A pressure mapping comparison of carved cushions made from different foams or a combination of foams.

Summary
To critically appraise various materials used in the construction of wheelchair cushions. Including how pressure map results vary when using different types of foam; thus determining whether it is better to use a specific type of foam or a combination of foams to distribute pressure away from at risk areas. Figure 1 shows the pressure mapping mat and computer software setup.

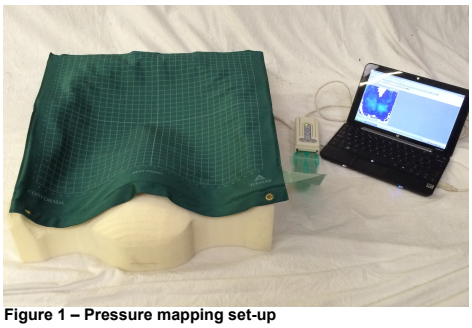


Figure 1 – Pressure mapping set-up

Aims and Objectives

- To discuss the properties of different types of materials of foam used in the construction of wheelchair cushions.
- To use pressure mapping to compare the pressure relief properties of each material used in the construction of cushion, as a single material or as a combination of materials.
- To use pressure mapping results to determine which type of cushion material applies the least pressure on load bearing area, specifically **ischial tuberosities, ITs.**

Background

One of the main purposes of a wheelchair cushion is to prevent pressure sores. When we sit, only one third of the body's surface is supporting the whole of its weight and blood flow is restricted (Karp, 1998). For example, people with spinal cord injuries experience muscle atrophy and circulation is limited further by the loss of muscle, which once served as a natural cushion (Karp, 1998).

Another important purpose of a wheelchair cushion is to distribute pressure evenly and provide optimum postural support for people with physical disabilities. In order to achieve optimum pressure distribution, the surface area must be increased. (Pressure = Force/Area). It is assumed that by making the cushion anatomically shaped, it provides pressure relief. Hence, the purpose of this study is to investigate this further.

Types of foam

All foams can be classified by three main properties:

- Density - the density of a material is defined as the mass per unit volume. It is a measure of how tightly the atoms of a material are packed
- Indentation Load/Force Deflection
- Modulus

Polyurethane foams vary greatly in their quality and properties depending on which chemicals and processes are used in their manufacture. They are open cell foams. It can provide a supportive and stable cushion that will maximise the surface contact area and re-distribute pressures away from bony prominences onto more fleshy areas. Potential issues are peak pressures and ability to weight shift. PU foam has a weight per cubic meter ratio of 50kg/m^3.

Visco-elastic foam (memory foam) cushion assists in the reduction of pressure to the user's vulnerable bodily points and areas, whilst providing stability and shock absorption. It also helps in the reduction and prevention of pressure ulcers as it envelops anatomical shapes well and a softer surface allows flow.

Plastazote (LD24) is a lightweight, rigid structure that provides good postural support. However peak pressures on bony prominences can be increased due to the construction of the cushion. Plastazote has a weight per cubic meter ratio of 24kg/m^3.

Large open cell foam (LOC) is similar in construction to Polyurethane foam but has larger open cells, which allow breathability over the surface area. This type of material is easy to keep clean due to the open cell construction of the cushion. Large open cell (LOC) foam has a weight per cubic meter ratio of 32kg/m^3.

As all the foams used at Consolor are high quality, they offer good resilience and are resistant to damage upon everyday use. The foams used can last up to 5 years, although over time foams will lose their resilience.

Technique

The subject was a 42-year-old able-bodied male. The 12 cushions were placed on a rigid surface and the subject was sat on each cushion for six minutes before the pressure mapping readings were taken. This is the recommended time according to a study conducted by Stinson et al. (2002) as it allows the foam to fully compress and contour to the body and also allows stabilisation of pressure mapping values. The subject was then pressure mapped sitting upright in every test, holding their trunk upright. An average of four readings per cushion were recorded to ensure that any anomalies or incorrect readings were eliminated. Figure 2 shows an example of the set up of the test on a client. To ensure that the results were only affected by the independent variables, the following factors were considered as fixed variables:

- Time (settling time before the readings are taken)
- Weight of subject
- Temperature (of environment)
- Level of humidity
- Sitting position (to maintain same position as much as possible)

Figure 2 – Example of the pressure mapping test set up.

Testing

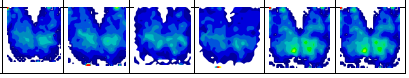
Pressure mapping was carried out using Conformat Clinical v7 in order to establish the difference in peak pressure under the ITs and average pressure over the seated surface.

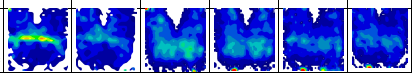
The 12 cushions were used in a variety of combinations:

Materials	PU	LD24	LOC	½" Visco Layer	½" Visco Insert	½" layer and ½" insert
Cushion 1	X					
Cushion 2	X			X		
Cushion 3	X				X	
Cushion 4	X					X
Cushion 5		X		X		
Cushion 6		X			X	
Cushion 7		X				X
Cushion 8		X				
Cushion 9			X			
Cushion 10			X	X		
Cushion 11			X		X	
Cushion 12			X			X

Results

Upon looking at the peak and average pressures, the following results were obtained:

	1	2	3	4	5	6
Cushion Description	PU foam	PU foam with ½" visco layer	PU foam with ½" visco insert	PU foam with ½" visco layer and insert	LD24 foam	LD24 foam with ½" visco layer
Peak pressure (mmHg)	90	89	86	84	128	110
Average pressure (mmHg)	48	44	44	43	52	47
Pressure mapping carried out with Tekscan CONFORMat clinical v7						

	7	8	9	10	11	12
Cushion Description	LD24 foam with ½" visco insert	LD24 foam with ½" visco insert and layer	LOC foam	LOC foam with ½" visco layer	LOC foam with ½" visco insert	LOC foam with ½" visco layer and insert
Peak pressure (mmHg)	91	81	100	91	79	72
Average pressure (mmHg)	44	40	49	46	41	42
Pressure mapping carried out with Tekscan CONFORMat clinical v7						

- When using contoured foam for the construction of a wheelchair cushion, PU foam offers maximum pressure relief under the ITs. An example of when this type of foam may be used over another is when a client requires good distribution of pressure as well as good postural support.
- Using a contoured foam cushion with a ½" memory foam layer in the construction showed that PU foam had the lowest peak pressure under the ITs as well as the average pressure on the seated surface.
- Using a contoured foam cushion with a ½" memory foam insert, it is observed that the peak pressure under the ITs is significantly reduced in all three materials used for the construction of the cushion. This is because the nature of the memory foam contours more, especially under the ITs, as it warms up. The LOC foam with a memory foam insert showed the lowest peak pressure under the ITs and lowest average pressure. Having a memory foam insert allows immersion of the ITs into the cushion and helps to alleviate peak pressure and allow flow – which helps in reducing shear stress.
- Using a contoured foam cushion with a ½" memory foam layer and a ½" memory foam insert achieves the greatest pressure relief in all three types of cushion. The LOC cushion with a ½" layer and ½" insert of memory foam results in the lowest peak pressure under the ITs and least average pressure on the seated surface. The may be because of the density of LOC per cubic meter – as it allows good pressure distribution and good support. Using it in combination with a memory foam insert and layer allows good contouring and pressure alleviation over bony prominences.

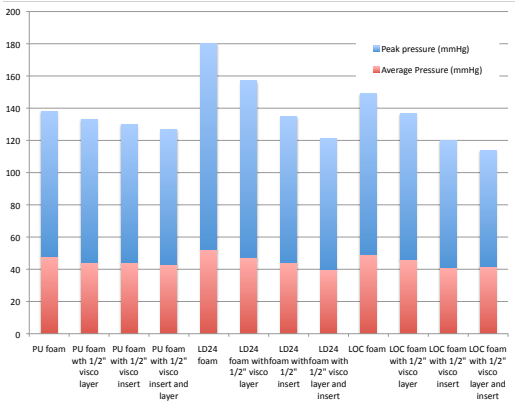


Figure 3 - The pressure mapping comparison of peak and average pressures from the different cushions.

Discussion

To achieve the ideal seated position, the contour of the cushion needs to work with the anatomy to provide all the support required. By shaping foam anatomically and layering different foams, the cushion will gain the best properties from a combination of foams by maximising surface contact area and decreasing the pressure in areas of greater risk.

Shear force is another factor which should be considered – as we tend to slide forward in the cushion, causing shear stress across the surface of the skin which results in a higher risk of the development of pressure sores. Sitting is a dynamic activity and it is difficult to measure shear stress using pressure mapping.

The pressure mapping results should not be solely used to determine the choice of material used for manufacturing a cushion, but the patient's specific postural needs. For example, for a client who requires a lot of postural support and pressure relieving properties, a Plastazote cushion with a memory foam insert and layer would be recommended; whereas a client who requires postural support as well as permeability, a large open cell foam cushion would be recommended.

Using appropriate materials in the construction of wheelchair seat cushions can:

- Improve pressure distribution by maximising the overall contact surface area.
- Reduce dynamic shear by providing some 'flow', which would allow bony prominences limited movement within the seat surface, which could be achieved using memory foam.
- Provide required levels of support so that the client remains in the intended position on the seat cushion.
- Provide breathability, which decreases heat and humidity at the tissue level.

It is important to note that good pressure distribution is only one important factor to consider whilst assessing for a wheelchair cushion. Other factors such as support, stability, shear reduction, and micro-climate should be considered to ensure that a holistic client centered approach is taken The pressure mapping shows how different materials, if used in the right conjunction can help to achieve the best possible solution for the client. It is often easy to 'pigeon-hole' clients according to their level of need but by looking at the whole picture, the clinician can make a well informed decision to ensure that maximum pressure relief is achieved as well as not compromising function and ability.

It is also important to note that whilst a pressure map can give important information about a specific individual sitting on a particular surface, the information cannot be generalised to other people or cushions as the same cushion under a different person may give completely different results.

A value alone does not predict whether a patient will acquire a pressure sore or not, there are other factors such as: posture, range of motion, strength, spasticity and movement, diet, health, and moisture, which will effect the seating provision. Hence, pressure mapping should not be used solely for seating provision but used as a tool to augment the decision making process.

References

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