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Title
Reducing skin temperature and humidity using a wheelchair cushion microclimate cover with active airflow

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None

Summary
We tested the extent to which a microclimate cushion cover with active airflow can help wheelchair users manage their microclimate more effectively and found that with permeable cushions the microclimate cover was effective in optimizing the microclimate of wheelchair users.

Introduction/ basics
The skin microclimate - that is, the temperature, humidity and airflow next to the skin surface - is an indirect pressure ulcer risk factor and a direct risk factor for the development of Moisture-Associated Skin Damage (MASD). Temperature and humidity affects the structure and function of the skin, increasing or lowering possible damage thresholds for the skin and underlying soft tissues (Kottner et al., 2018). When a patch of skin is warmed beyond approximately 33°C, local perspiration in the region increases markedly and the accompanying moisture causes maceration of the skin, which makes it more susceptible to breakdown (Lachenbruch, 2005). Additionally, moisture increase due to sweating or trans epidermal water loss results in increased skin breakdown as it also increases the coefficient of friction of the skin (Greasley, 2018). However, there is a lack of research and available solutions to the issue of microclimate management.

Material method; implementation/ process
The aim of this paper is to test the extent to which a microclimate cushion cover with active airflow (WA CC, see figure 2) can help wheelchair users manage their microclimate more effectively.

Using a modified ISO 16840-11 testing standard, we tested the WA CC on nine different popular wheelchair cushions. With the help of two iButton sensors (see figure 1 for placement) temperature and relative humidity levels between the seat and the client are measured every 30 seconds over a two-hour period. All tests were performed with one able-bodied male participant (197cm; 27-years-old; 115kg). The participant was instructed not to perform any movements during the time of the measurement that would lead to a lifting of the buttocks off the support. The results of the WA CC tests were compared to those when using the cushion brand's standard cover. All tests were performed in a small room in which the temperature and relative humidity are kept as constant as possible.

Results

Overall, the tests show that the WA CC is effective in reducing both relative humidity (mean reduction of 12.3%) and temperature (mean reduction of 2.3°C) significantly over a sustained period of two hours for eight out of nine cushion types tested. The mean temperature for these eight cushions is 31.75°C, the mean relative humidity is 47.6%. The only cushion for which the WA CC failed to reduce temperature and relative humidity more than the standard own-brand cover was a non-permeable inflatable air cell cushion (mean increase of 1°C and 4.5%). The environmental temperature was 23.8°C (±1.3°C) and environmental humidity was 40.7% (±12.7%).

The best results were found for the cushions which were the most permeable; a single-density foam, lattice honeycomb and an air & moisture permeable compartmented air cells cushion. One interesting finding was the interconnected neoprene air cells cushion, which is a non-permeable cushion, still the microclimate cover had some effect, to amplify this effect drainage holes were made in the base of this cushion, in between the interconnected neoprene air cells. This resulted in a cushion that was air and moisture permeable, and with the microclimate cover the mean temperature could be decreased with 1.4°C and the relative humidity with 28.9%.

Discussion/ conclusion; conclusion for the practice

This gives an indication of the dissipating temperature, perspiration and moisture levels that can be achieved when using the microclimate cover with active airflow and how it could help prevent the formation of pressure ulcers by reducing the skin temperature and skin surface humidity. The mean temperature for the cushions which are permeable are below the crucial threshold of 33°C. And the relative humidity was also a lot lower, which prevents maceration of the skin. Overall the microclimate cover prevented a rise of relative humidity compared to the start values. For the temperature it depended on the cushion tested, but in all cushions a stable state was reached and further increase in temperature was avoided. Depending on the clients needs it's worth looking at the type of cushion that is prescribed, because some cushions give better microclimate results then others, and the microclimate cover is more effective with some cushions then in others. Overall, we can state that the microclimate cover is effective in lowering the temperature and relative humidity next to the skin of a wheelchair user. More research needs to be done to look at the clinical effects of these findings.

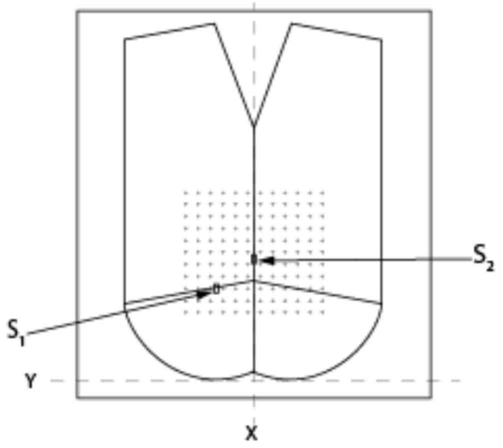
References

Greasley, S,. (2018) Reducing temperature at the seat-patient interface in carved foam seating. Department of Medical Engineering and Physics, King's College London.

Kottner, J., Black, J., Call, E., Gefen, A., Santamaria, N. (2018) Microclimate: A critical review in the context of pressure ulcer prevention. Clinical Biomechanics, 59, 61-70. Doi: 10.1016/j.clinbiomech.2018.09.010

Lachenbruch C. (2005) Skin cooling surfaces: Estimating the importance of limiting skin temperature. Ostomy Wound Manage, 51(2):70-79

Image: OTworld Figure 1 iButton placement_242.png



Sensor Number	X_{loc} (mm)	Y_{loc} (mm)	Sensor location by rows and columns of holes (from top left corner)
S1	-55	130	Row 9, Column 3,5
S2	0	175	Row 6,5, Column 6,5

Figure 1. The two iButtons used to log temperature and relative humidity were stitched onto the top of the seat cover at marks S1 and S2 in the figure above. This configuration derives from the ISO 16840-11 procedure.

Image: OTworld Figure 2 - WheelAir Cushion Cover_243.png

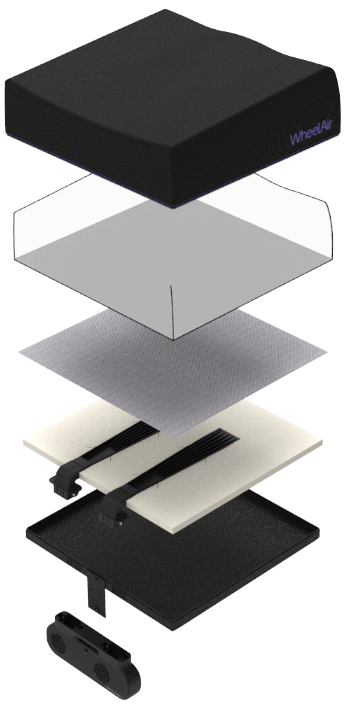


Image: OTworld Table 1 - values of all individual cushions_244.png

Cushion type/material	Standard cover		WA CC		Mean difference		Peak differences	
	mean T (°C)	*mean rH(%)*	*mean T (°C)*	*mean rH(%)*	*T (°C)*	*rH (%)*	*T (°C)*	*rH (%)*
Mixed-density foam	33.5	48.1	32.1	40.6	1.4	7.5	2.5	21.2
Lattice 'Honeycomb'	34.2	58.8	30.6	39.4	3.6	19.4	5.7	41.0
Single-density foam	34.1	47.9	29.9	35.9	4.2	12.0	5.2	21.0
Air & moisture permeable compartmented air cells	34.8	63.6	31.6	41.8	3.2	21.8	3.5	35.4
Non-permeable inflatable air cell	34.1	54.0	35.1	58.5	-1.0	-4.5	-0.3	-5.9
Single-density foam with gel insert	34.9	62.6	30.9	65.1	4.0	-2.5	4.7	12.8
Mixed-density foam with air insert	34.3	63.9	34.0	59.5	0.2	4.4	0.8	9.9
Interconnected neoprene air cells	33.4	67.4	32.9	60.3	0.5	7.2	1.0	12.9
Interconnected neoprene air cells with drainage holes	33.4	67.4	32.0	38.5	1.4	28.9	2.5	38.7

Table 1. All the values for the individual cushions, with standard cover and WA cushion cover and the mean and peak differences between the two. The peak difference indicates the max. point of difference, when this is negative the standard cover gives lower values then the microclimate cover. T=temperature, rH=relative humidity.