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## Investigation of the Lifespan for Wheelchair Cushions used on a Daily Basis

**David M Rivard, BS Mathematics**  
**The Shepherd Center**  
**Stephen Sprigle, PH.D., MSPT;**  
**Maureen Linden, MSBME**  
**Center for Assistive Technology**  
**and Environmental Access,**  
**Georgia Institute of Technology**

### ABSTRACT

Wheelchair cushions function to mediate seating pressures and provide postural stability. For the majority of cushions used on average 12 hours daily, the cover and interior components degrade at varying rates while performance for their intended purposes diminishes resulting in an increased risk for skin health deterioration and inadequate postural support. While age and use are determinants of cushion degradation, additional factors or combinations of factors contribute to rate of wear. At present there is no validated metric whereby clinicians and users may assess cushion condition and replacement of a potentially worn cushion. A multiple phase collaborative research project conducted at the Shepherd Center is currently testing the functionality and degradation of wheel chair cushions. Preliminary visual assessments indicate that some cushions are used inadequately while others responded to postural deformities. Loaded contour depth analysis revealed that age and cushion construction alone are not significant predictors. A supplementary benefit from this study is the documentation of critical factors to cushion wear and failure; whereby, clinicians and users can be

educated on proper care and preventative measures to reduce wear; whereby, optimizing health benefits for the user and possibly increasing the lifespan of the cushion.

## KEYWORDS

Pressure ulcers, degradation, testing, impact dampening, loaded contour depth

## BACKGROUND

In 2003, the average cost of hospitalization primarily for treatment of pressure sores was \$37,800 with an average stay length of 13 days (1). For hospitalized individuals whose primary diagnoses was Spinal Cord Injury 31% were between the ages of 18 to 44 and 14.1% between 45 to 64 (1). A variety of wheelchair cushions serving specialized purposes with alternative prevention methods are available to the user. One specific purpose and method is to reduce the harmful effects of seating pressures by operating on the principles of immersion and envelopment. *Immersion* is the distance the body sinks into the support surface and an increase in immersion leads to greater contact area at the buttock-cushion interface. As the contact area increases, the seated pressures are dispersed over a larger area resulting in decreased average pressures and a reduction of the pressure on bony prominences where skin breakdowns are most prevalent. (2).

Linden, et.al, used a laboratory-based simulated use protocols consisting of heat aging, laundering and cyclic loading to determine changes in immersion and material failure mechanisms for 90 cushions (3). Cushions were aged to their required SADMERC lifespans – 12 months for general use cushion, 18 months for other cushions. Approximately 8% of these cushions exhibited material failures (e.g., viscous fluid bladder failure). There was a statistical difference between immersion pre- and post test with 9.6% of cushions failing an overload immersion testing following simulated use (3).

Controlled simulated use testing can differ from the highly varied usage of cushions in every day use. Bench testing uses models loaded symmetrically, whereas in the real world, many users sit asymmetrically or in slouched positions. Cushions tested in a laboratory are adjusted according to manufacturer's requirements whereas in real life users do not always keep their cushion properly adjusted.

The information gained from laboratory testing provides uniform testing information with repeatable results; however, performance testing utilizing daily use cushions provides data which is more reflective of actual use. This real world assessment can serve as validation of simulated use test methods.

Currently, all cushions sold in the US are required to undergo a simulated use test. Most wheelchair cushions are required to pass the loaded contour depth and overload test after 18 months of simulated use, with only the 'general use' category requiring a 12 month test. However, cushions, like all DME, have a defined lifespan of 5 years even though they are tested for only a percentage of that time period. . If cushions fail or fatigue before the 5 year standard and after the warranty period, users may face the prospect of purchasing a cushion themselves or having to use a cushion that is no longer performing as intended.

This paper reports interim results of a five-year study on performance of cushions in everyday use. The objectives of the entire project include: (a) determine the functional lifespan of wheelchair cushions used in typical daily fashion, (b) verify or negate the 5 year expected lifespan for durable medical equipment (DME), (c) identify critical factors contributing to or accelerating degradation, and (d) develop a simple and comprehensive test to assist clinicians and users with the decision of replacement.

## **RESEARCH OBJECTIVES**

The objective of this paper is to report the results of loaded contour depth and overload tests of cushions in everyday use, and to relate test failures to the age and construction of cushions.

## **METHODS**

Cushions were collected from a convenience sample of wheelchair users seen by the seating clinic at the Shepherd Center. The client's cushions were evaluated by conducting performance tests, a visual inspection, questionnaires, and a postural evaluation. This paper reports only results from the Loaded Contour Depth Test.

The entire protocol can be briefly described as follows. Clients are asked to answer questions about cushion age and use, under what environmental conditions it is used, and if any repairs or component replacements were made.

A postural evaluation conducted by a physical or occupational therapist reports deviations/asymmetries of the participant's pelvis, trunk, hips, knees, and ankles to provide data reflective of the many symmetric and asymmetric seating positions from which to analyze how posture affects cushion wear. Cushion characteristics such as manufacturer, model, coding category, and material construction were documented. Visual inspection of the cushion is performed to assess cleanliness, and signs of wear or failure. Cushion components were photo documented for future visual comparative assessment. Participants undergo interface pressure testing. The cushion also undergoes pressure testing using a buttock model and an impact dampening test and loaded contour depth tests (4).

The loaded contour depth test measures the immersion of a standardized indenter and then applies an 33% overload to insure the cushion has not bottomed out. Cushion thickness was measured along left and right lateral support surfaces at a location 130mm forward of the rear cushion border using a single indenter applying 1.5N. A loaded contour jig (LCJ) with a height of 40mm and applying 135N +/- 5N was located at the 130mm position. The vertical distance from the support surface to the inferior surface of the LCJ was recorded after 180s. Following this normal load and overload event is simulated by increasing the load to 180N +/- 5N for an additional 60s with vertical distance recorded. This initial procedure is repeated twice within 300s of each other to allow cushion recovery (4).

## **RESULTS/DISSCUSSION**

Cushions from 55 wheelchair users were tested. Client ranged in age from 21 to 72 from both genders and primarily had a diagnosis of spinal cord injury. The cushions ranged in age from one week to 120 months. A variety of cushions were tested including air (n=17) and combinations of foam with viscous fluid (n=28) or air (n=10) bladders. All cushions included in this analysis met the criteria of a 'skin protection' cushion as defined by the Centers for Medicare and Medicaid Services. This designation requires that a cushion have a loaded contour depth of, at least 4 cm and an overload test of at least 3 mm..

Failure is defined when deflection after overload is not greater than 0.2. Twelve cushions (21.8%) failed the overload test. This is a higher rate than shown in previous laboratory fatigue testing (3). This may be, in part,

because the bench testing is meant to simulate cushion use over only 18 months. Cushions in this study were older with the average age of the cushions that failed being 43 months. Of the 55 cushions tested, six gel/foam and one air/foam cushions had a loaded contour depth measure of less than 4 cm. This means that they no longer met the minimum immersion requirements of a 'skin protection' cushion. All air cushions met the 4cm LCD requirement. A total of 15 out of the 55 cushions failed either the LCD or immersion test. Paired t-test results for the cushions that passed/failed the loaded contour measure concluded no difference in the mean ages (T-value 0.48, P-value 0.639 and a paired t-test on the cushions that passed/failed the overload test concluded no difference in the mean ages (T-value 1.26, P-value 0.221).

**Table 1 LCD and Overload test results of cushions no longer meeting minimum immersion requirements**

Mat Const	Loaded Depth	Overload Depth	Age in Months
Gel/Foam	2.9	0.2	27
Gel/Foam	3.7	0.2	33
Gel/Foam	3.3	0.2	12
Gel/Foam	3.8	0.3	60
Gel/Foam	3.4	0.4	36
Gel/Foam	3	0.2	47
Gel/Foam	3.2	0.3	54

**Table 2 LCD and Overload test results of cushions no longer meeting the overload minimum requirements**

Mat Const	Loaded Depth	Overloaded Depth	Age in Months

# Conclusion

Cushions used in everyday life are exposed to a variety of loading and environmental conditions. Even though cushions are supposed to be used for 60 months, data has not been collected that measures performance after everyday use. Data on 55 cushions indicate that 15 cushions failed the Loaded Contour Depth test or overload depth test- measures of immersion and bottoming out used by CMS. These cushions had been in use and average of 35 months at the time of testing. Additional data on more cushions is being collected that will help document the expected useful life of cushions. This information can be used by manufacturers to inform product development, and wheelchair users to better understand how cushions age and how long they might last.

# Bibliography

1. Russo, C. A. and Elixhauser, A. *Hospitalizations Related to Pressure Sores, 2003*. HCUP Statistical Brief #3. April 2006. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.hcup-us.ahrq.gov/reports/statbriefs/sb3.pdf>
2. Cochran G, Palmieri V "Development of Test Methods for Evaluation of Wheelchair Cushions." *Bulletin of Prosthetics Research* 17(1): 9-30.
3. Linden M, Sprigle S, Changes in Wheelchair Cushions as a Result of Simulated Use Protocols; RESNA 2006 Conference Proceedings, Atlanta, June 22-26, 2006, CD-ROM
4. International Organization for Standardization (ISO), *Wheelchair Seating-Part 2: Determination of physical and mechanical characteristics of devices intended to manage tissue integrity – Seat Cushions*, ISO 16840-2:2007

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Phone: (703) 524-6686 - Fax: (703) 524-6630