Reducing temperature at the seat-patient interface in carved foam seating

Sarah Greasley, Oxford Centre for Enablement
Additional author: Rick Houghton, Oxford Centre for Enablement

Summary
Preliminary experiments show that open-cell foam has passive cooling benefits in comparison to CM50 foam (closed-cell). Additionally, the use of integrated fans can provide significant cooling, with a more uniform temperature distribution. There is potential to expand this work to direct the air flow, and allow user operated temperature control.

Aims & Objectives
This work aims to reduce seating surface temperature in carved foam seating, both for comfort and pressure ulcer management. A viable testing method for analysing temperature at the seat-patient interface will be established. The passive cooling effects of open-cell foam will be tested, with the option to actively ventilate using fans. The possibility of channelling the fan ventilation to specific areas of higher temperature will also be investigated.

Background
User feedback has indicated that the greatest need for improvement in carved foam seating is the reduction of perspiration by the regulation of interface temperature [1]. It has been found that a subject's definition of a comfortable temperature varies with their current body temperature. Therefore the most comfortable chair should have a neutral effect on body temperature, allowing for air flow to/from the surroundings [2]. It is also known that the severity of pressure injuries correlates with an increase in applied temperature [3]. A reduction in seat-patient interface temperature would therefore have direct clinical benefits. There is currently very limited literature on seat-patient interface temperature in carved foam seating and, as there is no standardised testing method or data collection technique, it is difficult to compare results from different studies. While some studies use complex systems to model subjects, others use either patients or healthy volunteers. Many are also limited in terms of length of data collection or number of subjects. It has been seen in previous studies that the material properties of the cushion has the most significant effect on seat-subject interface temperature [4].

This study looks at the use of a new open-cell foam to make carved foam seating. The foam was successfully machined using a CNC milling machine, and pressure mapping results showed good pressure relieving properties. Temperature sensors (Analog Devices TMP37FT9Z, +5 → +100 °C) were permanently attached to a breathable cover beneath the groin, coccyx, right IT and right mid-thigh so recordings could be taken repeatedly from specific areas of interest. A data logger was used to record temperature variation at each location over a specified time period. Multiple preliminary tests were conducted on a healthy subject under 3 conditions: A) Custom contoured cushion manufactured from standard CM50 foam, B) Custom contoured cushion manufactured from open-cell foam, C) Custom contoured cushion manufactured from open-cell foam with fans providing forced ventilation.

In condition B, the open-cell foam was encased in an ABS shell with ventilation holes to allow for passive air flow. However, in condition C the ABS shell was sealed to direct air flow from the fans towards the patient. The interface temperature was found to vary slightly between repeated tests; however this did not correlate with varying room temperature, which was measured throughout each test and observed to have no effect on results. It was found that in tests A and B, the groin was at the highest temperature with the same temperature distribution observed for all repeated tests.

The open-cell foam provided consistent passive cooling at all 4 specified locations, with temperatures after 45 minutes being an average of 0.9 ± 0.2 °C cooler. Forced ventilation provided increased cooling with a maximum of a 4.0°C of cooling observed at the sacrum after 45 minutes. Cooler temperatures were also seen at all other locations, and statistical analysis showed these decreases to be statistically significant ($p \leq 0.05$) at all locations. Subjective observations from multiple subjects also revealed this cooling to be significant.

Discussion

From these preliminary results, a repeatable testing protocol will be established, and multiple healthy subjects will be tested under each condition for a specified time period. It will be necessary to determine after what time the temperatures plateau for each condition, as this was not observed to happen within the timescales specified by previous research [5]. However, it is expected that the temperature profile will be consistent across all subjects [6]. Only one previous study has used fans to attempt to actively cool patients [1]. This was done by cutting channels for air flow into the foam and resulted in a very uneven temperature distribution. However, the results from our experiment show that active cooling in open-cell foam can produce a far more uniform temperature distribution with a comfortable drop in temperature. Alternatively the air flow could be directed by sealing areas of the open-cell foam or use of non-breathable covers. This will be investigated in the next stage of this research. Additionally the fans were shown to lower the temperature when turned on at any point during the experiment. Cooling could therefore be controlled automatically by switching the fans on/off at specified temperatures or as desired by the user. This will also be investigated.

The main challenge associated with previous use of porous materials in seating is bacterial growth. The open-cell cushions can be washed through under a shower; however, the cushion will have to be dried and these issues will have to be addressed to enable clinical use.

References

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Email: sarah.greasley@ouh.nhs.uk