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CLINICAL REVIEW
THERAPEUTIC SURFACES

The effect of support surface design on skin temperature: A comparison of passive and active systems

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Introduction:

Most support surfaces designed for clinical applications appear to be deceptively simple pieces of equipment[1] but may vary considerably in their technical profiles. Their primary function is to comfortably support the patient in an appropriate position and are used to prevent and treat pressure ulcers, by controlling the load and micro-environment at the skin/surface interface. There are an expanding number and type of support surfaces on the market, ranging from Foam Mattresses (FMs) to sophisticated air fluidised bead beds[2]. By selecting a suitable surface, tissue-damaging parameters such as pressure, moisture and temperature can be controlled thus preserving the health of weight-bearing tissues. Different types of support surface have different capacities for controlling these parameters at the skin-support surface interface.

Alternating Pressure Redistributing Mattresses (APRMs) are widely used both in the institution and homecare settings. Several comparative investigations[3,4,5] concerning temperature and humidity at the skin/surface interface involving FMs and low air loss (LAL) mattresses have been reported in the scientific literature. However, no studies to date using APRMs have been found.

The present preliminary study compares the skin temperature, humidity and interface pressure in three different types of mattresses: a conventional hospital foam (Standard Hospital Mattress, STM Healthcare, UK), an APRM (*AUTO logic® 200* System, ArjoHuntleigh) and a LAL mattress (*Breeze®* System, ArjoHuntleigh).

Methods and Materials:

Three healthy adult volunteers participated in the investigation. The details of the subjects for the study are shown in *Table 1*. The testing was done in a room in which temperature was maintained between 23°C and 25°C for the duration of the measurements. Temperature and relative humidity (RH) were measured continuously using Gemini data loggers (Tinytalk, Gemini Data Loggers (UK) Ltd).

Continuous recordings of pressure at the skin-mattress interface were taken as described in previous studies[6]. The sensors were attached side by side at the sacrum when the subject was lying on the right hand side.

Temperature and humidity sensors were also attached on the left greater trochanter, in order to record the unloaded parameters, thus each subject acted as his/her own control. Baseline readings were taken with the subject side-lying on the right greater trochanter. The subjects were left to acclimatise for at least 15 minutes, before starting the tests for a further period of 90-minutes. While carrying out measurements on the APRM and the LAL system, the subject was positioned carefully so that the sensors rested on top of an inflated cell of the mattress.

S.No.	Subject	Sex (M/F)	Age (yrs)	Weight (kg)	Height (m)	Index $Kg \div M^2$
1	AM	F	29	55	1.59	21.8
2	SH	F	57	69	1.76	22.3
s	PA	M	66	72	1.72	24.3

Table 1: Subject characteristics

Results:

Figures 1a and *1b* (back page) show a typical example of the changes in temperature and humidity measured on a subject lying on the 3 different support surfaces. In all cases, the trend was an increase in temperature and humidity between the start and finish of the test. The increase in skin temperature from baseline was +1.2°C, +1.6°C and +3.3°C in the case of the APRM, LAL system and FM respectively. Also, the increase in skin humidity from baseline was +18%, +19% and +51% in the same products. Additionally, the humidity signal was cyclic in the case of the APRM, varying by ±10%, whereas it was only slowly changing in the case of LAL system and FM.

Although there is insufficient data to perform meaningful statistics, there appeared to be an improvement in results obtained on the powered compared to the non-powered systems, with greatest changes recorded on the FM and no apparent difference between LAL system and APRM.

Average, as well as individual values of all the parameters for all three subjects are given in *Table 2*.

FOAM					
Subject	**Start T**	**End T**	**Start H**	**End H**	**Maxm IP**
AM	32.2	35.7	43.9	100	27
SH	33.0	36.1	54.0	100	30
PA	31.9	35.2	48.5	100	28
Average	**32.4**	**35.7**	**48.8**	**100.0**	**28.3**

AUTO LOGIC					
Subject	**Start T**	**End T**	**Start H**	**End H**	**Sacrum IP**
AM	32.6	33.9	50.1	66.3	0 - 30
SH	31.8	32.6	45.3	61.2	0 - 40
PA	31.8	33.5	49.3	71.1	0 - 27
Average	**32.1**	**33.3**	**48.2**	**66.2**	**0 - 32.3**

BREEZE					
Subject	**Start T**	**End T**	**Start H**	**End H**	**Sacrum IP**
AM	31.8	33.9	55.3	79.6	17
SH	32.5	33.0	51.2	70.3	21
PA	32.2	34.4	41.7	56.2	15
Average	**32.2**	**33.8**	**49.4**	**68.7**	**17.7**

Table 2: Temperature, humidity and pressure under the sacrum

Discussion:

In the formation of pressure ulcers, from a biological point of view, the magnitude and time of pressure remain the most important parameters[7]. However, high temperature and humidity at the skin/surface interface make the support surface uncomfortable. In addition, presence of moisture at the skin/surface interface increases the coefficient of friction, thus making the skin prone to maceration and leading to infection. It would appear from the data that while there was very little difference between the performance of the APRM and LAL system, in that both provided a very similar and fairly stable microclimate at the skin-mattress interface, the FM mattress produced a clear increase in skin temperature and humidity.

A temperature increase of the skin increases the metabolic demands of the tissue with increased oxygen consumption. For every 1°C (1.8°F) rise in body temperature, there is approximately a 10% increase in metabolic rate[8]. Providing tissue perfusion remains optimised and blood flow unhindered, this raised metabolic demand may be met without compromising tissue integrity. However, in those patients for whom spontaneous repositioning is difficult and for whom pressure is not periodically relieved, prolonged vessel occlusion combined with increased and unmet metabolic demand could be implicated in the development of pressure ulceration.

Unlike APRM's the LAL mattress is often described[9] as the device which helps to maintain skin moisture and temperature. Flam et al[4] compared the change in skin temperature and moisture on a LAL support system and a FM. Both products showed the same increase in temperature during the first 15 minutes but the skin temperature on the LAL system seemed to stabilise in approximately 115 minutes. Skin temperature on the FM and LAL system rose to approximately 96.8°F (36°C) and 95.5°F (35.3°C) respectively, over a three-hour test period. The results also indicated that on average, skin temperature on the LAL system was significantly lower (1.2°F or 0.7°C) than that of the FM.

By contrast to LAL systems, APRMs have been primarily designed to encourage reperfusion by means of simulating the off-loading achieved by natural postural change; yet these appear to deliver effective control of temperature and humidity similar to that seen in LAL systems.

The effectiveness of alternating pressure in the prevention of ulcers whereby tissues are periodically rendered completely free of load has been recognised[7] for a long time. Despite some authors[10,11] suggesting a link between alternating pressure and tissue damage, the evidence suggests that this assertion is clearly misleading, as this modality has provided excellent clinical outcomes in well designed field and laboratory studies[12,13].

From the results of the present investigation, it appears that the alternating pressure modality plays an important role in the reduction of skin temperature and humidity and would appear equally effective in maintaining a fairly stable temperature-humidity environment at the mattress-skin interface.

Conclusion:

From the literature search and the present preliminary work, it appears that all support surfaces under moderate pressure generate an increase in skin temperature and moisture between the body and the support surface. However, on average, the increase under the sacrum was found to be much lower in the *Breeze* mattress (LAL), and the *AUTO logic 200* (APRM) compared with the standard FM.

There was hardly any difference in either the skin temperature or the humidity over 90-minutes between the *Breeze* and the *AUTO logic 200* mattresses. With heel ulceration being the second most common site for pressure ulceration due to substantially higher tissue interface pressures and concomitant disease; in future this could be the site of choice for further investigation using a larger number of subjects.

References:

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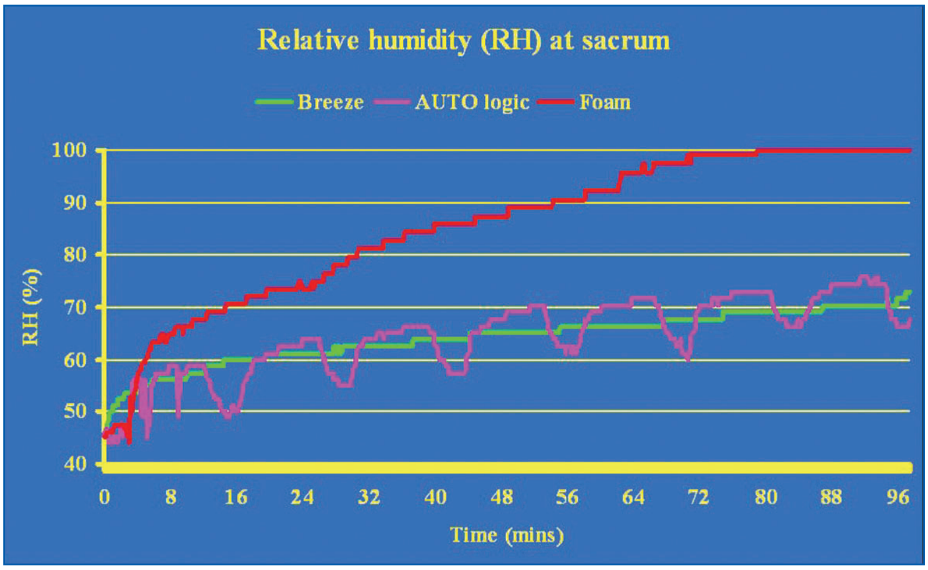

Figure 1a.

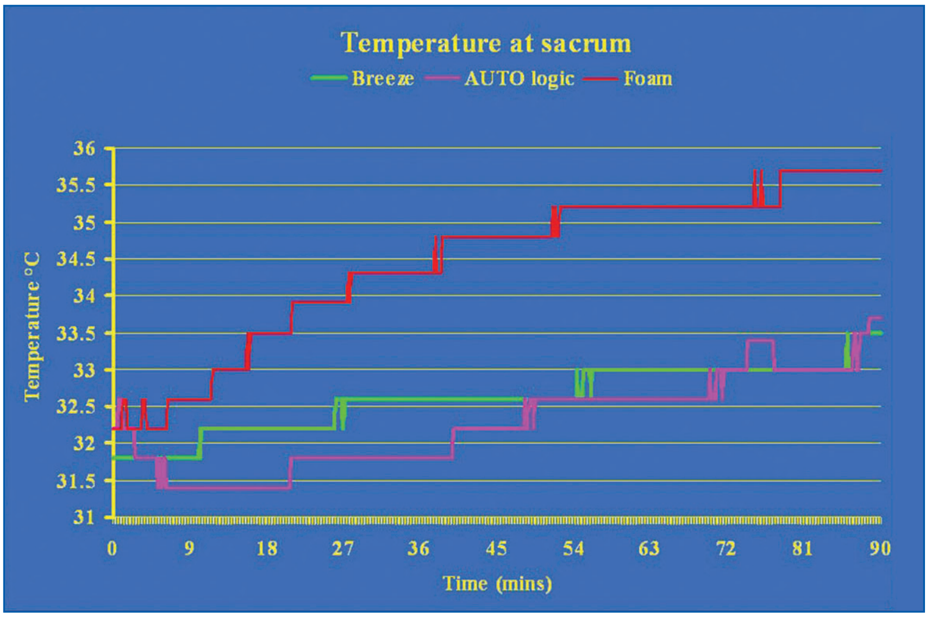

Figure 1b.

Key Points:

- Foam mattresses produce a rise in temperature and humidity at the mattress-skin interface.
- Both alternating pressure redistributing mattress technology and low air loss support surfaces manage the skin microclimate – there is little difference between the two.
- Tissue that is exposed to an increase in metabolic demand is more likely to suffer damage when that demand cannot be met.
- Alternating pressure is an efficient method of increasing tissue perfusion[12].