

REDUCING PRESSURE ULCER RISK IN THE OPERATING ROOM

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ABSTRACT: Pressure ulcers are a significant clinical and financial issue for healthcare facilities. In the operating room, prevention strategies may be limited to pressure redistribution surfaces due to the inability to reposition the patient during surgery. Six operating room pads were evaluated by interface pressure mapping using six normal, healthy volunteers of varying weight and BMI. Overall and peak pressure distributions separated the pads into two groups. Thicker pads with variable densities and multiple layer construction provided improved pressure redistribution when compared to the single layer, two inch thick pads. Pad performance is affected by thickness, variable density, ticking composition, patient weight and positioning. The choice of operating room pad is more critical for heavier patients.

Recent pressure ulcer prevalence surveys have shown an overall pressure ulcer prevalence of 13.4% in the acute care setting and a nosocomial pressure ulcer prevalence of 6.4% in 2006 and 2007¹. When examined on a hospital unit basis, overall prevalence of up to 30% has been reported². The presence of a pressure ulcer adds a median 4.6 days to a hospital stay³, a significant clinical and financial burden.

Up to 23% of nosocomial pressure ulcers have been shown to originate in the operating room, and may represent up to 42% of the hospital's total cost to treat pressure ulcers⁴. Up to 12% of all surgical patients may develop a pressure ulcer that originated in the operating room.⁵

Pressure ulcer prevention strategies include staffing, protocol, and technology approaches^{6,7}, and are typically directed at specific hospital units such as the intensive care unit. The operating room has seen notably less activity in these efforts. The increased risk to the patient during the intra-operative time period is often unappreciated, as the tools to assess that risk are generally inadequate.⁸ As a result, ulcer formation is commonly blamed on post-operative care unit.

A common misconception is that the period of time a patient spends in the operating room is insufficient to generate a pressure ulcer. Surgical techniques have evolved significantly and new technologies and procedures have increased the complexity and time required for surgery. Improvements in anesthesia have made these extended surgeries clinically feasible.⁹ While the absolute time required to develop a pressure ulcer may be patient specific, depending on co-morbidities, various studies have suggested they may occur within a 1 to 4 hour time frame,¹⁰⁻¹² well within the range of current surgical procedures. Operations lasting more than 4 hours have been shown to double the risk of developing a pressure ulcer.¹³

The operating room environment may increase the risk for pressure ulcers in several ways. Patients are kept immobile for long periods of time and due to anesthesia can no longer voluntarily shift their weight, feel pain, or voice a complaint. Certain anesthetic agents may decrease peripheral circulation and perfusion, particularly in elderly patients.¹⁴ Skin and body temperatures may be controlled by warming blankets or other artificial means, but an ideal temperature is difficult to maintain.

Pressure ulcers originating in the operating room may also present differently. These ulcers may present as deep tissue injury rather than a standard ulcer. Skin tone may make the initial recognition difficult.¹⁵ The initial presentation may be delayed sufficiently such that it is not attributed to the surgical procedure, and its eventual discovery post-operatively may not be communicated back to the operating room staff.

Recent pressure ulcer prevention and treatment guidelines developed by an NPUAP/EPUAP collaboration¹⁶ devote an entire section to the operating room in part because the operating room environment is so different from the rest of the hospital. The guidelines recommend proper positioning and the use of a pressure redistributing mattress.

Repositioning strategies for pressure ulcer prevention may be impractical or contraindicated during a surgical procedure. One of the few prevention options remaining is a pressure redistributing surface. Advanced powered air or fluidized surfaces may adequately reduce or redistribute pressure, but may also introduce unanticipated and unwanted movement of the patient, increasing the surgical risks. The stability of the patient on the surface is a critical safety issue. Therefore, the requirements of the surgical environment constrain the surface technology options. This study was performed to demonstrate the interface pressure characteristics of six operating room surfaces.

METHODS

Subjects consisted of six normal healthy volunteers. Subject demographics are shown in TABLE 1. Subjects ranged from 69 to 435 pounds, and BMI from 18.6 (normal) to 59.0 (extremely obese).

SUBJECT	GENDER	WEIGHT	HEIGHT	BMI (kg/m ²)
1	Female	69 lbs.	51 in.	18.6
2	Female	117 lbs.	63 in.	20.7
3	Male	180 lbs.	68 in.	27.4
4	Female	205 lbs.	66 in.	33.1
5	Male	300 lbs.	73 in.	39.6
6	Male	435 lbs.	72 in.	59.0

Six surfaces (Allen Medical Systems, Acton, MA) were tested as listed in TABLE 2. Surfaces comprised a range of thicknesses from 2 inches to 4¼ inches, with materials ranging from high density foam to a multi-layer construction. Total body in-

terface pressures were determined with an Xsensor Interface Pressure Sensor pad and an Xsensor Interface Mapping System (XSENSOR Technology Corp., Calgary, Alberta, Canada). Subjects laid on the surfaces in random order in both supine and lateral positions for a minimum of two minutes or until the pressure map reached equilibrium.

An overall pressure distribution value was determined as the mean pressure for all sensors recording > 10 mm Hg. Peak pressures were determined over a 1 square inch area of 4 adjoining sensors at either the heel or the sacrum (or trochanter if in lateral positioning). Finally, a high pressure distribution performance index was determined as the amount of a subject's total load supported (TS) at pressures of ≥ 32 mm Hg, calculated from the equation:

$$TS_{P_i} = \frac{(P > P_i - P_i) * (N > P_i) * (0.25 \text{ in.}^2)}{51.715}$$

In this equation:

$P > P_i$ = the mean pressure reading of all sensors on a pressure map reporting pressures greater than P_i (measured in mmHg)

$N > P_i$ = the number of sensors on a pressure map reporting pressures greater than P_i

The first term in the equation produces the average pressure (PSI) of all cells with a reading greater than P_i . The second term in the equation produces the contact area (in.²) that is supported by cells with a reading greater than P_i . That is, the number of sensors on a pressure map reporting pressures greater than P_i ($N > P_i$) multiplied by the area of each sensor (0.25 in.²) on a pressure map. The product of the two terms provides the amount of a given subject load (lbs.) supported at pressures greater than P_i .

RESULTS

The overall pressure distributions as a function of subject weight are shown in FIGURES 2 and 3. The overall pressure distribution data separates into two groupings, the 2" thick Standard and Deluxe surfaces, and the thicker Astrus Elite and Alto surfaces. No significant differences were observed between the Standard and Deluxe surfaces in either the supine or lateral positioning. For all surfaces tested, overall interface pressures increase linearly with increasing weight. Representative interface pressure maps for subjects 1, 3 and 5, showing the range

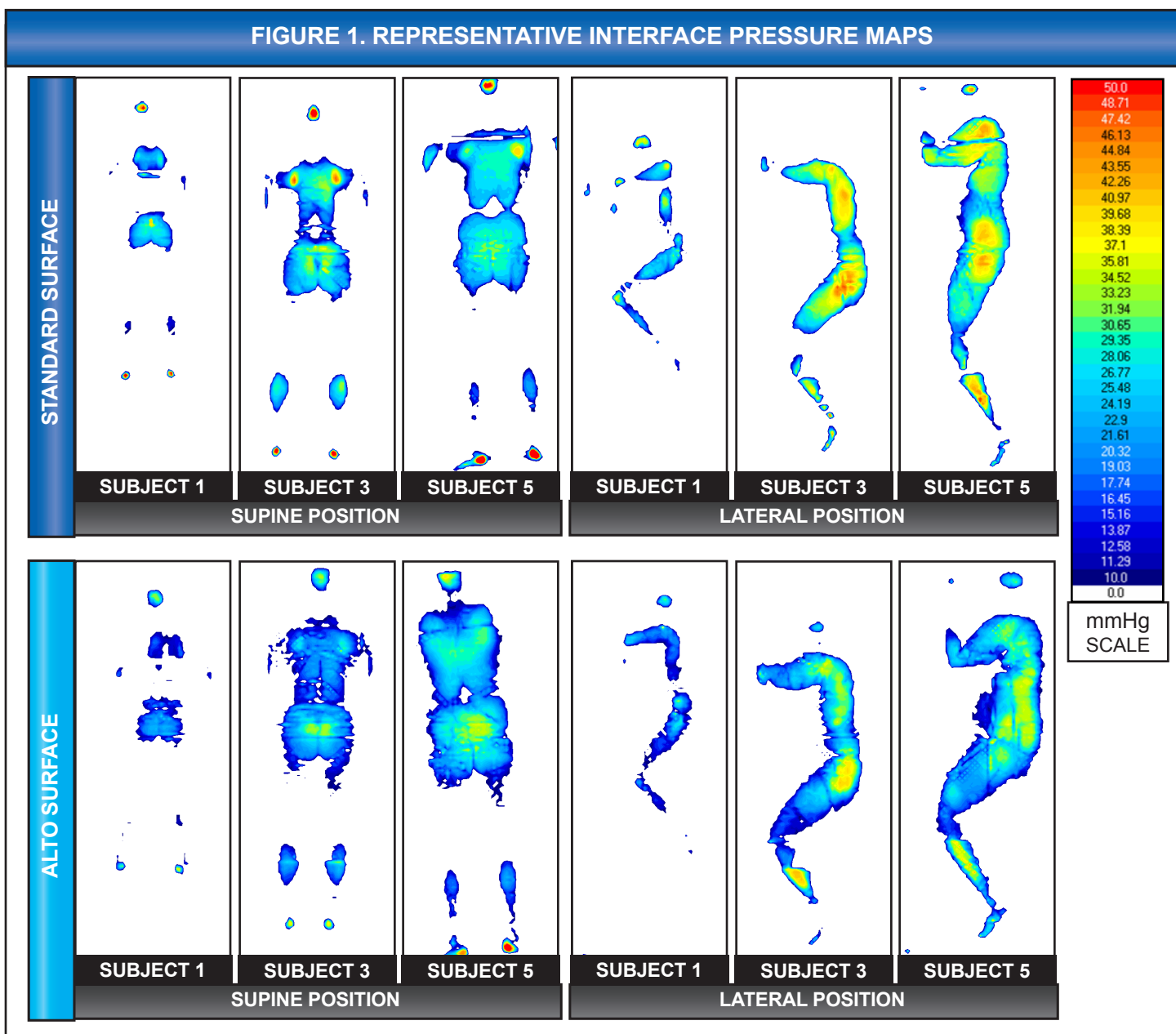
of surface performance are shown in FIGURE 1. The lowest overall pressure distribution was observed with the Alto and Alto-Gel surfaces. These are the thickest of the pads tested, and are the pads with variable densities.

Representative peak pressures are shown by the peak supine heel pressures (TABLE 3). As the subject weight increases the thicker pads show an approximate two fold increase across the range, while the 2” pads show an approximate three fold increase across the range.

The high pressure performance index shows an exponential rise, with the data again falling into two groupings. The Standard and Deluxe pads showed poorer performance as compared to the Astrus and Alto pads, particularly in the supine position (FIGURES 4 and 5).

DISCUSSION

Several variables affect the selection of a pressure redistributing surface for the operating room. The weight of the patient may have a significant effect on the choice of surface. Lighter patients, such as subjects 1 and 2, may not require the thicker, multi-layer surfaces as demonstrated by the low overall pressure distributions (FIGURES 1-3) and the relatively small changes in peak pressures across multiple surfaces (TABLE 3). With respect to overall pressure distribution, surface performance is a function of thickness, with the 2” thick surfaces performing essentially equivalently. Within a given surface, increases in subject weight show linear responses in overall pressure distributions, which should be of predictive value when considering the time period of the intended surgical procedure.



Immersion and envelopment are critical components of pressure redistribution. The deeper the patient sinks into the surface (immersion) and the more the surface conforms or molds to the body contours (envelopment), the greater the pressure redistribution.¹⁷ Though immersion and envelopment were not specifically evaluated in this study, comparison of the top and bottom rows of FIGURE 1 appears to indicate greater immersion and envelopment with the thicker surfaces in that a larger body surface area and more body detail are visible in the pressure maps.

The non-linear increases in high pressure distribution as a function of subject weight, suggests the choice of surface is more critical for heavier patients (FIGURES 4 and 5). Peak pressures for heavier subjects show approximately a two fold difference between different surfaces, equating to a 30-50% pressure reduction (TABLE 3). The thicker surfaces may have a greater capacity for immersion for these patients while multi-layer construction with varying densities may provide greater capacity for envelopment resulting in improved pressure redistribution for these patients.

SUMMARY

Operating room pad performance is affected by several variables, which can be extrinsic, such as the subject's weight, or intrinsic compositional variables. In this study, pad performance is shown to be affected by thickness, variable density, ticking material, patient weight and positioning. The peak heel pressure in the heavier subjects generally showed a 30-50% reduction on the thicker, multi-layered surfaces. Within a given surface, increases in subject weight show linear responses in overall pressure distributions, which should be of predictive value when considering the time period of the intended surgical procedure. The non-linear increases in high pressure distribution as a function of subject weight, suggests the choice of surface is more critical for heavier patients, who show approximately a two fold difference between different surfaces. For these patients the thicker surfaces may have greater capacity for immersion and envelopment, thereby resulting in improved pressure redistribution.

ACKNOWLEDGEMENTS

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Competing Interests: Samantha Baron is an employee of Allen Medical Systems. Wendy Crain, Rachel Hornbach, and Gordon MacFarlane are employees of Hill-Rom Inc.

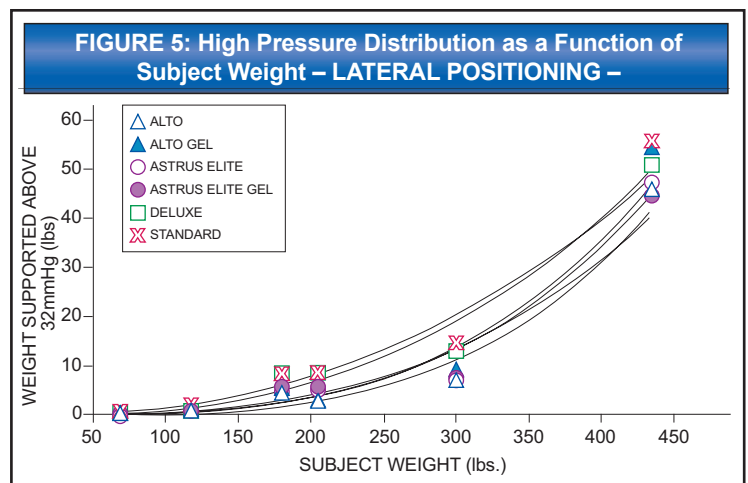
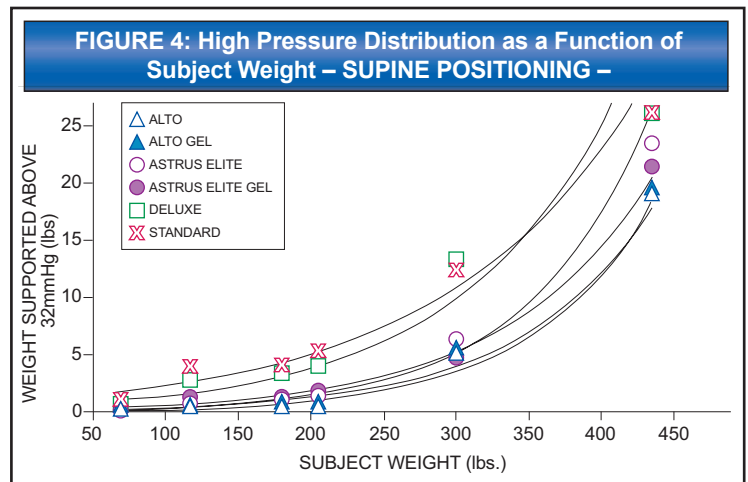
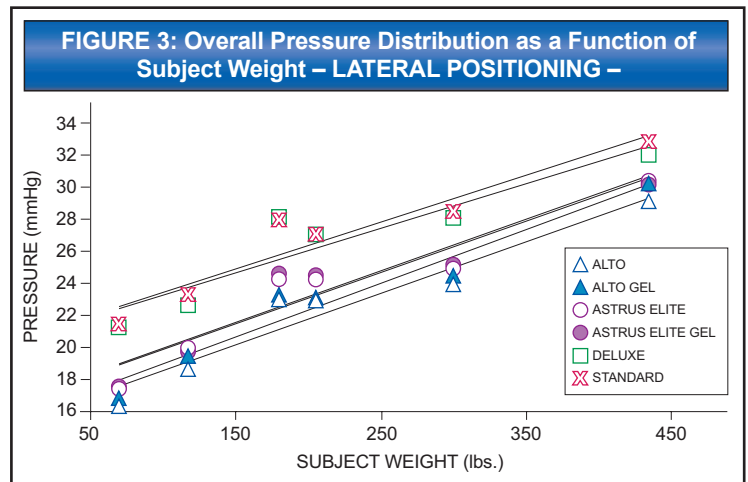
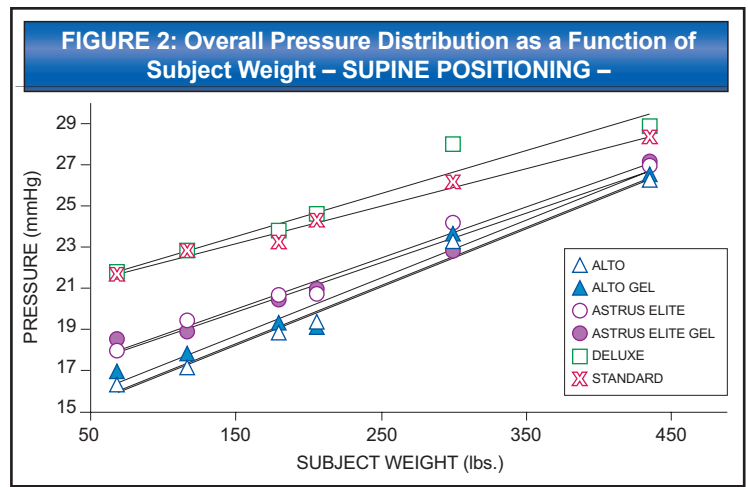


TABLE 2: CHARACTERISTICS OF TESTED SURFACES

SURFACE VARIABLE		STD.	DELUXE	ASTRUS	ASTRUS GEL	ALTO	ALTO GEL
THICKNESS		2"	2"	3"	3.25"	4"	4.25"
TICKING	Vinyl Ticking	●					
	4-Way Stretch Urethane		●	●	●	●	●
LAYERS	Visco Elastic			●	●	●	●
	Medium Density Foam			●	●	●	●
	High Density Foam	●		●	●	●	●
	Diaphragm			●	●	●	●
	Gel				●		●
CONSTRUCTION	Solid	●	●	●	●		
	Varied Density					●	●

TABLE 3: PEAK SUPINE HEEL PRESSURES (mm Hg)

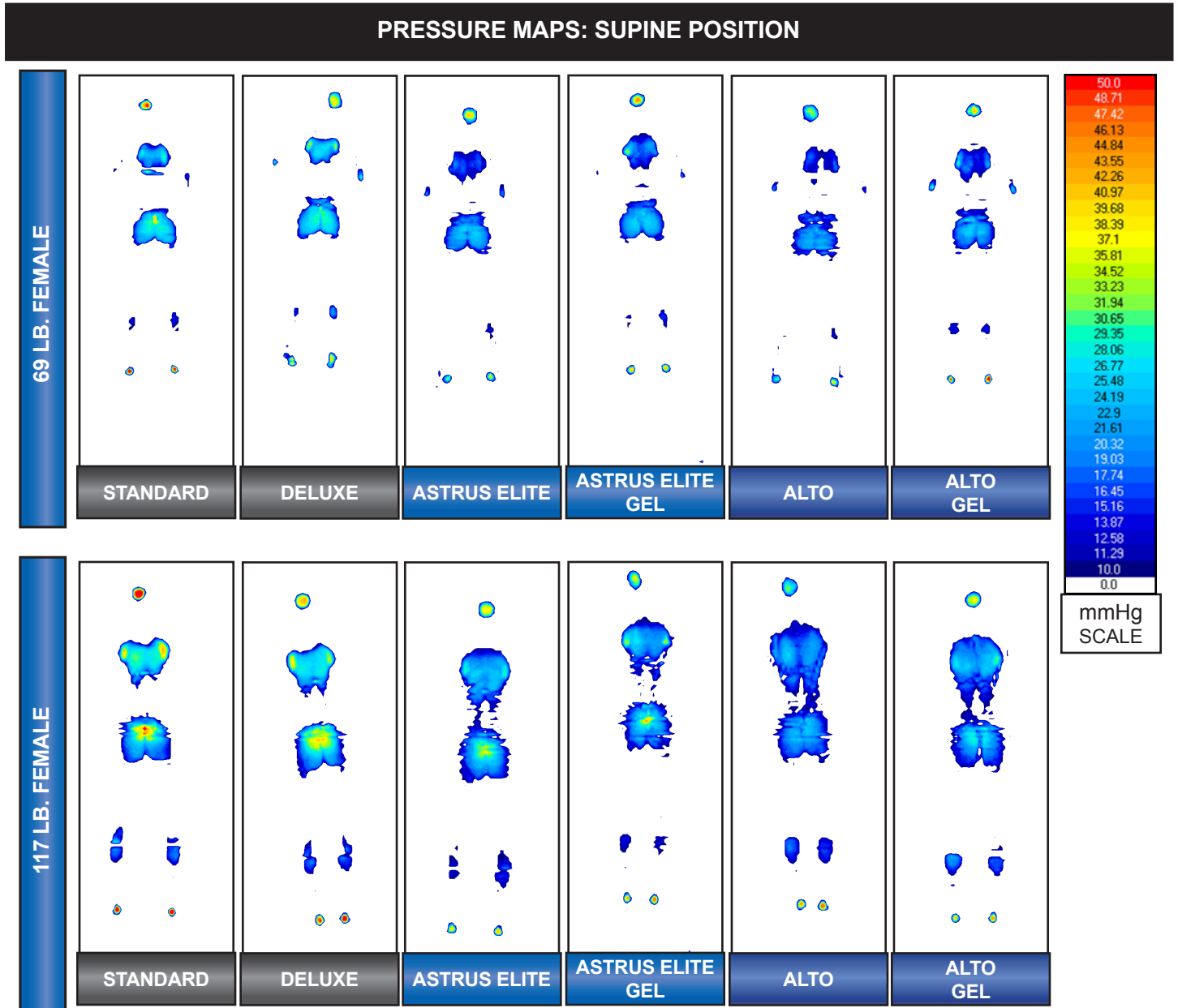
SURFACE	SUBJECT #1	SUBJECT #2	SUBJECT #3	SUBJECT #4	SUBJECT #5	SUBJECT #6
Standard	44.7	53.7	62.6	110.0	130.8	88.6
Deluxe	42.1	51.1	48.2	72.1	92.7	77.5
Astrus Elite	37.9	44.6	42.7	64.7	69.0	85.1
Astrus Elite Gel	32.2	40.0	44.1	54.9	81.6	56.4
Alto	40.4	41.1	40.7	47.8	74.2	50.1
Alto Gel	37.6	42.3	40.5	45.2	72.4	56.7

APPENDIX

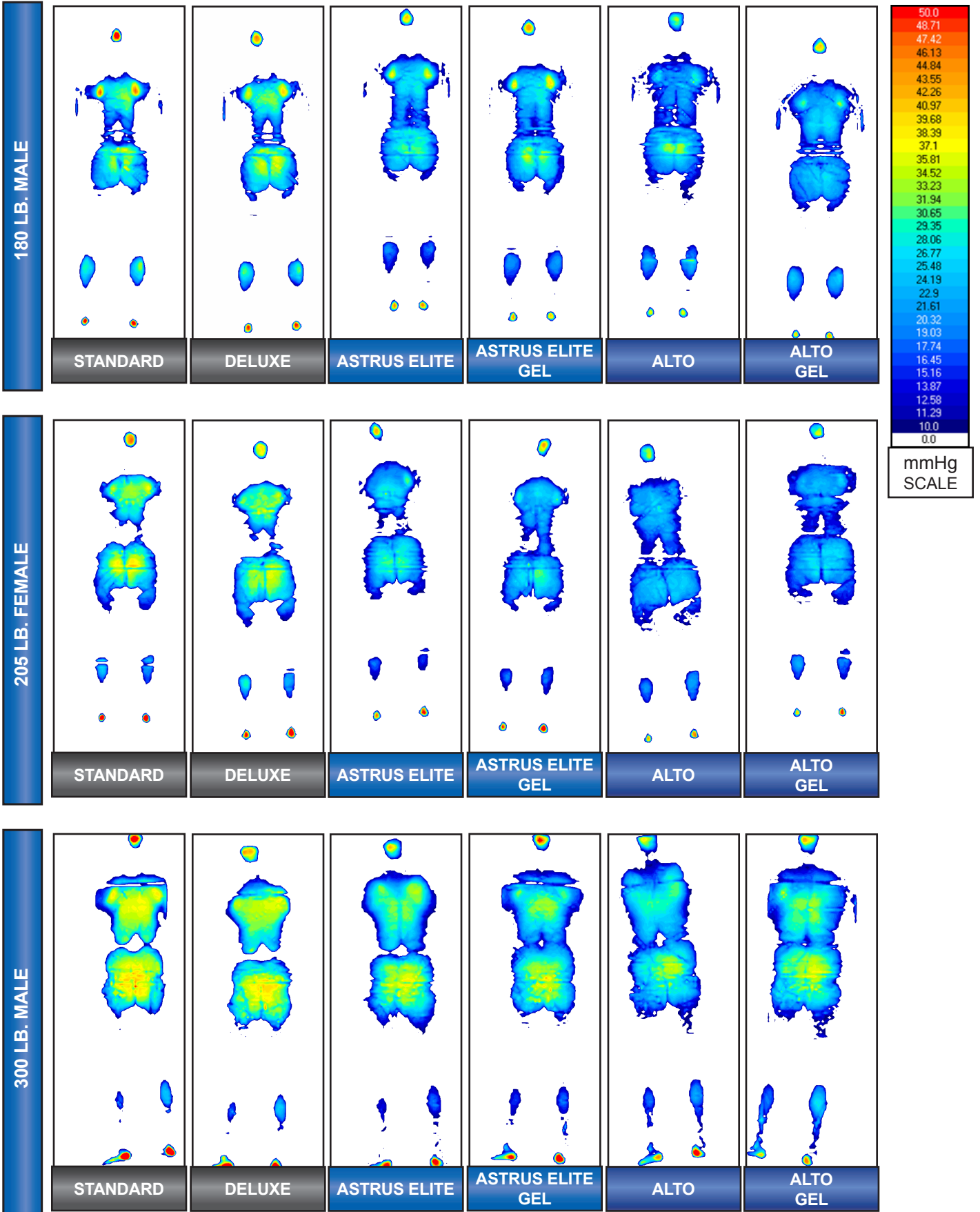
Below you will find pressure maps for all six test subjects in both the supine and lateral positions. Each pressure map displayed is only one of a possible six of its kind that could have been displayed. Care was taken to ensure that the image displayed is representative of a typical pressure map of the situation, somewhere between the extremes.

The interface pressure maps included in this report are specific to this study and should not be compared to interface pressure maps outside the scope of this study.

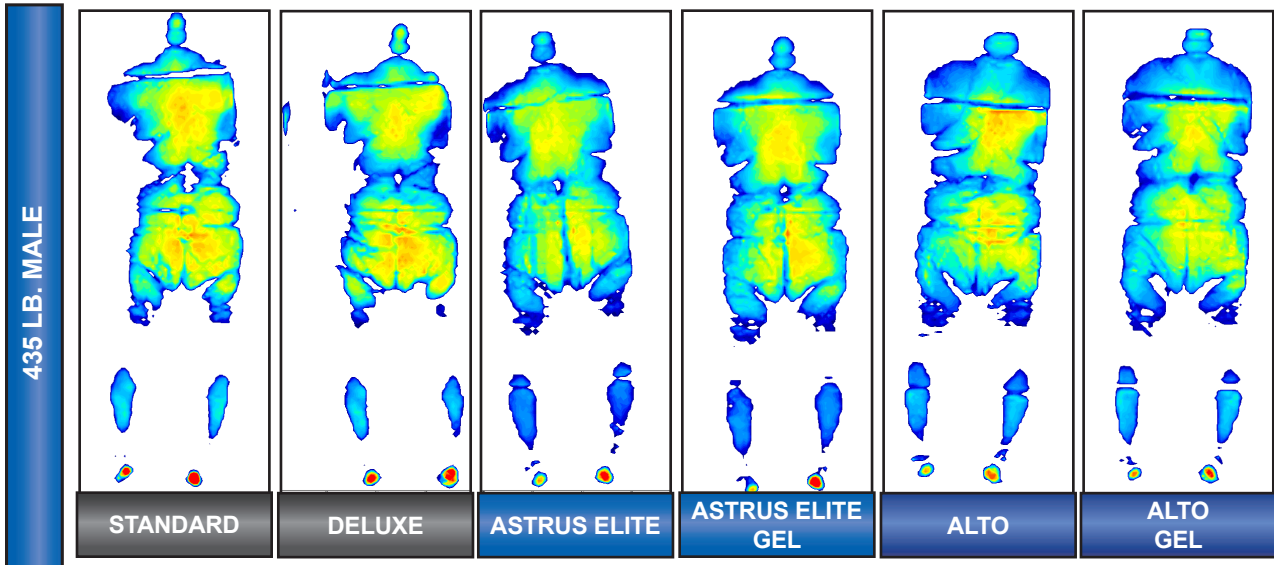
The maximum value on the legend bar is set at 50mmHg for all conditions.



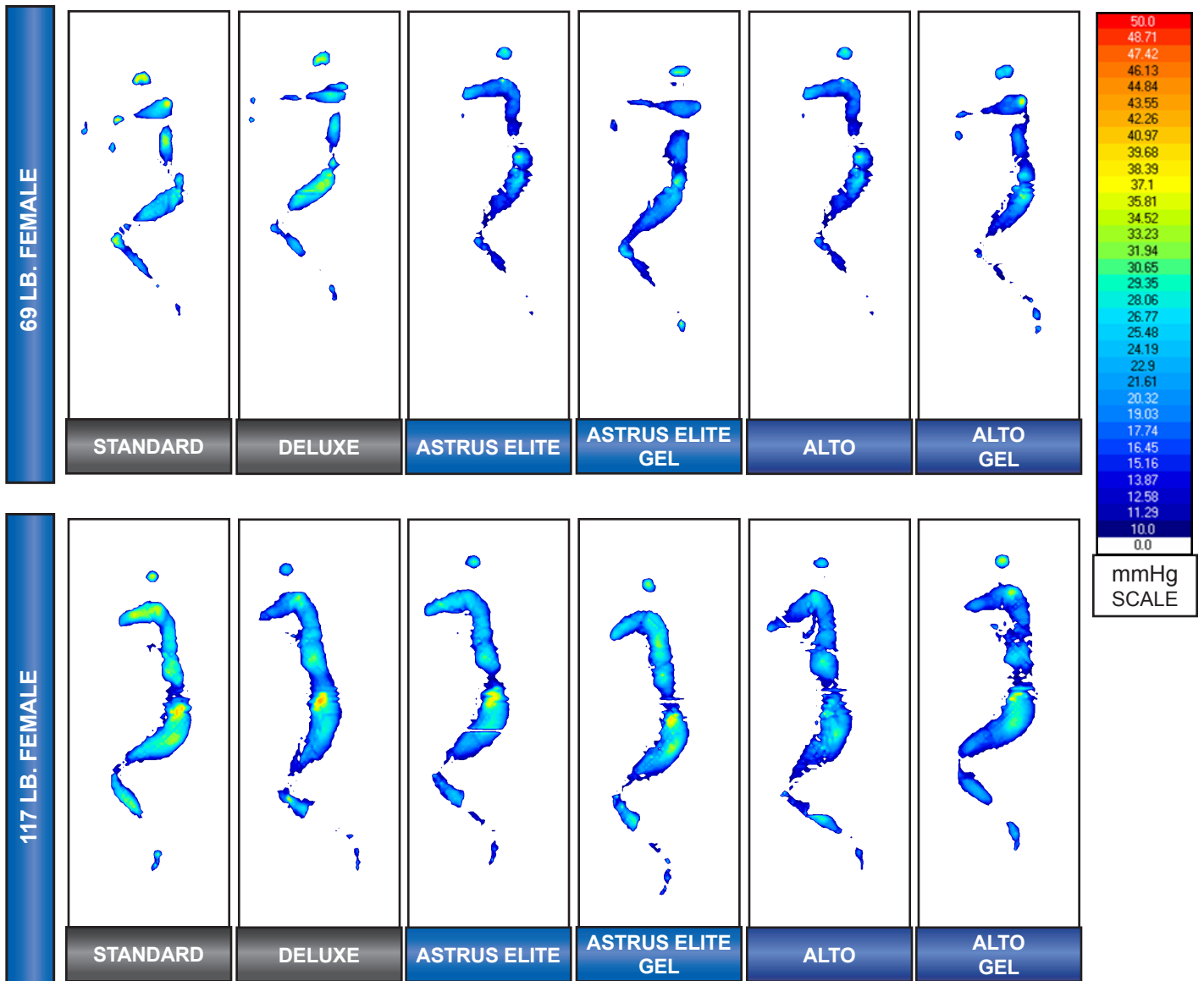
PRESSURE MAPS: SUPINE POSITION (CONTINUED)



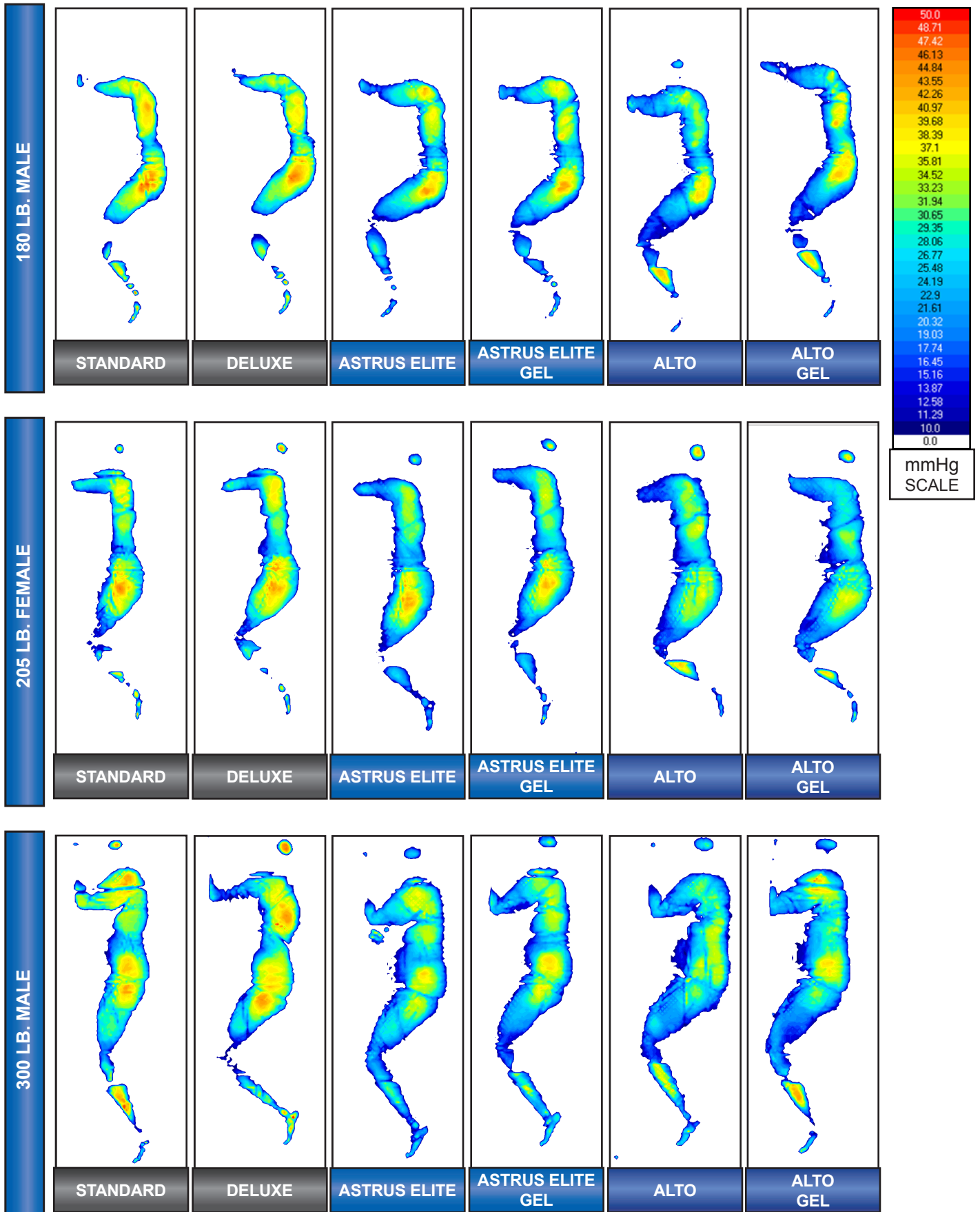
PRESSURE MAPS: SUPINE POSITION (CONTINUED)



PRESSURE MAPS: LATERAL POSITION

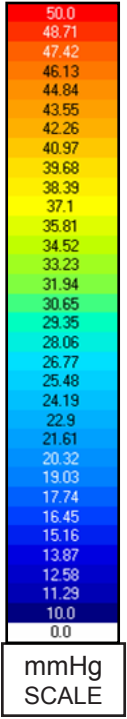
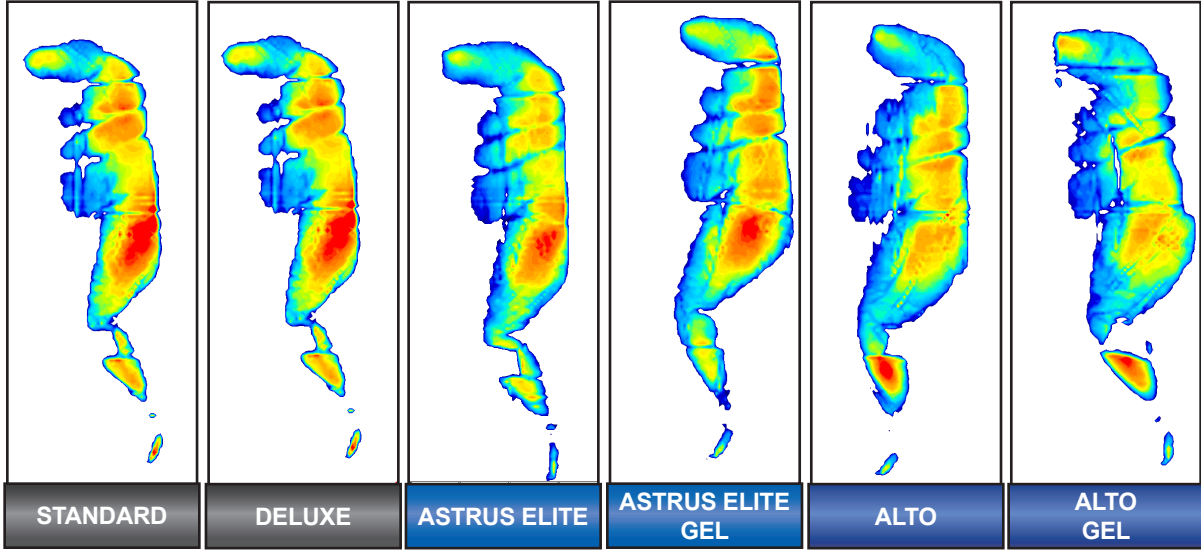


PRESSURE MAPS: LATERAL POSITION (CONTINUED)



PRESSURE MAPS: LATERAL POSITION (CONTINUED)

435 LB. MALE



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