INTRODUCTION
Pressure injuries are a major, yet common, complication affecting wheelchair users’ health and quality of life. [1] They are often due to experiencing pressure over long periods of time from sitting without performing pressure relief maneuvers. Pressure injuries treatment is lengthy, expensive, and severely limits functional capacity. Due to this, wheelchair cushion and seating system designs are used to maintain tissue integrity and proper posture. [2]

Over time, cushions may experience degradation of mechanical properties which inhibits their ability to properly support the user. Changes in these properties can indicate that some cushions wear, a bottoming out effect occurs, which reduces their pressure-distributing characteristics. This study assessed the effects of simulated aging on a cushion cohort using performance standards.

What are Performance Standards?
- Consensus documents specifying procedures to test and quantify cushion characteristics related to pressure injury prevention
- Established Nationally (ANSI/RESNA in US) and Internationally (ISO) by designated committees of diverse stakeholder representatives

How can YOU use performance standards?

CUSHION PERFORMANCE CHARACTERIZATION TESTS

| LOADED CONTOUR DEPTH & OVERLOAD DETECTION | Simulated aging is a procedure that subjects the cushion to a variety of conditions representing typical use over an extended period of time. Performance characteristics are measured before and after the procedure to evaluate the stability of the cushion’s key performance metrics over time and with use. Small changes pre and post aging would reflect a cushion that maintains its functionality.

Simulated Aging Protocol:
A cohort of 21 cushions of varying designs were selected to represent general use, skin protection, and positioning cushions on the market at the time of selection. The RESNA WC-3.5 seating standard defines methods of aging estimated to represent 18-24 months of use. [3] Simulated aging methods were performed in the following order: disinfection, laundering, accelerated aging for half the indicated time period, cycling loading at room temperature, accelerated aging for half the indicated time period, disinfection, and laundering. Disinfection and laundering were performed according to manufacturer instructions. Accelerated aged cushions were held at 50°C for 3 days at 50°C for cushions containing materials that degrade at elevated temperatures or 11 days at 70°C otherwise. The cyclic loading procedure repeatedly applied a 500N force for 1750 cycles through a rigid indenter modeled after the buttocks and thighs.

In order to determine the effects of simulated aging on the cushion cohort, the cushion performance characteristics tests were conducted before and after one aging cycle. The testing was performed with a static-aged test and Wilcoxon signed-rank test when normality was not found. All correlations were conducted with a 95% confidence interval. Additionally, small, medium, and large effect sizes were categorized as 0.0 to 0.3, 0.4 to 0.6, and 0.7 and above, respectively.

RESULTS
Statistically significant changes were found within the impact damping, hysteresis, and horizontal stiffness characterization testing. A higher horizontal stiffness indicates better comfort and postural stability. A lower Impact 1: Impact 2 ratio indicates better distribution of energy after initial contact, decreasing tissue loads and reducing bounching.

DISCUSSION

| Load Contour Depth | The minimum simulated aging method in the RESNA standard had a clear effect on cushion performance characteristics. Results from loaded contour depth, hysteresis, impact damping, and horizontal stiffness characterization testing indicated decreased cushion performance after approximately 18-24 months of use. The simulated testing showed cushion stiffening, decreased immersion and decreased stability. While those that measured pressure distribution directly showed an improvement in pressure after aging. These changes can greatly impact a user’s risk of pressure injuries. Continued testing after additional aging cycles is underway to assess the lifespan of a cushion and what changes are to be expected with extended use.

| CONCLUSIONS

Simulated Aging:
- Simulated aging is a procedure that subjects the cushion to a variety of conditions representing typical use over an extended period of time. Performance characteristics are measured before and after the procedure to evaluate the stability of the cushion’s key performance metrics over time and with use.

Effect of simulated aging on cushion performance metrics

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Variable</th>
<th>Pre-Aging Mean (SD)</th>
<th>Pre vs Post t 1 p-Value</th>
<th>Pre vs Post t 2 p-Value</th>
<th>Pre vs Pre Post Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loaded Contour Depth</td>
<td>Loaded Contour Depth (mm)</td>
<td>48.6 (13.8)</td>
<td>2.7 (0.5)</td>
<td>4.1 (1.7)</td>
<td>6.3 (1.0)</td>
</tr>
<tr>
<td>Loaded Overload Defects</td>
<td>Loaded Overload Defects (mm)</td>
<td>0.5 (0.2)</td>
<td>1.7 (0.1)</td>
<td>1.7 (0.1)</td>
<td>0.8 (0.1)</td>
</tr>
</tbody>
</table>

*Note: t values indicate the statistical significance of the change.*

A cushion’s ability to conform to the user and maintain the contour shape.

| Impact Damping | Impact 1 | Impact 2 | Impact Ratio (%)
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1.31 (0.31)</td>
<td>1.05 (0.15)</td>
<td>1.22 (0.25)</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Impact Ratio (%)*

Cushions with higher additional immersion under normal and overload conditions and slightly increased stability. A lower mean pressures. Reasons might include a change in immersion and decreased stability. While those that measured pressure distribution directly showed an improvement in pressure after aging. These changes can greatly impact a user’s risk of pressure injuries. Continued testing after additional aging cycles is underway to assess the lifespan of a cushion and what changes are to be expected with extended use.

<table>
<thead>
<tr>
<th>Hypertension</th>
<th>Hydrostatic (250N)</th>
<th>Hydrostatic (500N)</th>
<th>Hydrostatic (250N)</th>
<th>Hydrostatic (500N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>139.4 (6.8)</td>
<td>135.7 (6.3)</td>
<td>54.8 (4.0)</td>
<td>50.9 (4.3)</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Hypertension*

Hysteresis measures the amount of energy lost to the wheelchair cushion during a cycle of loading and unloading. When a wheelchair is navigating rough surfaces, such as dropping down a flight of stairs or off a curb, a cushion with a larger hysteresis value transfers less energy to the user’s tissues, thus absorbing more energy itself. Hypertension at 250N and 500N decreased after indicating more energy could be transferred to the user’s buttocks, thus increasing soft tissue injury risk.

Impact Damping
- Higher values within the Impact 1 and Impact 2 metrics indicate less stability for the user through bounching and higher energy transfer to buttock tissue. Both metrics increased after aging indicating worse cushion performance.

Horizontal Stiffness
- High horizontal stiffness may offer greater postural stability, but the change of tissue deformation increases due to shear forces at the cushion interface. The decrease in Peak and Final forces post aging indicates decreased stability but may help to accommodate in-seat movement and transfers through lower shear forces.

REFERENCES

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