Evaluation of static and powered hybrid mattresses

KEY WORDS
- Mattresses
- Powered hybrid
- Pressure ulcer
- Pressure ulcer prevention

Pressure ulcer prevention has long focused on the reduction of the magnitude and duration of skin and soft tissue loading. Recently, a new pressure-redistributing (PR) patient support surface modality has emerged that combines foam and air cells. These hybrid mattresses can be used in static (or reactive) mode to increase envelopment and immersion of patients sleeping on these surfaces, or they can be connected to a pump unit to sequentially inflate and deflate the air cells so providing an active support surface (alternating pressure). This study compared the contact pressures applied while ten healthy volunteers rested upon a powered hybrid PR mattress, a non-powered hybrid mattress and a foam mattress. Accordingly, the highest pressure recorded at the sacrum and buttocks was used to compare these static surfaces with the powered hybrid mattress. No statistically significant differences were found between the coefficient of variation across the five support surface configurations suggesting that each surface provided similar levels of envelopment ($F=2.18$, $p=0.086$). The minimum contact pressure applied by the powered hybrid mattress was lower than the pressures applied to the sacrum by the foam mattress ($p=0.015$), the powered hybrid in static mode ($p=0.009$) and the maximum pressures applied by the powered hybrid mattress ($p=0.000$). Body contact area was higher upon the non-powered hybrid mattress than the powered hybrid in static mode ($p=0.003$) and the powered hybrid when the lowest contact pressures at the sacrum were observed ($p=0.052$). No other differences between the tested mattresses achieved statistical significance.

Pressure ulcer prevention has long focused on the reduction of the magnitude and duration of skin and soft tissue loading. This approach has seen a wide range of pressure-redistributing (PR) patient support surfaces introduced into health care facilities over the past 40 years. The effectiveness of these PR surfaces is often unclear (National Pressure Ulcer Advisory Panel [NPUAP], European Pressure Ulcer Advisory Panel [EPUAP] and Pan Pacific Pressure Injury Alliance [PPPIA], 2014) and numerous pressure ulcer epidemiological studies identify that the number of people with or developing pressure ulcers remains high (NPUAP, EPUAP, PPPIA, 2014). Surrogate non-invasive outcome measures of support surface effectiveness have been widely reported (for example, Tissue Viability Society, 2010) and include the pressure exerted by the support surface upon the skin and underlying soft tissues. Over the past years, a new PR surface modality has emerged which combine foam and air cells. These hybrid mattresses can be used in static (or reactive) mode to increase envelopment and immersion of patients sleeping on these surfaces or they can be connected to a pump unit to sequentially inflate and deflate the air cells so providing an active support surface (alternating pressure). To date there is limited clinical evidence around the impact of hybrid mattresses on pressure ulcer incidence, although Fletcher et al (2016) reported a 56% reduction in pressure ulcer incidence after introduction of hybrid mattresses. This evaluation adds to the on-going discussion around the impact

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of hybrid mattresses through a comparison of the contact pressures applied while healthy volunteers rested upon a powered hybrid PR mattress, a non-powered hybrid mattress and a foam mattress.

OBJECTIVE OF THE EVALUATION

To determine contact pressures while healthy volunteers rested supine upon a powered hybrid mattress, a non-powered hybrid mattress and a foam mattress.

DESCRIPTION OF METHODS

This evaluation measured contact pressures while healthy volunteers rested upon a powered hybrid mattress (Hybrid-Power, Drive DeVilbiss Healthcare) used in both its 'static' and 'dynamic' operating phases — while static, the powered hybrid acts like a foam mattress enveloping and immersing the volunteers so reducing peak contact pressures. While used dynamically, a pump is attached to the hybrid mattress and air cells inflate and deflate under the volunteers in a 10-minute cycle. The pump unit was set to an inflation pressure appropriate for the weight of the subject. The contact pressure data gathered while the volunteers rested upon the powered hybrid were compared with contact pressures applied while the volunteers rested upon a non-powered hybrid mattress (Hybrid-Air, Drive DeVilbiss Healthcare) or a foam mattress (Permaflex Plus, Drive DeVilbiss Healthcare).

All devices used in this evaluation were CE marked and used within their intended purpose. This evaluation was reviewed by Cardiff University School of Medicine Research Ethics Committee with permission granted for the evaluation to be undertaken.

Ten adult volunteers (aged over 18 years with no upper limit) were invited to rest on the three mattresses types. All participants were drawn from the staff of the Welsh Wound Innovation Centre. There were limited inclusion and exclusion criteria associated with this study — subjects had to be aged over 18 years, able to lie upon the mattresses and able to stand up after the tests were completed.

Subjects were asked to wear loose fitting clothing during the measurement period and while supine they lay flat on their backs, head supported by one pillow, with feet no more than shoulder width apart and their arms resting by their side. No bed sheets were introduced between the volunteer and the surface of the mattresses.

Contact pressures were measured using a BodiTrak 3510 pressure measurement mat (Vista Medical, Canada) with surface dimensions of 203 cm by 86 cm with 1,728 pressure sensors. All pressure measurements were performed at the Welsh Wound Innovation Centre under direct control of a research nurse supervised by a research scientist.

The pressure mapping system was placed under the supine volunteer and pressures were recorded for 10 minutes on the

Figure 1. Typical pressure map showing distribution of pressure while supine on the static powered hybrid

foam mattress, the non-powered hybrid and the powered hybrid acting in static mode and then for 20 minutes (dynamic phase of the powered hybrid mattress). All pressure measurements were saved to computer and analysed as described below.

Static mattresses

Each 10-minute pressure measurement recording consisted of numerous static frames showing the pressures applied at a moment in time. The pressures seen within frame 1500 were taken as a reference point for analysis *(Figure 1)*, this frame matched approximately 5-minutes rest upon the static mattresses. Four measures were recorded from frame 1500:

- Peak pressure applied to any part of the body (mmHg)
- Peak pressure applied to the sacrum and buttocks (mmHg)
- Coefficient of variation (%); the lower the coefficient of variation the more evenly pressure was distributed across the volunteer's body
- Area of contact (cm^2); the greater the area of contact, the better the envelopment of the volunteer by the mattress surface. Contact area was calculated from the number of pressure sensors that registered 5mmHg or higher.

Dynamic phase of the powered hybrid mattress

Each 20-minute pressure measurement recording was viewed by the lead author with the four measures described above recorded for frames 1340, 2837, 4336 and 5836, approximating 5-minute intervals between data capture. The anatomical point within the sacrum and trunk region that displayed the highest contact pressure in frame 1340 was identified, and the pressures applied to this anatomical location in the remaining three frames (marking 10, 15 and 20 minutes) rest upon the dynamic powered hybrid mattress was recorded to show how contact pressure changed at a single anatomical location over 20-minutes rest upon the powered hybrid mattress.

The sensors of the pressure mat were calibrated before use using the standard calibration container available from the Boditrak manufacturer. All pressure sensors were accurate to +/-20% (Vista Medical, Canada) with a range of 0mmHg to 100 mmHg. Contact pressures over 100 mmHg could only be displayed as 100 mmHg given that this was the maximum pressure detectable by the pressure mat. The pressure mat was set to only record sensors that had at least 5 mmHg applied allowing the area of body contact with the mat to be measured as sensors with no pressure applied were excluded from this calculation.

All statistical tests were conducted using one-way analysis of variance using the SPSS V24 statistical software package (SPSS Inc, USA) with post-hoc comparisons between support surfaces where the ANOVA indicated statistically significant differences existed. Five support surface configurations were tested in each ANOVA — foam mattress, non-powered hybrid, powered hybrid in static mode, powered hybrid showing maximum contact pressure and powered hybrid with lowest contact pressure. Independent t-tests were used to compare the effect of demographic changes (age and body mass index [BMI]) upon contact pressures.

RESULTS

Ten subjects were recruited; nine females and one male with demographic information given in *Table 1*. *Table 2* illustrates the peak contact pressure (mmHg), the coefficient of variance (%) and contact area (cm^2) measured among the subjects as they rested supine on the powered hybrid mattress, the non-powered hybrid and the foam mattress. Accordingly, the highest pressure recorded at the sacrum and buttocks was used to compare these surfaces with the powered hybrid mattress. Three ANOVA tests were conducted comparing pressure, area of contact and coefficient of variation upon each support surface. No statistically significant differences were found between the coefficient of variation across the five support surface configurations suggestion that each surface provided similar envelopment ($F=2.18$, $p=0.086$). Statistically significant differences existed between the maximum contact pressures and the area of contact across the five support surface configurations (pressure $F=6.22$, $p=0.00$; area $F=5.50$, $p=0.001$). However post-hoc comparisons identified few statistically significant differences between surfaces — the minimum contact pressure applied by the powered hybrid

Table 1. Subject demographic information

Subject	Mean	Standard deviation	Range
Age (years)	45.4	12.6	30–61
Body mass index (kg/m^2)	26.8	3.8	21.8–33

Table 2. Peak contact pressure, coefficient of variation (CoV) and body contact area measured upon the powered hybrid mattress, the non- powered hybrid and the foam mattress

Support surface	Peak pressure at sacrum (mmHg) (SD)	CoV (%) (SD)	Area of contact (cm^2) (SD)
Foam mattress	70.8 (15.9)	61.8 (6.2)	3388.9 (576.1)
Non-powered hybrid	62.8 (20.4)	63.6 (11.0)	3497.1 (649.7)
Powered hybrid in static mode	72.0 (13.4)	61.9 (4.5)	2601.3 (408.2)
Powered hybrid (maximum contact pressure)	79.9 (16.4)	69.2 (8.1)	3123.6 (385.8)
Powered hybrid (minimum contact pressures)	46.7 (12.7)	60.6 (4.7)	2833.2 (453.1)

SD=standard deviation

mattress was lower than the pressures applied to the sacrum by the foam mattress (p=0.015), the powered hybrid in static mode (p=0.009) and the maximum pressures applied by the powered hybrid mattress (p=0.000). Body contact area was higher upon the non-powered hybrid mattress than the powered hybrid in static mode (p=0.003) and the powered hybrid when the lowest contact pressures were applied (p=0.052). No other differences between the tested mattresses achieved statistical significance.

Body contact area tended to be influenced by subject BMI, with those subjects having BMI above the median value (25.5 kg/m^2) having greater contact with the mattress surface *(Table 3)* although this difference only approached statistical significance upon the foam mattress. Minimum sacral contact pressures were lower among the heavier subjects upon the powered hybrid mattress. No differences were seen between the coefficient of variation measured among lighter and heavier subjects upon the tested mattresses.

Trends in contact pressures were also seen among subjects older or younger then the median age of the group (45.5 years). Body contact area tended to be higher among younger subjects (trend not statistically significant) while there was a less even distribution of pressure across the body among older subjects with the maximum contact pressure tending to be higher among older subjects *(Table 4)*.

CONCLUSION

This study set out to determine whether there were differences between the contact pressures applied by a powered hybrid mattress, a non-powered hybrid and a foam mattress. The results suggest the following:

- There were few statistically significant differences between the contact pressures applied by the three surfaces with the minimum contact pressures applied by the powered hybrid mattress being lower than the pressures applied by the foam mattress, the powered hybrid when in static mode and the maximum pressures applied by the powered hybrid mattress
- Body contact area was higher upon the non-powered hybrid mattress than the powered hybrid in static mode and the powered hybrid when the lowest contact pressures were applied
- Sacral contact pressures were influenced both by the age of the subjects and their BMI

Table 3. Peak contact pressure at the sacrum, coefficient of variation (CoV) and body contact area measured upon the powered hybrid mattress, the non-powered hybrid and the foam mattress by body mass index (greater or below the median value of 25.5 kg/m² for the subject group)

Support surface	Peak pressure at sacrum (mmHg) (SD)			CoV (%) (SD)			Area of contact (cm²) (SD)		
	Low BMI	High BMI	Significance	Low BMI	High BMI	Significance	Low BMI	High BMI	Significance
Foam mattress	73.5 (7.8)	68.2 (22.3)	NS	61.7 (5.0)	61.9 (7.9)	NS	3049.6 (237.8)	3728.2 (634.4)	0.05
Non-powered hybrid	57.0 (13.6)	68.5 (25.8)	NS	62.7 (8.3)	64.4 (14.2)	NS	3119.6 (343.4)	3874.6 (689.5)	0.06
Powered hybrid in static mode	73.1 (5.3)	70.9 (19.3)	NS	63.1 (3.2)	60.9 (5.7)	NS	2468.6 (291.5)	2733.9 (590.9)	NS
Powered hybrid (maximum contact pressure)	79.2 (13.5)	80.7 (6.1)	NS	69.6 (6.8)	68.9 (10.0)	NS	2924.3 (291.5)	3322.9 (387.9)	NS
Powered hybrid (minimum contact pressure)	54.6 (13.1)	38.8 (6.1)	0.04	60.5 (3.5)	60.7 (6.0)	NS	2603.7 (335.0)	3062.6 (466.9)	NS

NS=not statistically significant; SD=standard deviation

Table 4. Peak contact pressure at the sacrum, coefficient of variation (CoV) and body contact area measured upon the powered hybrid mattress, the non-powered hybrid and the foam mattress by age (greater or below the median value of 45.5 years for the subject group)

Support surface	Peak pressure at sacrum (mmHg) (SD)			CoV (%) (SD)			Area of contact (cm²) (SD)		
	Younger	Older	Significance	Younger	Older	Significance	Younger	Older	Significance
Foam mattress	65.9 (16.8)	75.7 (15.3)	NS	60.3 (4.3)	63.3 (7.9)	NS	3508.5 (504.9)	3269.3 (675.4)	NS
Non-powered hybrid	63.9 (26.3)	61.6 (15.5)	NS	63.4 (14.4)	63.7 (8.2)	NS	3666.4 (638.1)	3327.9 (686.2)	NS
Powered hybrid in static mode	64.9 (10.8)	79.1 (12.7)	0.09	58.6 (2.7)	65.4 (3.0)	0.006	2785.9 (449.9)	2416.6 (295.3)	NS
Powered hybrid (maximum contact pressure)	77.6 (13.8)	82.3 (20.1)	NS	63.6 (2.0)	74.9 (8.0)	0.016	3226.9 (380.4)	3020.3 (404.2)	NS
Powered hybrid (minimum contact pressures)	45.1 (8.8)	48.4 (16.8)	NS	58.1 (2.7)	63.0 (5.2)	0.095	3064.2 (375.5)	2602.1 (432.9)	NS

NS=not statistically significant; SD=standard deviation

The interpretation of the peak contact pressures applied to the heels is challenging given the full saturation of these pressures where applied pressure over 100mmHg was reported as 100mmHg. This is a limitation of the pressure mat used in this study and results should be confirmed using alternative pressure mats with higher maximum recordable pressures. WUK

REFERENCES

Fletcher J, Tite M, Clark M (2016) Real-world evidence from a large-scale multisite evaluation of a hybrid mattress. *Wounds UK* 12(3): 54–61

National Pressure Ulcer Advisory Panel, European Pressure Ulcer Advisory Panel and Pan Pacific Pressure Injury Alliance (2014) *Prevention and Treatment of Pressure Ulcers: Quick Reference Guide.* Emily Haesler (Ed.). Cambridge Media: Osborne Park, Australia

Tissue Viability Society (2010) Laboratory measurement of the interface pressures applied by active therapy support surfaces: a consensus document. *J Tissue Viability* 19(10): 2–6