White Paper

Hybrid pressure relieving support surfaces and clinical appropriateness – a comparative analysis

pressure care and patient handling specialists

Novis Healthcare is a specialist in the supply of pressure care and manual transfer equipment solutions designed to help prevent pressure wound and skin integrity issues caused by limited mobility and disability. We support a specialised range of clinical healthcare products designed for hospitals, aged care facilities, rehabilitation providers and the home care community.

After 15 years focused on pressure injury prevention and treatment through research, design and innovation, Novis believes that the majority of pressure injuries are preventable. Through product innovation, professional collaboration and clinical excellence, Novis is committed to delivering successful patient outcomes to achieve this goal.

Introduction

Pressure injuries (PI) remain one of the most significant, preventable adverse events within the Australian healthcare system, resulting in substantial financial and social costs[1].

In an attempt to address this situation, The Australian Commission on Safety and Quality in Healthcare published ten standards to provide a consistent and uniform set of measures of safety and quality for application nationally across a wide variety of health care services, of which 'Preventing and Managing Pressure Injuries' is one[2] .

Best practice management plans, including access to appropriate equipment are deemed necessary to implement effective prevention strategies.

Background

According to the National Pressure Ulcer Advisory Panel[3], the plethora of support surfaces available on international healthcare market can be broadly classified under two main categories; namely reactive support surface and active support surface.

A **reactive support surface** is also known as a **static support surface**, which is defined as "A powered or non-powered support surface with the capability to change its load distribution properties only in response to applied load[3]"

Examples of reactive support surfaces include mattresses comprising of foam (single layer or multi layer), air or gel filled, air-fluidised, low air loss or constant low pressure mattresses. These surfaces work by reducing the applied pressure by maximising the contact area[4] due to increased 'immersion'. The greater the area of immersion, the more the load is distributed, therefore resulting in decreased pressure on the more vulnerable sections of the body such as the heels and sacral area.

An **active support surface**, also known as a **dynamic support surface**, is "A powered support surface, with the capability to change its load distribution properties, with or without applied load[3]"

Unlike the reactive support surface, active support surfaces proactively remove the contact interface pressure between the body and the support surface. This process is referred to as 'off-loading', and is achieved by the use of air cells that are cyclically inflated and deflated by an external power source, such as an electronically controlled air pump. A well designed active support surface results in a rapid drop in interface pressure to stimulate reactive hyperaemia, mimicking natural body movement [4].

A typical example of these support surfaces are **alternating pressure mattresses**.

Over the past decade a new class of support surface has emerged, claiming to deliver the benefits of both an active and reactive support surface and therefore offering a simpler choice of support surface selection[5] .

There are several names for this type of product but they are commonly known as a '**Hybrid Support Surface**' or a '**foam-and-air combination surface**', comprising of a combination of air cells and static foam layers.

There is a lack of clarity however, as to the scientific benefit of these support surfaces; and how they compare to other reactive support surfaces, patient suitability and which clinical setting is most appropriate for use.

Objective

As it is well accepted that support surfaces should be chosen on an individual patient basis, depending on the specific needs of pressure redistribution, therapeutic function and desired clinical outcomes[6], the aim of this study is to examine the effectiveness of various support surfaces (**reactive** and **active**) according to their immersion and pressure redistribution performance, whilst evaluating and comparing the performance of several foam-air combination '**hybrid**' support surfaces to establish if they offer any benefits compared to conventional reactive and active (alternating air) surfaces.

For the purpose of this research, three brands of '**hybrid**' surfaces were selected. While each product features a combination of polyurethane foam layers and air cells, each mattress is significantly different in design and construction.

Brand A - Swedish manufacturer

This support surface has eight alternating air cells which are encased in foam, topped with a thin layer of high resilience foam closest to the patient. The patient's body is constantly in contact with the top layer of foam, regardless of the air cells inflating and deflating over a 10 minute cycle. Brand A claims to be able to treat up to a Grade 4 pressure injury for patients weighing up to 180 kilograms.

Brand B – British manufacturer

This support surface consists of a foam head cell and 14 transverse alternating air cells, each containing a rectangular foam core to provide support when the air cells are deflated. It is claimed that intermittent off-loading of pressure can be achieved when the pump is put in alternation mode. Brand B claims to be suitable for patients at 'very high risk' of pressure injury, with a maximum user weight of 254 kilograms.

Brand C – Australian manufacturer

This foam-air combination support surface is designed to function as a reactive surface. The 8 transverse alternating air cells are covered by high-resilient foam and a convoluted visco-elastic memory foam top layer to assist in achieving greater immersion. Brand C claims to be suitable for patients 'at risk' of pressure injury that can adequately reposition themselves, with a maximum user weight of 230 kilograms.

Methodology

Equipment used

A full body XSENSOR™ mat was used to conduct pressure mapping and evaluate the performance of each mattress, both in terms of immersion and pressure off-loading. All interface pressure measurements were taken using the XSENSOR X3™ from the XSENSOR Technology Corporation.

The XSENSOR X3™ is composed of a single bed sized pressure mapping mat with a grid of 160x64 individual pressure sensors. Pressure range was 0-60mmHg and interface pressure maps were saved at intervals of 0.5 seconds.

All mattresses were set up according to the manufacturer's instructions on a standard hospital bed frame and sleeping platform. The mattresses were placed directly onto the bed base with the XSENSOR X3™ mat placed directly on top of each mattress. The system was left to operate for a minimum of one cycle (10-12 minutes, as specified by the manufacturer) at maximum pressure before commencement of testing for 1 hour.

Control

A control support surface was used as a point of reference to assess the variable features of each mattress, whilst assessing a base level of immersion (Test 1) and variance of pressure (Test 2).

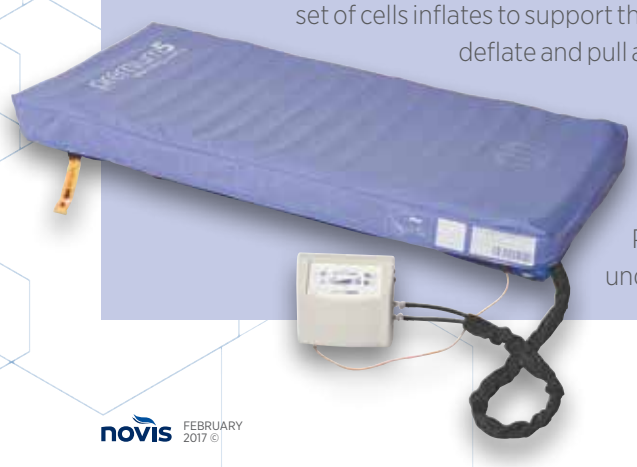
Test 1 Control – Three Layer Static Foam Mattress:

As a comparator, the BetterLiving Three Layer hospital grade foam mattress was chosen as a control. This high quality foam mattress has been used by Australian healthcare facilities for many years and is listed on several state hospital contracts. The top layer is visco-elastic memory foam.

Test 2 Control - Alternating Pressure Mattress Overlay:

The Premium 5 Alternating Mattress Overlay is a powered support surface, with the proven capability to change its load distribution properties, with or without applied load, as specified by the NCUAP standards. This mattress has been actively used by Australian healthcare facilities for more than ten years and is listed on a variety of state, hospital and aged care contracts. This active support surface was chosen as a comparator due to its similar cell height to the comparative mattresses.

The Premium 5 is a true alternating pressure mattress (APM) which features 15 alternating air cells from torso to foot areas, and 3 static (non-alternating) head cells. This APM uses 1-in-2 alternation mode (A & B cells). During an alternation cycle, one set of cells inflates to support the body, while the second set of cells deflate and pull away from the body. This provides off-loading of pressure on the skin, promoting reactive hyperaemia and tissue reperfusion. As per the manufacturer's instructions, the Premium 5 was placed on a 50mm foam underlay for additional safety.



Test Subject

- Male
- 1.68 metres tall
- Weighing 80kg
- BMI of 27

The same subject is used for each mattress tested.

All tests took place with the subject placed in a standardised supine position (lying flat on back; legs shoulder width apart; arms resting by the side.)

Test Duration

Tests were conducted on two consecutive days in February 2016. The first cycle of each mattress was not recorded, to allow for the subject to settle into the mattress. Each mattress was tested for one hour from point of second cycle.

Test 1: '**Reactive**' Support Surface – Immersion Performance

To appropriately assess the performance of a reactive surface, a number of conditions must first be established, including the contact area of the body and the amount the body 'immerses' into the support surface[4].

Assessments Conducted for Test 1

- Level of immersion into the support surface. Torso and limbs were assessed. Head area was not included in this assessment.
- Average pressure across area of immersion.
- Pressure Area Index (PAI) – areas of pressure below certain threshold (Percentage of body mass under the following levels of pressure when immersed into the mattress):
  - Below 40mmHg
  - Below 30mmHg
  - Below 20mmHg
  - Below 10mmHg
- Control comparison – Three layer foam mattress, with memory foam top layer

In testing the hybrid mattresses, the subject was positioned with the sacrum over the apex of an inflated cell. The subject was left to rest over one complete cycle, allowing the system to stabilise, before data was taken over the complete second cycle.

The subject was placed on each mattress so the scapula area was resting on a cell from Set A, while the sacral region was resting on a cell from Set B. The control unit was adjusted to a pressure level appropriate for the test subject's weight according to the manufacturer's instructions.

Data was analysed to report maximum and minimum pressure measurements, plus the time spent at or below interface pressure thresholds of 10, 20, 30 and 40 mmHg.

Test 2: **'Active'** support surface – Pressure Off-Loading Performance

In order to examine the validity of the claim that a hybrid support surface is as effective as a traditional active support surface, we need to demonstrate dynamic changes of interface pressure over each alternation cycle, as well as evidence of complete off-loading of pressure from body areas at greatest risk of pressure injury[4].

Assessments Conducted for Test 2

- The amount of off-loading occurred on each mattress, from cell to cell, over a one hour period, measured in mmHg. Evidence of alternation (changes in pressure from cell to cell throughout the alternation cycle) from each set of cells (referred to as Set A and Set B) with pressure mapping images. Test begins from second cycle to allow subject to settle in to mattress. Tested changes in pressure were recorded for one hour.
- The amount of time that was spent at less than 10mmHg and at zero interface pressure.
- The removal of pressure from the at-risk sacral area of the test subject; the time elapsed at the lowest point of pressure; as well as the difference between the highest and lowest recorded interface pressure levels during alternation.
- Comparing all five mattresses used in Test 1 and Test 2 will assess how much pressure is removed in total, and for what period of time.
- Control: 1-in-2 cell alternating pressure mattress overlay.

Results

Test 1: '**Reactive**' Support Surface – Immersion Performance

In terms of overall immersion area (body contact), Brand A (Swedish) and Brand B (British) did not perform as well as a 3-layer foam static mattress, as shown in tables below. The Triple Layer Foam Mattress (Control) presented a total of 3458cm^2 body surface immersion, which was 16% greater than Brand A and 18% greater than Brand B. Only Brand C (Australian) performed better than the control with regards to area of immersion, possibly due to the use of convoluted memory foam for contact with the body.

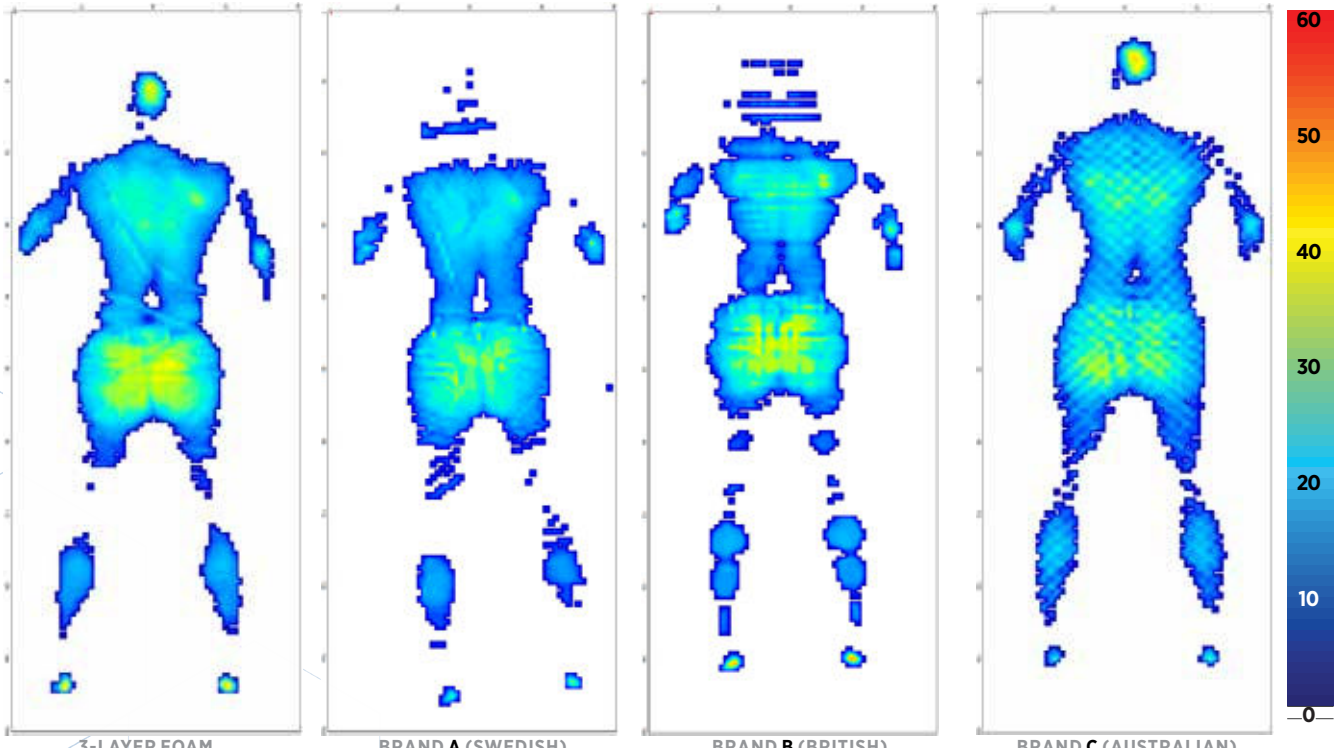
The difference in average pressure between all four mattresses was only 2.3 mmHg*, which is unlikely to offer a significant therapeutic advantage of one system over the other.

Table 1 Summary Results

	Area of immersion*		Average pressure across area of immersion *		Pressure Area Index (percentage of immersion area under a given pressure threshold)			
					Below 40 mmHg	Below 30 mmHg	Below 20 mmHg	Below 10 mmHg
Three Layer foam with memory foam top	3458 cm^2	2 nd	22.2 mmHg	4th	99.3%	81.2%	44.2%	2.9%
Brand A (Swedish)	2974 cm^2	3 rd	19.9 mmHg	1st	100%	90.1%	54.5%	3.5%
Brand B (British)	2927 cm^2	4 th	21.5 mmHg	3rd	99.2%	81.8%	49.6%	1.9%
Brand C (Australian)	3759 cm^2	1st	20.3 mmHg	2nd	99.9%	87.7%	51.4%	2.7%

*Head region not included

Figure 2 Summary Results



Test 2: Evidence of Alternation

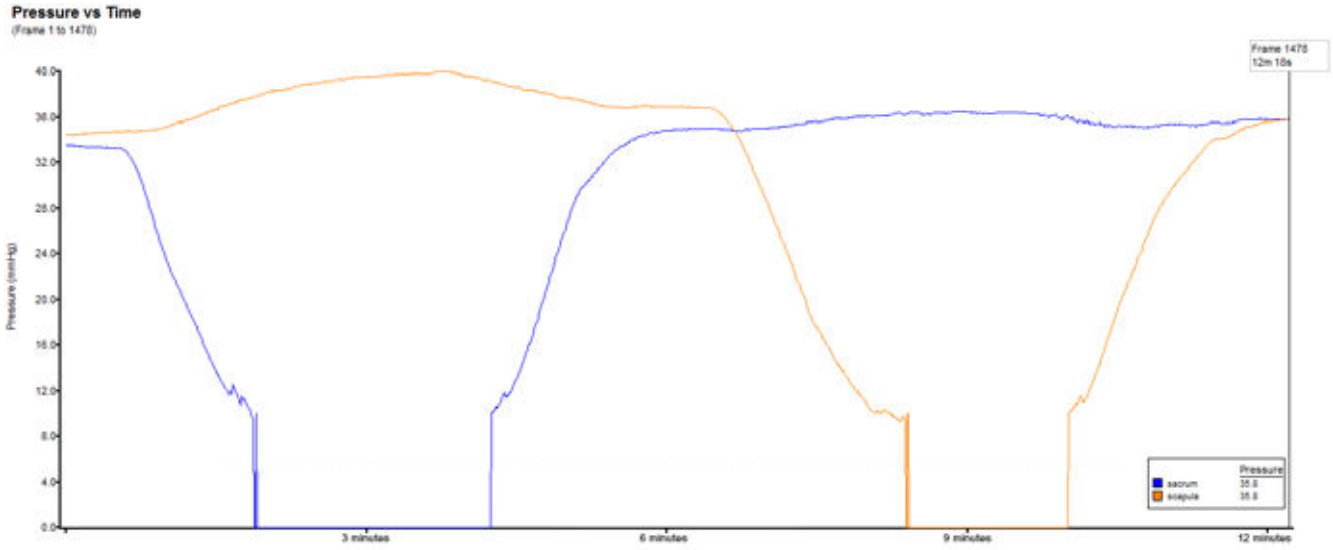
As stated by Lyn Phillips[4], although some support surfaces may be considered 'hybrid' by design (ie those surfaces that can either be switched between active and reactive), each modality should be measured independently as there is not any one technique that does both simultaneously without compromising reliability[4]. Test 2 was performed to establish evidence of alternation and promotion of reactive hyperaemia.

Pressure readings from sensors grouped directly under the left scapula (represented by the orange line) and the sacrum (represented by the blue line) were taken and charted against one alternation cycle of 12 minutes.

Control: True dynamic air mattress

Figure 3 highlights regions under the scapula and sacrum of the Control experienced significant and rapid pull-away, represented by the near vertical drops in pressure levels to well below 10mmHg interface pressure. In addition, there were also periods of low pressure on the scapula and sacrum for at least one third of the alternation cycle time of 12 minutes. This could not be duplicated with any of the Three 'hybrid' support surfaces.

Figure 3 Control - Sacral and Scapula interface pressure



Pressure mapping, seen in Figure 4 below, illustrates the effective alternation of cell sets A and B. Note the alternating areas of high pressure (represented by the yellow-green regions of the maps) on each image represent the pressure peaks of each cell set.

Figure 4 Control - Pressure Mapping

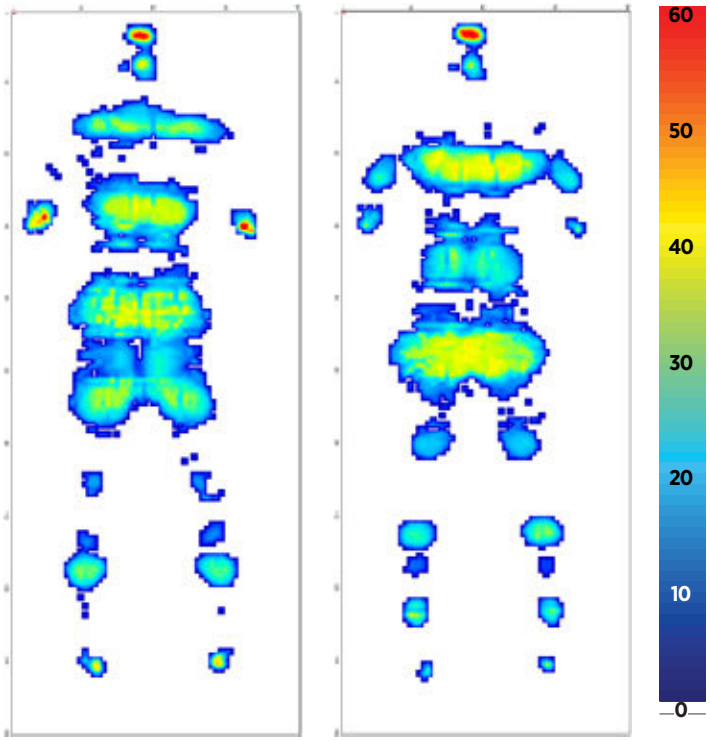


Figure 5 below illustrates pressure under sacral area of an average of 34mmHg, dropping to below 10mHg interface pressure within 80 seconds. It remained at <10mmHg for well over two minutes, during which the sacrum experienced zero to negligible pressure, allowing for adequate tissue reperfusion (reactive hyperaemia). This could not be duplicated with any of the three 'hybrid' support surfaces.

Figure 5 Control - Sacral Interface Pressure

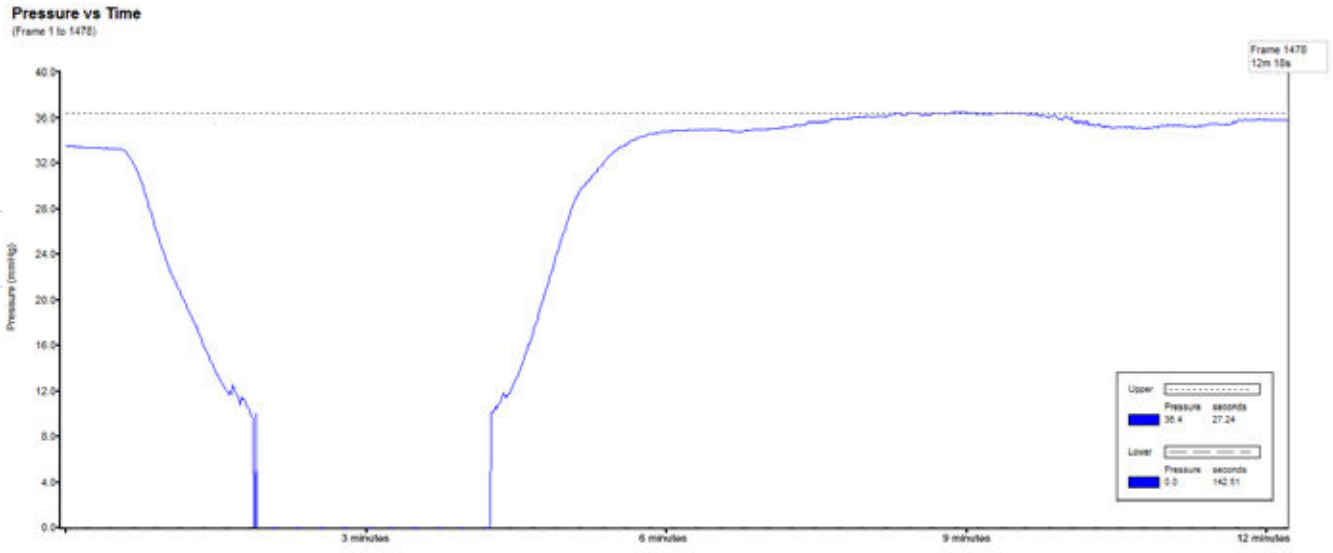


Figure 6 Brand A – Sacral Interface Pressure

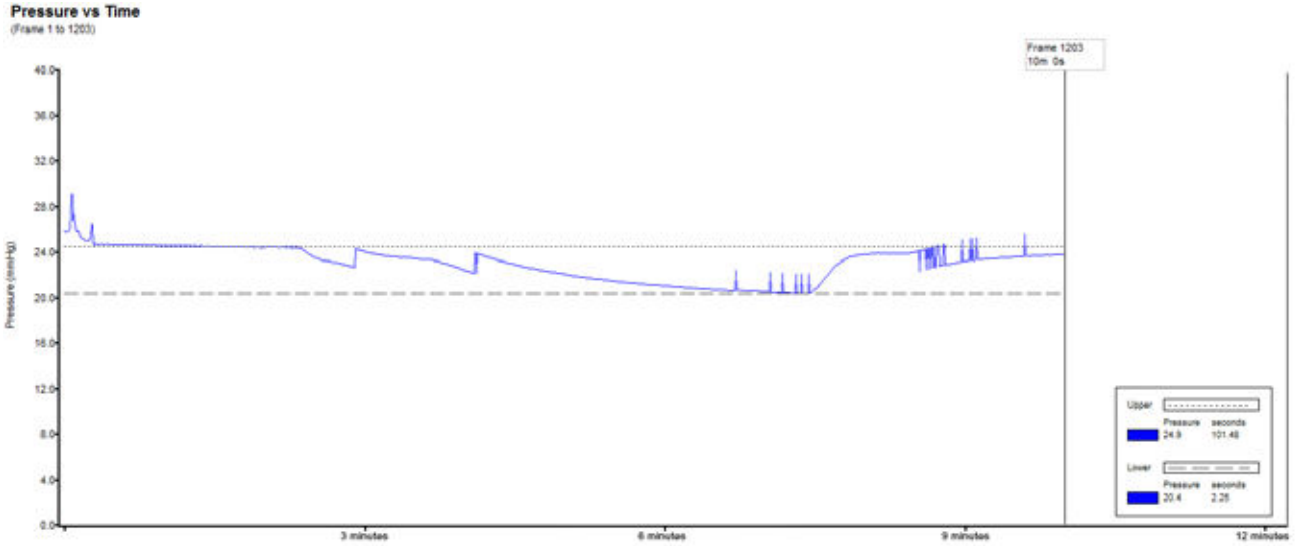


Figure 7 Brand B – Sacral Interface Pressure

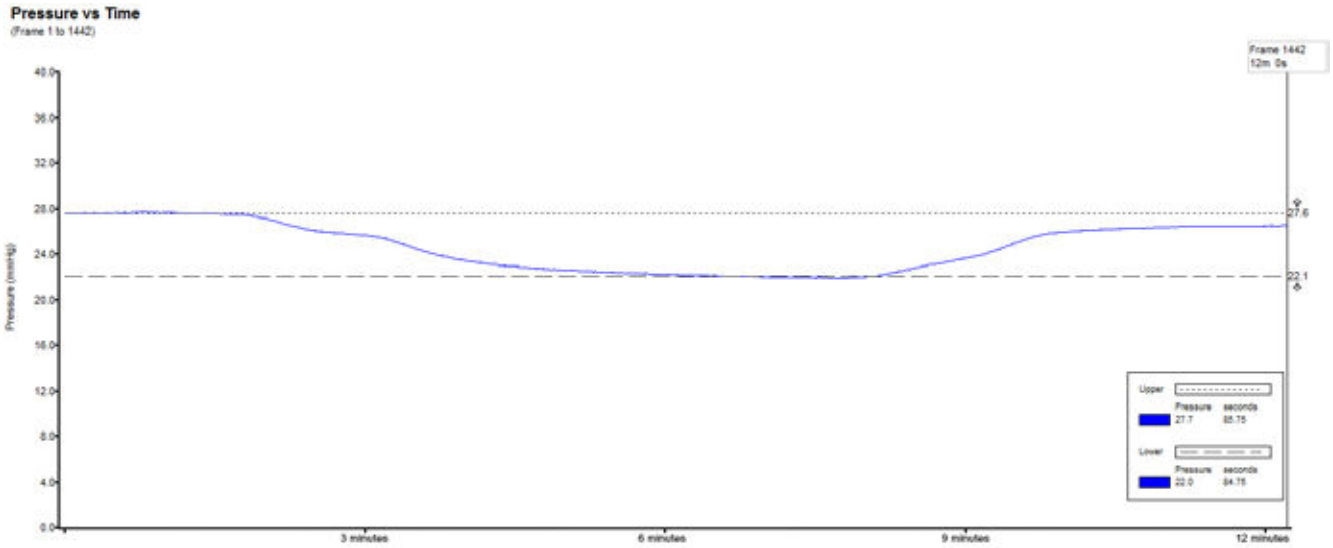


Figure 8 Brand C – Sacral Interface Pressure

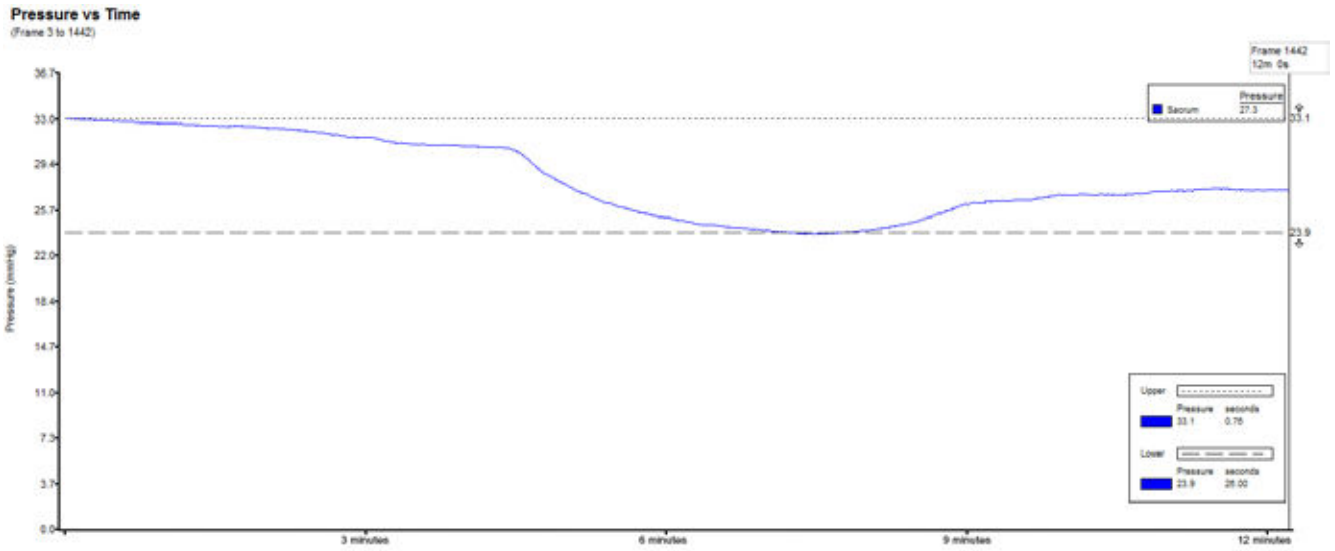


Table 9 Average Sacral Pressure Comparison: Active versus Combination

	Peak Pressure	Lowest Pressure	Variance	Period of Pressure under 10mmHg
Alternating Pressure mattress	34 mmHg	0 mmHg	34 mmHg	144 seconds
Brand A (Swedish)	24.5 mmHg	20.4 mmHg	4.1 mmHg	Not Achieved
Brand B (British)	27.7 mmHg	22.0 mmHg	5.7 mmHg	Not Achieved
Brand C (Australian)	33.1 mmHg	23.9 mmHg	9.2 mmHg	Not Achieved

Discussion

Is a 'hybrid' support surface really the best of both worlds?

Some manufacturers claim that a 'hybrid' support surface is able to deliver both the benefits of a static surface – namely comfort and support – as well as the benefits of an alternating mattress – namely the effective redistribution of interface pressure between the patient's skin and the support surface.

This study reconfirms finding by Lyn Phillips[4] that while the 'hybrid' support surfaces are effective reactive surfaces, they do not meet the criteria to be considered active support surfaces and should not be considered as a substitute for a true alternating pressure mattress.

According to Phillips[4], "the cycle amplitude (note: variance between peak and lowest pressures) is particularly important because to achieve a 'favourable' low pressure perfusion condition, the body must be lifted clear of the deflated segments by resting upon the fully inflated cells." No foam-air combination mattress tested is shown to demonstrate this capability, and therefore these mattresses should NOT be seen as a replacement for active/dynamic surfaces.

It is therefore important that when selecting an appropriate support surface for any patient, a "hybrid" support surface should be regarded more as a high-end, reactive support surface, and its performance should be judged on patient immersion and pressure is redistributed through maximising the contact area.

Conclusion

Where should a combination foam-air support surface be used?

It is well documented that patients 'at risk' of pressure injury that cannot adequately reposition/be reposition at least every half-hour[7], as well as those who are considered at 'very high risk' despite their ability to reposition[8] should be placed on an active air alternating support surface.

There are a group of patients, however, who do not fit this criteria but may require more than a standard foam support surface, such as a foam-air 'hybrid' mattress. This may be especially true for situations where considerations of comfort outweigh therapeutic effectiveness, such as:

- palliative care
- patients with dysmorphic body shape (body weight concentrated in the pelvic area and above knee double amputees)
- assistance with pain management for certain neurological conditions
- post-surgery/acute illness as a 'step-down' option from active (alternating pressure) surfaces to reactive (foam) surfaces.

Regardless, sound nursing practice should never be overlooked – and if a patient is unable to reposition adequately, or is at high risk of developing a pressure related injury, they should be placed on a true alternating pressure mattress with the understanding that a genuine 'one size fits all' support surface does not exist.

References

1 Nguyen K-H et al., Australian Health Review, 2015, 39, 329–336
Van Den Bos J et al., Health Affairs 2011; 30(4): 596-603

2 Australian Commission on Safety and Quality in Health Care, *National Safety and Quality Health Service Standards (September 2012)*. Sydney. ACSQHC, 2012.

3 National Pressure Ulcer Advisory Panel (NPUAP) *Support Surface Standard Initiative,* 2007

4 Phillips, L. *Interface pressure measurement: Appropriate interpretation of this simple laboratory technique used in the design and assessment of pressure ulcer management devices.* (2007). Primary Intention, Vol 15, No.3

5 Fletcher J et al. *Estimating the costs associated with the management of patients with chronic wounds using linked routine data.* Wounds International, March 2015

6 National Pressure Care Ulcer Advisory Panel (NPUAP), European Pressure Care Ulcer Advisory Panel (EPUAP), Pan Pacific Pressure Injury Alliance (PPPIA) 2014

7 Ramstadius B., Sharp C.A., Carter R. and Cavanagh J. *Pressure Injury Prevention Guidelines*, 2000

8 National Health Service (NHS) Pressure Surface Recommendations, 1995
Pressure Injury Quick Reference Guide NPUAP/EPUAP/PPPIA 2014

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