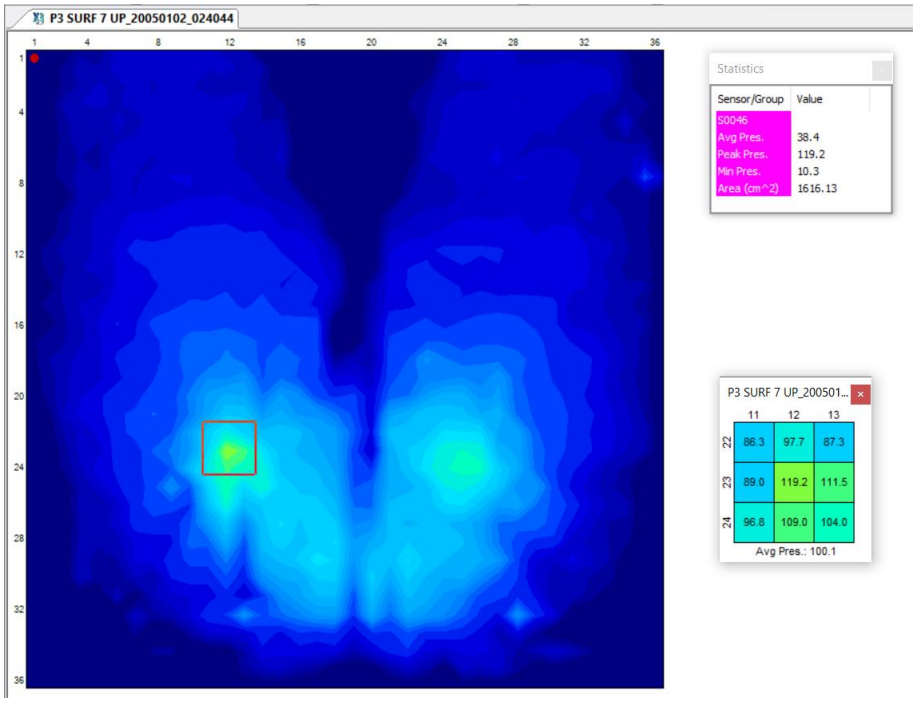
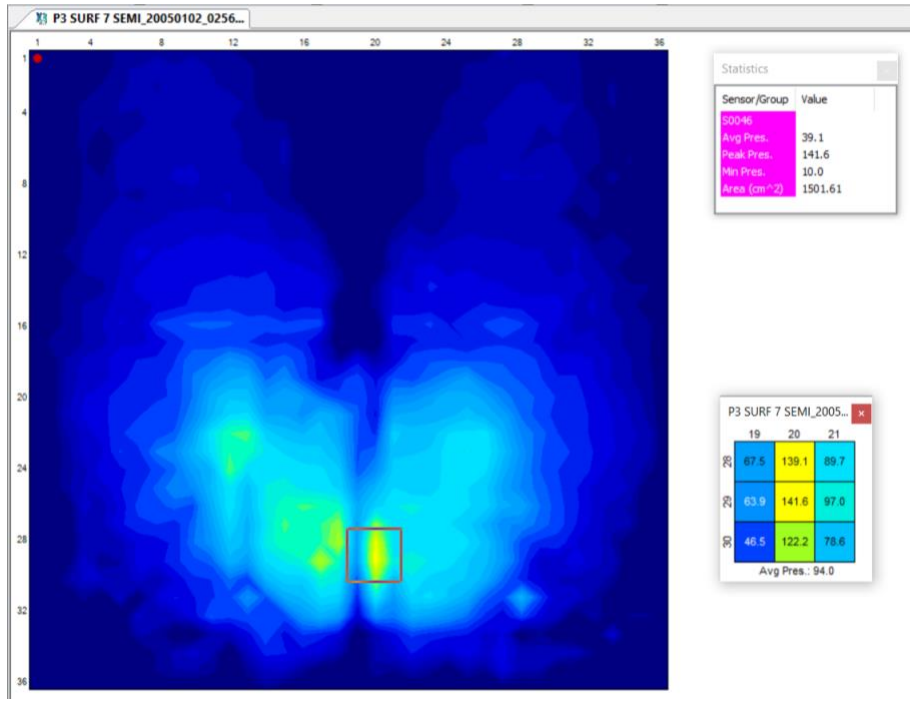
Surface 6 Dynaform

Participant 3 seated upright

Participant 3 semi reclined

“Not comfortable on deflate mode of cycle – numb bottom”





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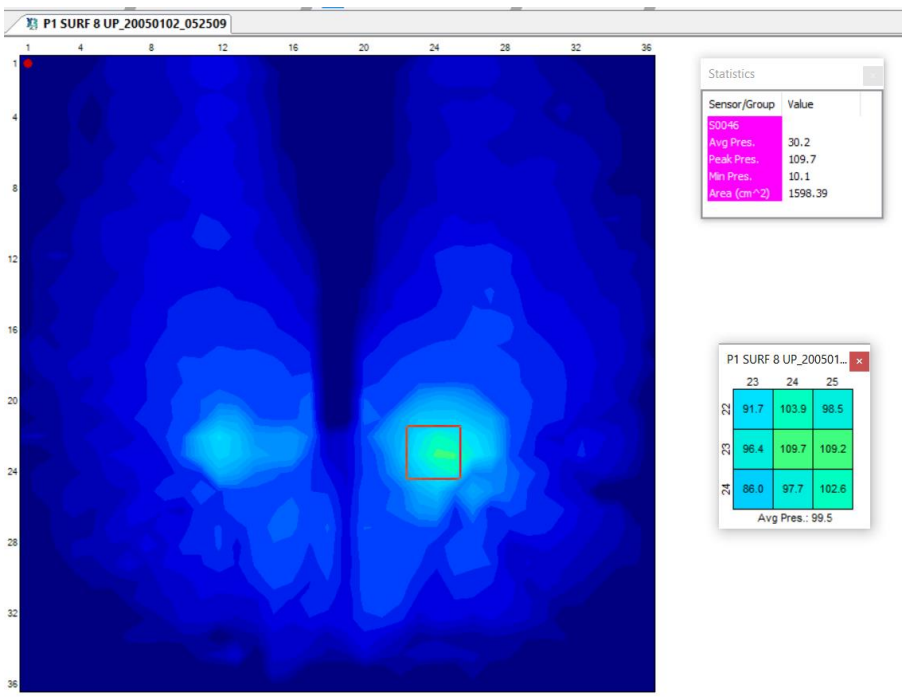
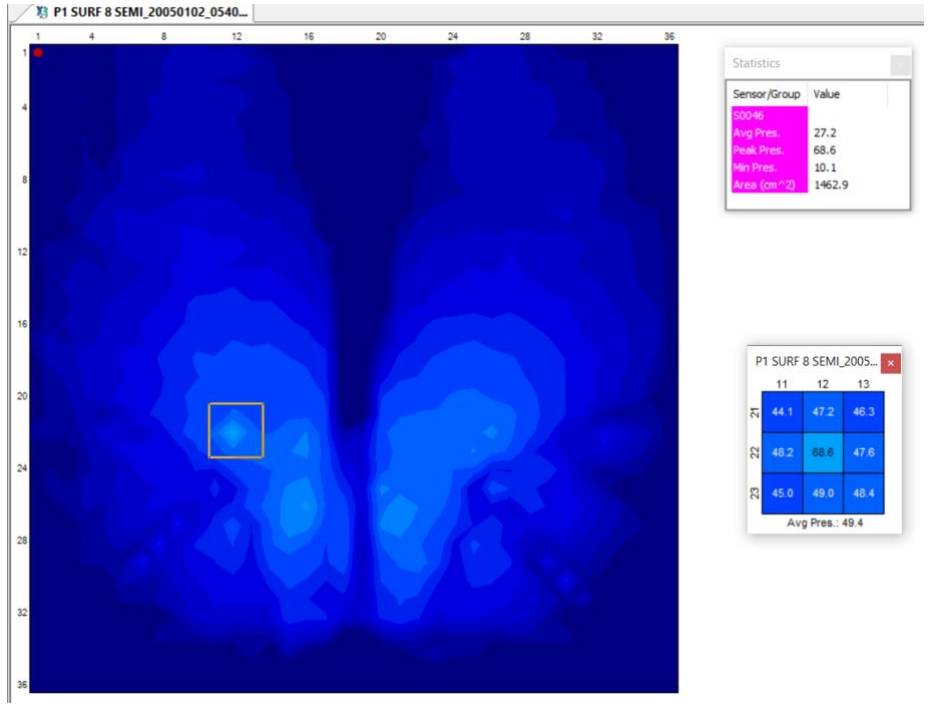
Surface 7 Levitex

Participant 1 seated upright

“Feels softest, favourite one”



Participant 1 semi reclined



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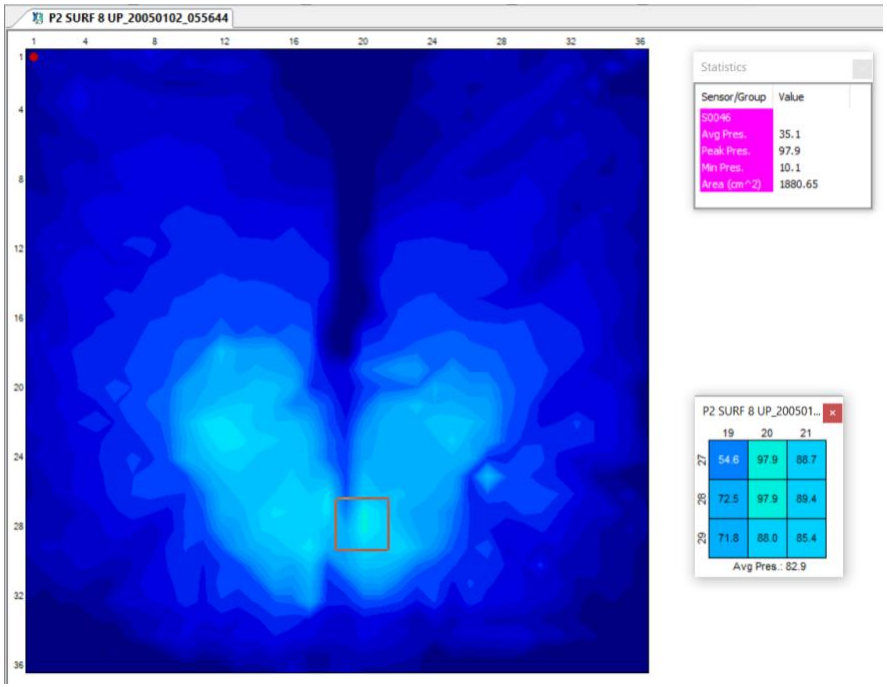
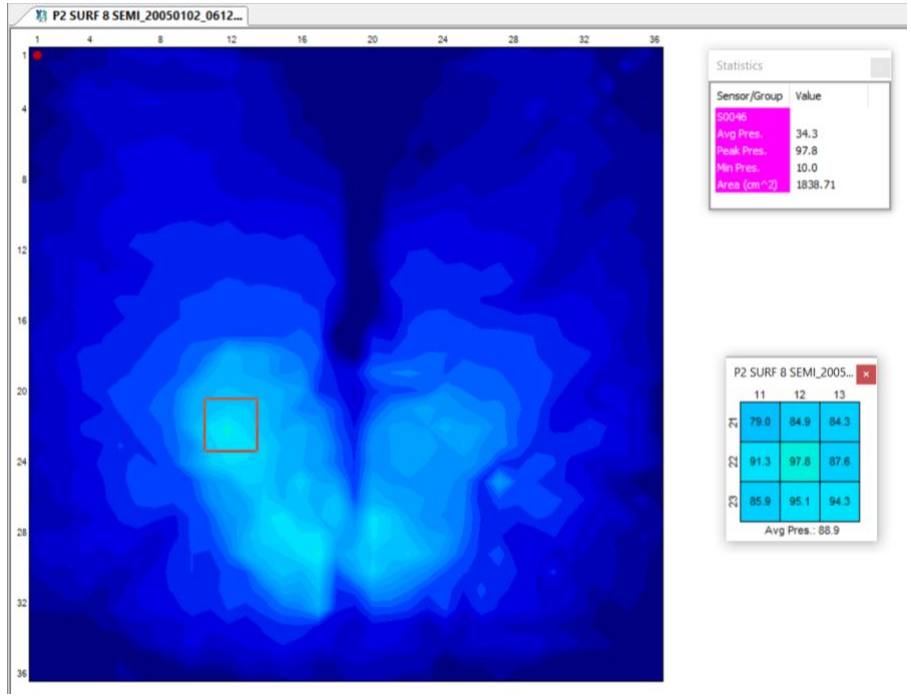
Surface 7 Levitex

Participant 2 seated upright



Participant 2 semi reclined



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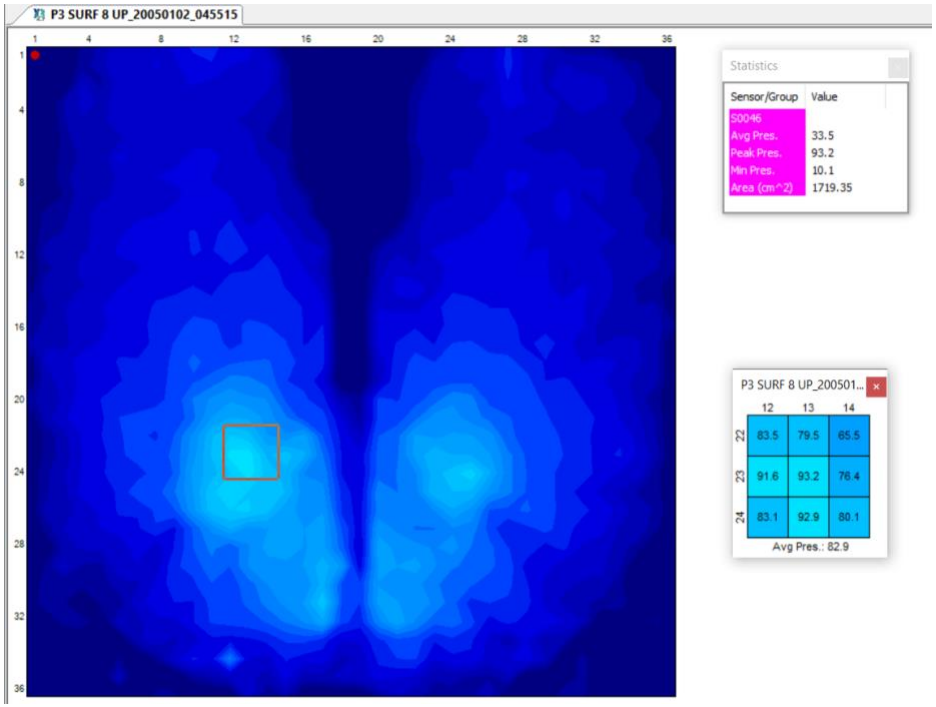
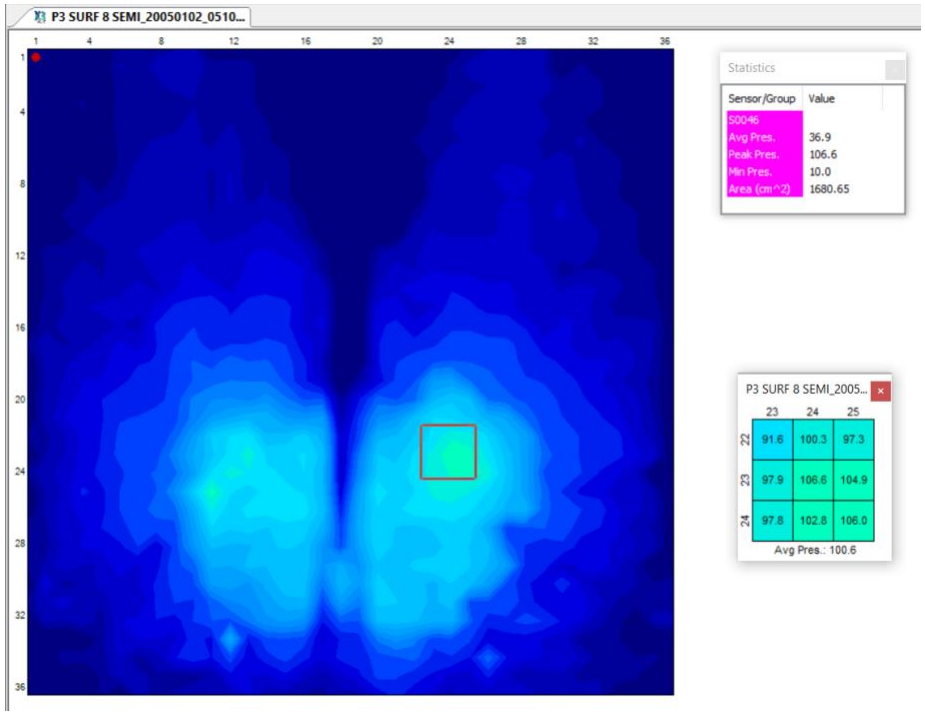
Surface 7 Levitex

Participant 3 seated upright



Participant 3 semi reclined



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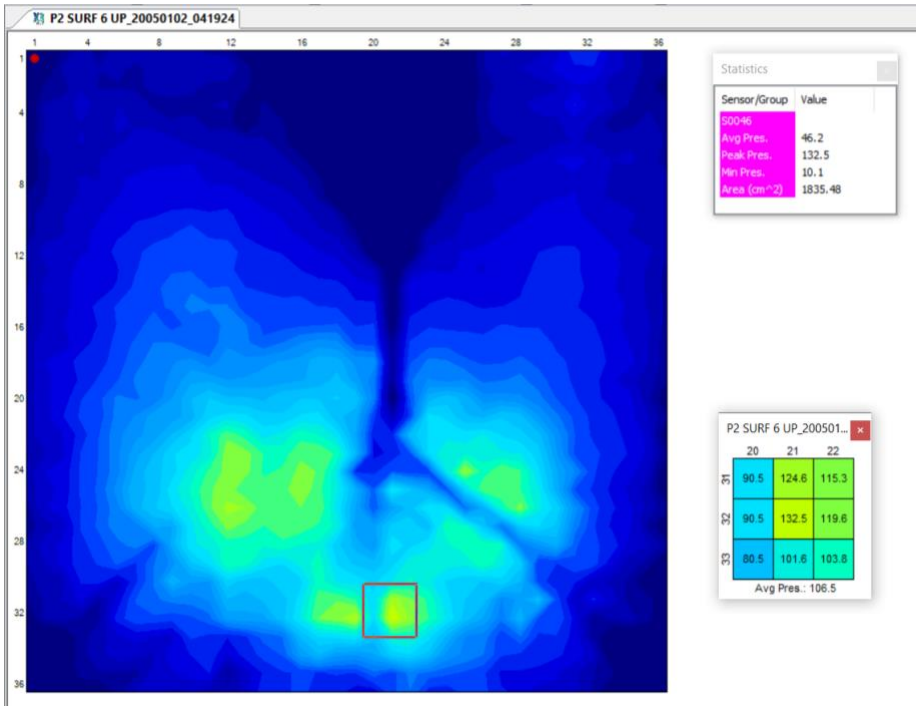
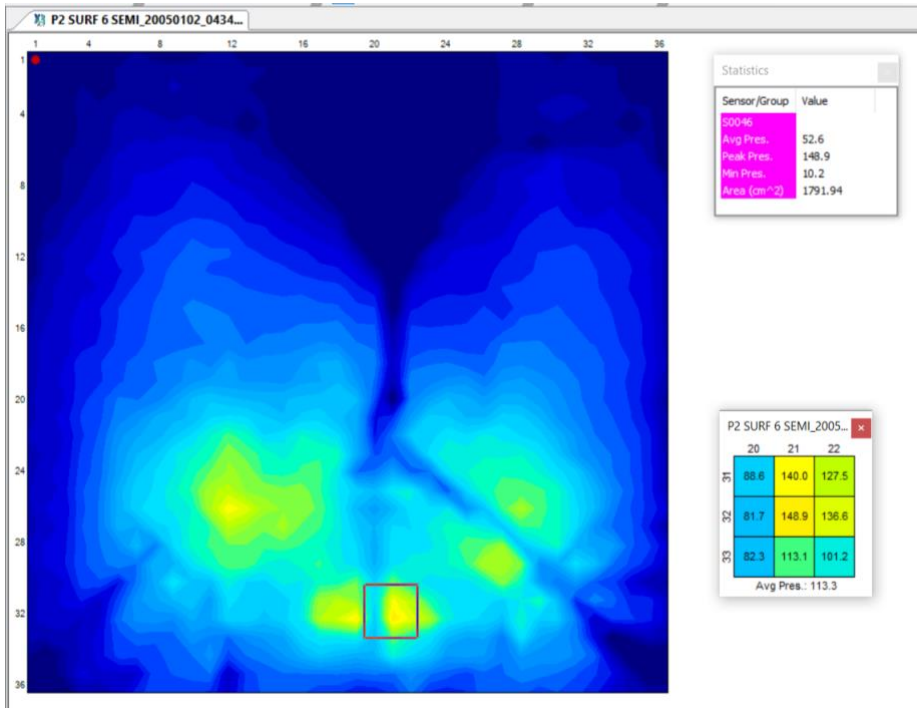
Original surface 6 – Airform

(ONLY one mapping session – cushion rejected from study due to very high peak pressures at sacrum and reported discomfort)

Participant 2 seated upright





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