LINET

MAXIMIZING PRESSURE RELIEF WITH ZERO PRESSURE ENABLED BY THE VIRTUOSO

BACKGROUND

Patients at health care facilities depend on nursing care, and some, due to their illness and age, can become highly dependent, which places them at risk for pressure injuries. Patients in ICU settings often develop pressure injuries in areas such as thesacrum and heels due to prolonged periods in one position, insufficient or unavailability of repositioning, and their health conditions. In Australia, 10.8% of ICU patients developed a pressure injury 36 hours after admission (Latimer S, 2019). The overall prevalence of pressure injuries in ICU is 26.6%, and those ICU-acquired reach 16.2% (Labeau SO, et al. 2021). The most affected areas were the sacrum (37%) and heels (19.5%) (Labeau SO, et al. 2021).

In acute care, the prevalence of hospital-acquired pressure injuries fluctuates between 6 to 18.5% worldwide (Tervo-Heikkinen TA, 2022). Patients in these departments might be slightly more mobile, but still limited by illness or recovery needs. Maintaining regular repositioning schedules is essential but often challenging due to staffing constraints. Observational studies reveal that patients who make small, frequent shifts in position have notably lower rates of pressure injuries. However, for many in acute care, restricted movement due to post-surgical recovery or acute illness makes it difficult to perform such shifts independently, emphasizing the need for staff-assisted repositioning, and the use of specialized pressure-relieving mattresses and support surfaces (Chaboyer W, 2013).

This white paper explores the capabilities of the Virtuoso system, which provides pressure air alternating mattresses for ICU and acute care settings. It demonstrates the effectiveness of Zero pressure – achieved through complete cell deflation – using pressure maps and their analysis.

CONCLUSION

The Zero Pressure feature, combined with a 3-cell alternating design, offers great pressure relief. Pressure mapping has allowed for the visualization of how the mattress alternates throughout all three phases of its cycle.

In the analysis of pressure maps, we focused on high-risk areas such as the scapula, sacrum, and heels, examining how pressure was relieved in these areas when the cells deflated. In the supine position, the average pressure was reduced by 34.7%; in the 30° Semi-Fowler position, by 46%; and with the elevated thigh rest, by 43.9%. Overall, the average pressure reduction across all positions was 41.5%, demonstrating effective pressure relief over sensitive areas. This is further supported by a smaller contact area when a cell deflates, which was reduced by 46.4%.

This white paper provides evidence of the effectiveness of 3-cell alternation for pressure relief. From the perspective of patient physiological processes, Evans's study, which investigated how pressure relief impacts blood return to offloaded tissue, demonstrated that the Virtuoso's 3-cell design with Zero Pressure and a 7.5-minute cycle promotes circulation and tissue oxygenation (Evans Z, 2024).

In conclusion, patients benefit from the effective pressure relief provided by the Virtuoso design. However, it is essential to remember that this does not eliminate the need for patient repositioning. From pressure maps it is visible, that it is not possible to remove pressure entirely, and for some patients, even low-pressure levels may be harmful if sustained for prolonged periods.

How pressure air alternating mattresses reduce pressure injury development

Choosing the best support surface for a patient can be challenging. Understanding the different designs of support surfaces requires proper training and a clear hospital strategy for preventing pressure injuries. From the perspective of a specialist, guidance can be found in the EPUAP Clinical Practice Guideline 2019, which recommends selecting support surfaces based on the following five factors: (EPUAP/NPIAP/PPPIA, 2019):

1. Level of immobility and inactivity,
2. Need to manage microclimate and reduce shear,
3. Patient size and weight,
4. Number, severity, and location of existing pressure injuries (PIs),
5. Risk of developing new pressure injuries.

Skin can tolerate high pressure for short periods or low pressure for extended periods.

(Linder-Ganz E, 2006)

These factors help determine whether a foam or pressure air mattress can meet a specific patient's needs. However, it is not always clear – and there is no consensus – on the ideal design of a pressure air mattress. It is useful to consider how PIs develop and how support surfaces can reduce this process.

From the basics, what are pressure injuries? Pressure injuries occur due to prolonged pressure on the skin and underlying tissues, particularly over bony areas. The amount of pressure tissues can tolerate over time depends on the individual's susceptibility and tolerance, as well as the intensity and duration of the pressure (EPUAP/NPIAP/PPPIA, 2019). Skin can tolerate high pressure for short periods or low pressure for extended periods (Linder-Ganz E, 2006). Although the threshold for PI development varies according to each individual's susceptibility and tolerance, which cannot be influenced by support surfaces, the intensity and duration of pressure can be managed through the support surface's design.

HOW ALTERNATING SUPPORT SURFACES INFLUENCE THE AMOUNT AND DURATION OF PRESSURE

The amount of pressure applied to a patient's body is affected by the type of support surface, but patient posture must also be taken into consideration. The duration of pressure results from prolonged immobility. From a design perspective, only alternating support surfaces can address both the amount and duration of pressure.

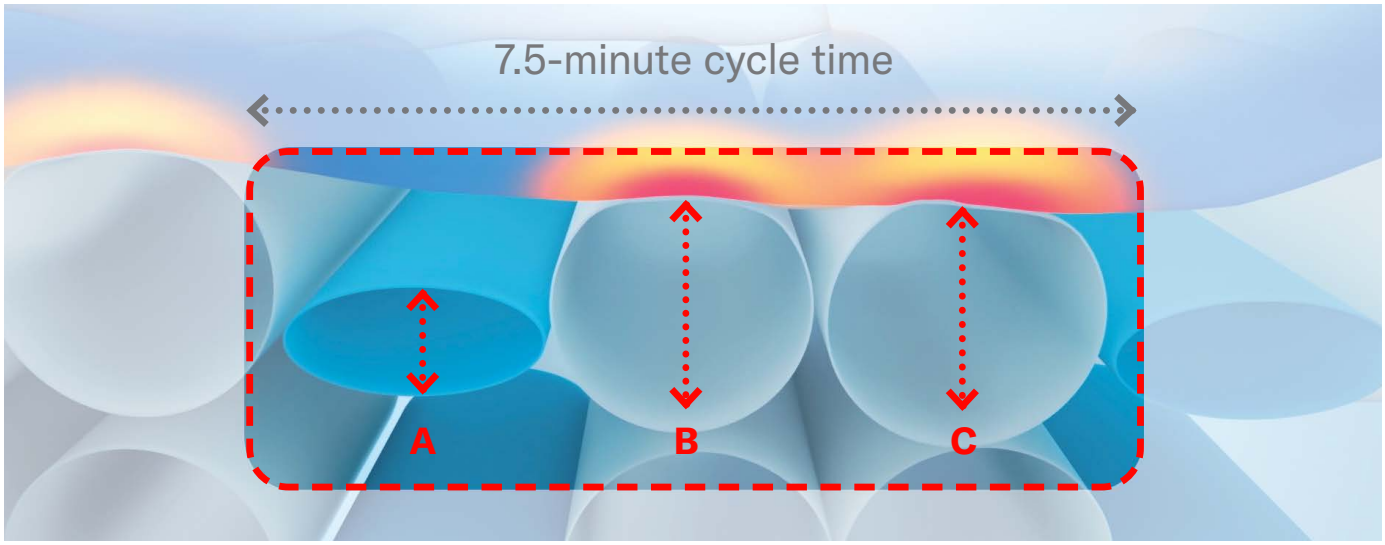
Alternating pressure air mattresses periodically offload bony prominences, which mimics natural small body movements. The reduced pressure on the patient's body caused by a deflated cell is known as 'pressure relief'. The amount of pressure can be also influenced by setting the internal pressure inside the mattress, which is not possible with foam mattresses. The pressure needs to be set according to patient weight, to provide pressure redistribution on inflated cells without the risk of bottoming out. The duration of the pressure is controlled by the alternating cycle, which is described as the time it takes to inflate and deflate all cells.

Posture affects the amount of pressure, because of the increase in load on bony prominences. Sitting, side-lying, and prone positions can increase pressure on areas vulnerable to PI development. For example, a sitting posture raises pressure under the ischial tuberosities and sacral areas, making these regions particularly susceptible to injury (Efteli, 2023). Frequent, minor position changes significantly lower injury risk, as demonstrated in a study where patients shifting hourly showed a marked decrease in injury occurrence (Efteli, 2023). Also, the sitting position substantially increases lthe load on the mattress over a small area, and consequently raises the risk of 'bottoming out' on pressure air, where surface deformation goes beyond critical immersion and effective pressure redistribution is lost.

The LINET solution of Zero Pressure with the Virtuoso

Linet's Virtuoso range of overlays and mattresses uses a unique 3-cell alternating design. This configuration allows complete deflation of a cell, while the remaining inflated cells support the patient's body, preventing bottoming out. This full deflation is called Zero Pressure, which maximizes pressure relief under the patient's body. During the alternating cycle, 66% of the body is always supported, while 33% is relieved from pressure. By the end of each cycle, all body areas are offloaded.

Another key feature behind the Virtuoso's success is the 7.5-minute alternating cycle. This concept dates back to 1961, when a study conducted by Exton-Smith demonstrated that frequent pressure relief allows blood circulation to return to ischemic tissues, thus preventing pressure injuries. In the study it was observed that none of the patients who moved more than 51 times during the night (from 11 pm to 6 am) developed tissue damage (EXTON-SMITH AN, 1961). Based on these findings, the Virtuoso is equipped with a 7.5-minute cycle, equivalent to 56 movements during the night.

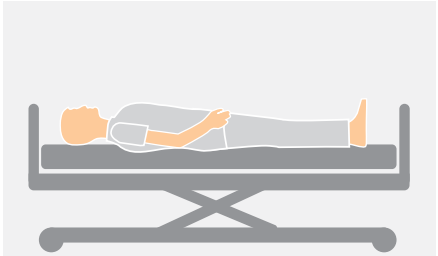


None of the patients who moved more than 51 times during the night developed tissue damage.

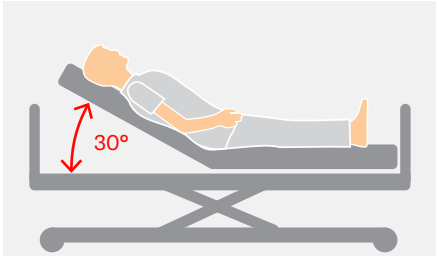
(EXTON-SMITH AN, 1961)

Pressure mapping demonstrates pressure relief with Zero Pressure

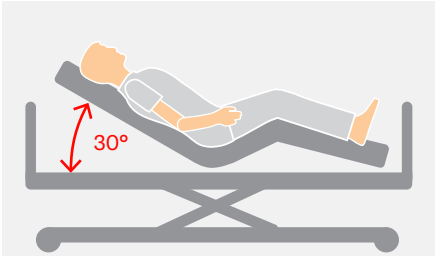
To validate the Virtuoso's Zero Pressure relief, pressure mapping was conducted with an XSensor Pro high-resolution pad. The Virtuoso 200 mattress was placed on LINET's Essenza 300 bed, with two volunteers: a 50 kg female and an 89 kg male. Pressure mapping was performed with the volunteers in three positions: Supine, 30° Semi-Fowler and 30° Semi-Fowler with thigh rest. During testing, the compressor was set to the 7.5-minute alternating cycle, and the mattress pressure was adjusted to match each volunteer's weight (Level 1 for the 50 kg volunteer, Level 3 for the 89 kg volunteer). In the 30° Semi-Fowler position, the Fowler Boost feature automatically increased mattress pressure to prevent bottoming out.



SUPINE POSITION



30° Semi-Fowler position

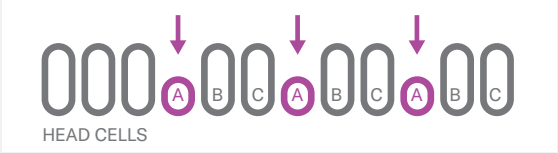


30° Semi-Fowler position with thigh rest

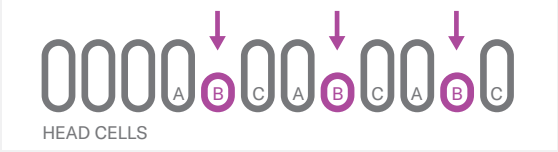
The average pressure and contact area were analyzed in three cells located under the scapula, sacrum, and heels. Measurements were taken across all phases of the alternation (Phases A, B, and C). The reduced pressure and smaller contact area in the deflated cell phase demonstrate the effectiveness of Zero Pressure across different patient positions.

3-CELL ALTERNATING CYCLE

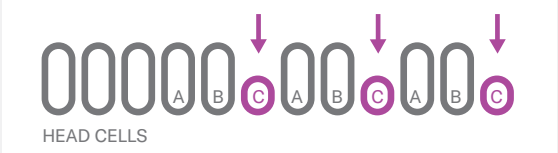
PHASE "A"



PHASE "B"



PHASE "C"

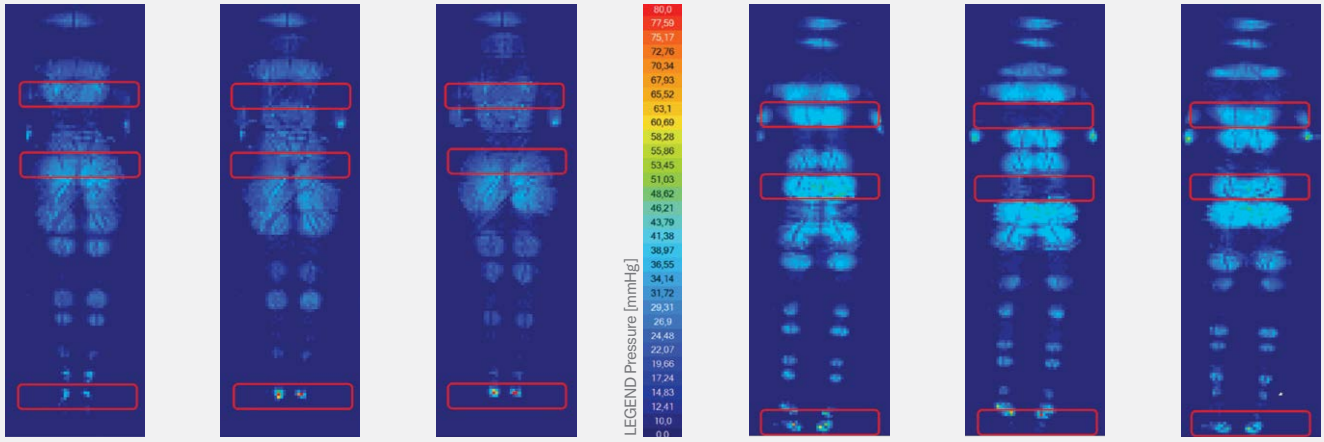


In 3-cell alternating mattresses, there are three phases. During the first third of the cycle, cell A is deflated while cells B and C are inflated (Phase A). In the second third of the cycle, cell B is deflated while cells A and C are inflated (Phase B). In the last third of the cycle, cell C is deflated while cells A and B are inflated (Phase C).

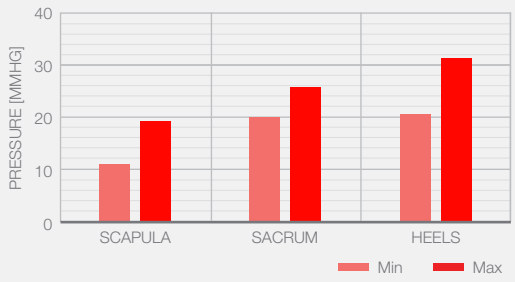
Note: The head cell remains inflated by default. On the Virtuoso 300 and PRO versions, head cells can be deflated or set to alternate according to patient needs.

RESULTS OF PRESSURE MAPPING IN SUPINE POSITION

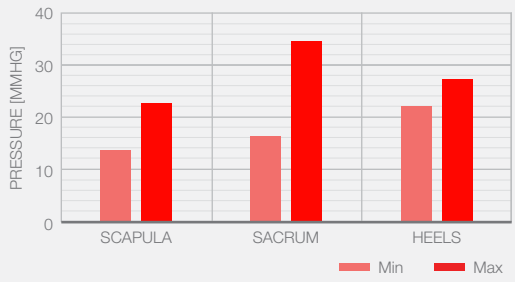
50 KG VOLUNTEER | **89 KG VOLUNTEER**



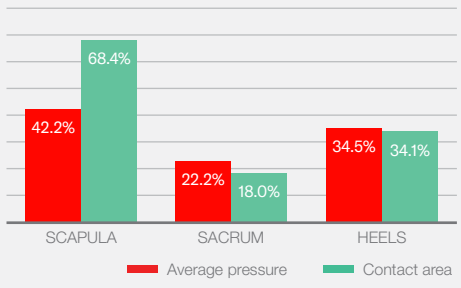
GRAPH 1 | Minimum and maximum of average pressure between phases



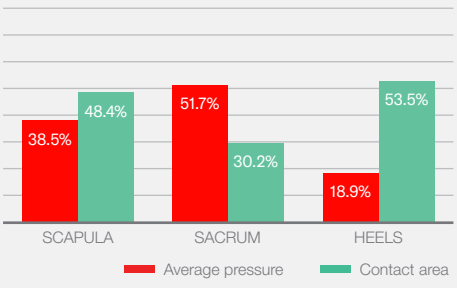
GRAPH 2 | Minimum and maximum of average pressure between phases



GRAPH 3 | Reduction of average pressure and contact area between phases



GRAPH 4 | Reduction of average pressure and contact area between phases

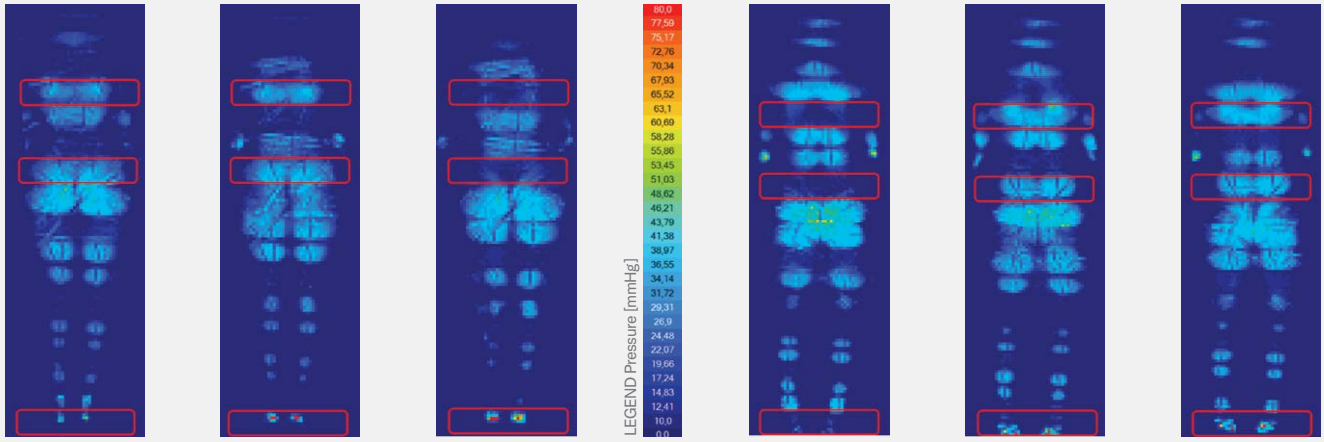


Summary

In the supine position, both volunteers experienced pressure relief at the scapula, sacrum, and heels. The 50 kg volunteer had higher maximum pressure at the heels, while the 89 kg volunteer's maximum pressure was at the sacrum. When cells deflated, the 50 kg volunteer had an average reduction of 33% in pressure and 40.2% in contact area, while the 89 kg volunteer experienced an average reduction of 36.4% in pressure and 44.2% in contact area.

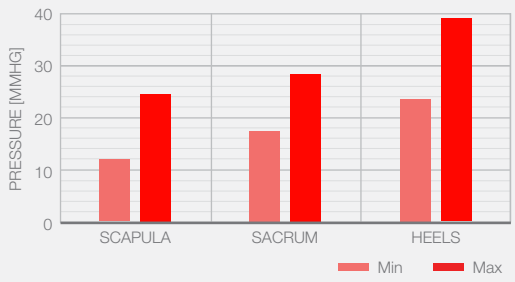
RESULTS OF PRESSURE MAPPING IN 30° SEMI-FOWLER POSITION

50 KG VOLUNTEER | **89 KG VOLUNTEER**

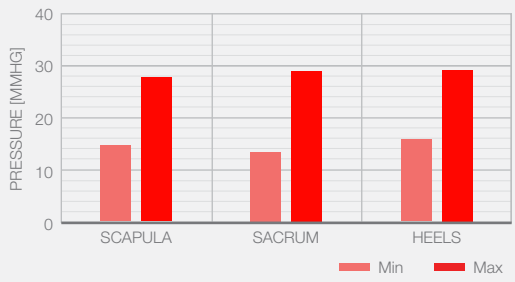


A phase | B phase | C phase | A phase | B phase | C phase

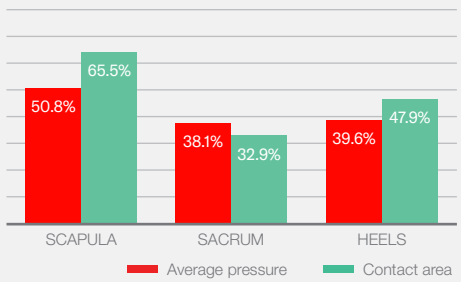
GRAPH 5 | Minimum and maximum of average pressure between phases



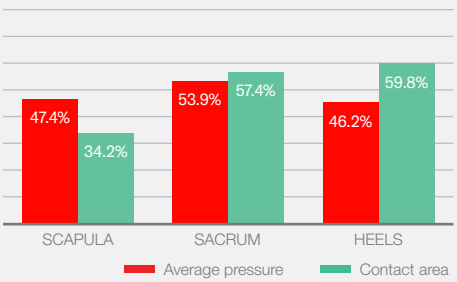
GRAPH 6 | Minimum and maximum of average pressure between phases



GRAPH 7 | Reduction of average pressure and contact area between phases



GRAPH 8 | Reduction of average pressure and contact area between phases



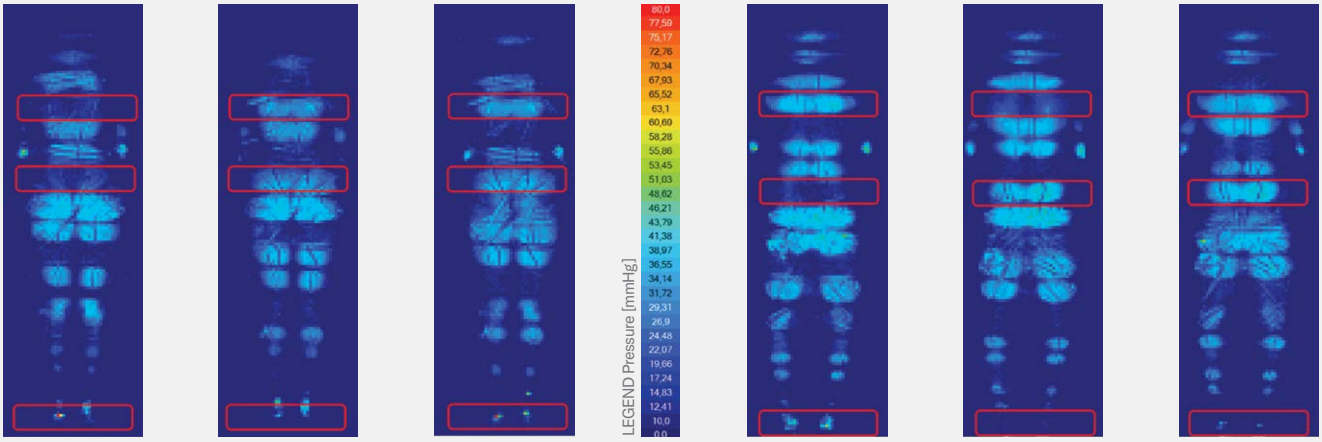
Summary

In the 30° Fowler position, an increase in pressure at the sacrum is evident compared to the supine position due to the shift in the volunteer's weight, which is especially noticeable in the buttock area on the pressure maps. However, this increased sacral pressure was observed only in the 50 kg volunteer.

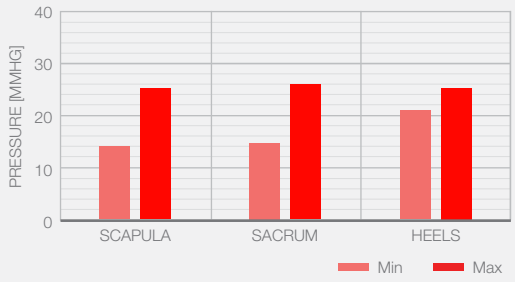
When cells deflated, the 50 kg volunteer experienced an average pressure reduction of 42.8% and a contact area reduction of 48.7%, while the 89 kg volunteer saw reductions of 49.2% in pressure and 50.4% in contact area. The increased pressure reduction is likely influenced by the Fowler boost feature, which raises internal mattress pressure to prevent bottoming out.

RESULTS OF PRESSURE MAPPING IN 30° SEMI-FOWLER POSITION WITH THIGH REST

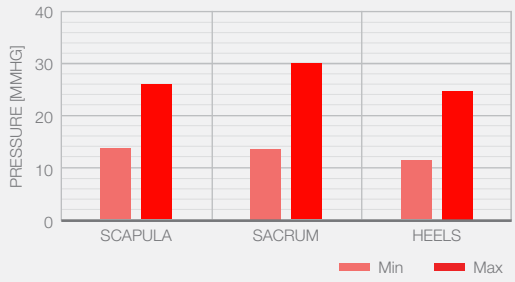
50 KG VOLUNTEER | **89 KG VOLUNTEER**



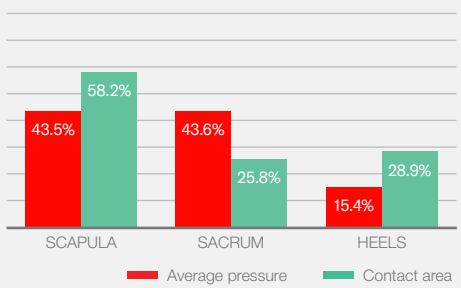
GRAPH 9 | Minimum and maximum of average pressure between phases



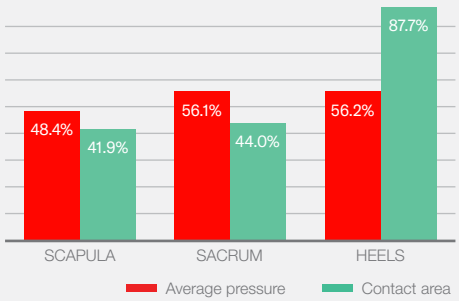
GRAPH 10 | Minimum and maximum of average pressure between phases



GRAPH 11 | Reduction of average pressure and contact area between phases



GRAPH 12 | Reduction of average pressure and contact area between phases



Summary

In this measurement, the backrest remained elevated to 30° as in the previous measurement, but the thigh rest was elevated to the maximum angle of approximately 22°. This position allowed for improved pressure redistribution, as shown by a decrease in average pressure across the analysed cells. The main effect of the elevated thigh rest was observed at the heels, where pressure was redistributed to the calf area.

Due to lower pressure values, the 50 kg volunteer experienced a reduced average pressure and contact area reduction – 34.2% and 37.6%, respectively. The 89 kg volunteer, however, achieved better results, with reductions exceeding 50% in both measures: specifically, a 53.6% reduction in pressure and a 57.9% reduction in contact area.

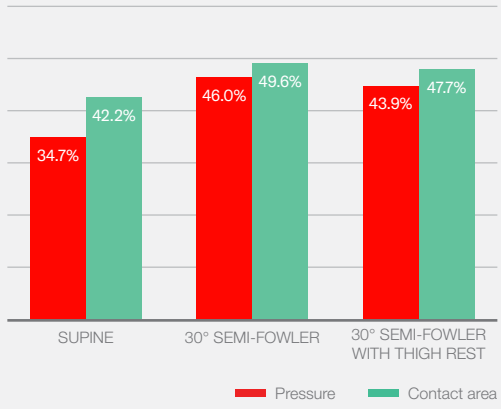
DISCUSSION OF PRESSURE MAPPING RESULTS FOR THE VIRTUOSO

The measurements clearly show a reduction in both pressure and contact area across all patient positions. The Virtuoso demonstrates an average pressure reduction of 41.5% and a contact area reduction of 46.4% when the cells are deflated, for both patients in supine and Semi-Fowler positions. These results, shown in Graph 13 for each position, indicate the effectiveness of the alternating cycle in significantly offloading pressure and contact area. This helps to relieve pressure on the body, promoting circulation and oxygenation of tissue, as supported by Evans's study (Evans Z, 2024).

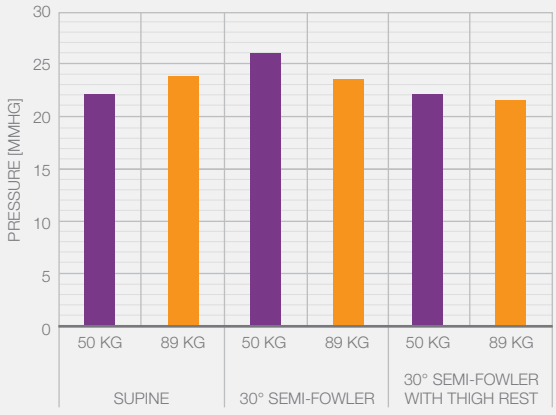
Graph 14 displays the pressure values for both volunteers in all positions, providing further insight into the impact of posture on pressure distribution.

The highest pressure was observed in the 30° Semi-Fowler position, where the load shifts to the pelvis, particularly for the 50 kg volunteer. However, when the thigh rest was elevated, pressure redistribution improved significantly, as seen in the lowest average pressure values for both volunteers.

GRAPH 13 | Overall reduction of average pressure and contact area for all volunteers in scapula, sacrum and heels



GRAPH 14 | Average pressure for both volunteers in scapula, sacrum and heels during phases



The Virtuoso demonstrates an average pressure reduction of 41.5% and a contact area reduction of 46.4%, when the cells are deflated.

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