

TASK: S-1 CUSHION DESIGN FOR ULCER PREVENTION

Investigators: David M. Brienza, Patricia Karg, Jue Wang, Chen-Tse Lin
Collaborators: Ying-Wei Yuan, Qiang Xue

Rationale

The prevention of pressure ulcers through the use of custom contoured foam seat cushions (CCFSCs) is one aspect of seating that can benefit the user through investment in research. The efficacy of using CCFSCs has been shown in clinical trials [Sprigle, et al 1990] and is being established on a larger basis now that CCFSCs are commercially available. Computer-aided design and manufacture (CAD/CAM) technology related to CCFSCs is limited to anatomical measurement, ad-hoc data processing and shape editing techniques, and the automated manufacturing of cushions. The expansion of this technology to systematic data processing techniques requires that the existing gap in scientific knowledge concerning the relationship between support surface shape and interface pressure distribution be filled. The research

proposed in this task will work to fill this void in knowledge. The flow chart of Figure 31(a) depicts the current design process. The weaknesses of this procedure is the dependence of the outcome on the clinician's knowledge and experience, and the trial and error iteration involving repeated cushion manufacturing, both of which add cost to the end product. The improved prescription process is illustrated in Figure 31(b). Generic modification formulas, dependent on parameters like functional ability, tissue tone, age, body weight, and gender, will be used to eliminate the need for extraordinary skill and experience on the part of the therapist and the trial and error process. The proposed work focuses on the needs of populations with specific requirements for specialized and/or custom seating for pressure relief as a prophylaxis for pressure ulcers.

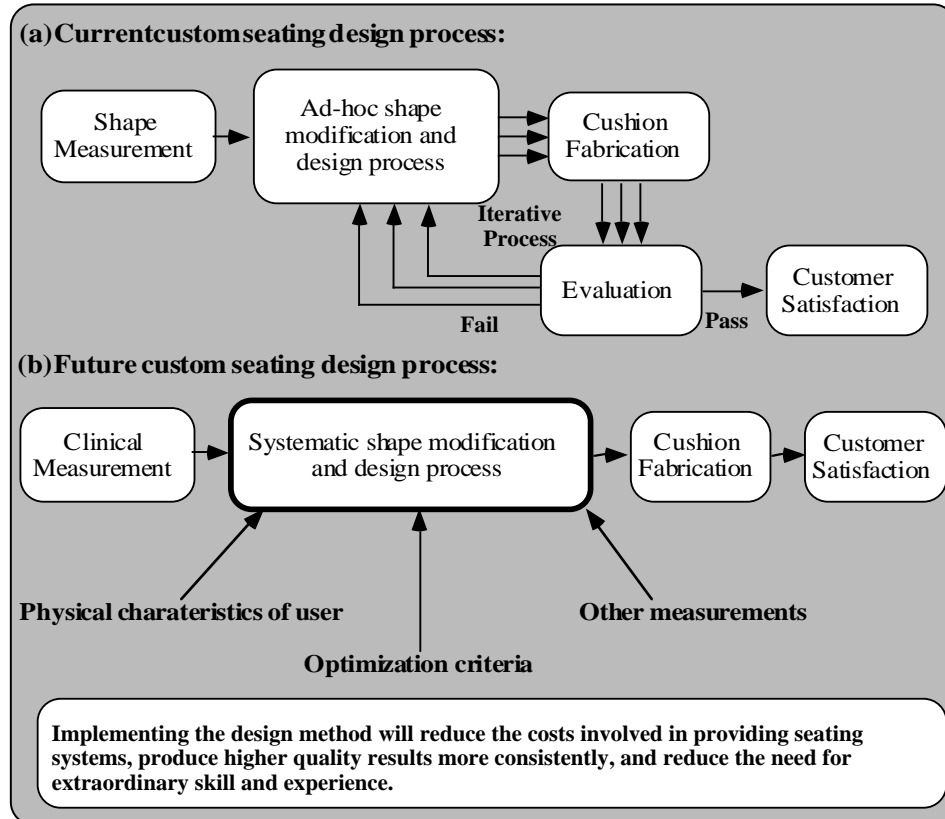


Figure 31(a) - Current custom seating design process (b) Future custom seating design process.

Goals

1. To develop generic seat contour shape modification techniques for persons with SCI and elderly persons.
2. To add to the body of scientific knowledge related to custom seat support surface design.

In Year III, the first year of this project, efforts focused on the analysis and dissemination of previously collected data [Brienza, et al 1996]. During the progression of work in Year III, we identified the need to further investigate the relationship between external forces and soft tissue responses. Understanding this relationship is critical to the design of effective support surfaces. Thus, Year IV work continued the analysis of the pressure and shape data for elderly and spinal cord injury subjects. A third manuscript was published [Brienza and Karg, 1998].

In order to develop the cushion design techniques, the complex shape data had to be reduced. A technique using singular value decomposition was developed to normalize and reduce the shape data. Further analysis of the normalized data can then be accomplished using a factor analysis such as principle component analysis. Initial work has been done to characterize the shapes and determine their relationship with interface pressures on a flat surface.

Year V continued to define the relationship between interface pressure and surface shape from the existing shape libraries. This information will be used to develop design and shape modification techniques. A pilot study will be done to test and refine the technique(s). The ultimate goal will be to develop a method to design contoured cushions from clinically accessible measures such as interface pressures on a flat surface, anatomical dimensions and other characteristics of the user.

Outcome Summary

The interface pressure distributions between flat foam cushions and the buttocks of seated test subjects were compared to custom contoured cushion surface shapes generated with a seated buttock contour gage. Our hypothesis was that pressure measurements

could be used to generate a contour equivalent to that obtained with a force deflection contour gage. The study was performed in a university medical center using SCI (12) and elderly (30) test subjects. Interface pressure was measured using a pressure mapping pad. Contour shape was measured using an electronic force deflection contour gage. Pressure and contour information were reduced prior to analysis using singular value decomposition. Polynomial regressions were performed on the values in the first singular vectors of the corresponding pressure and contour decompositions. Relationships best described by cubic polynomials were detected between pressure and contour shape suggesting that interface pressure predicts optimal contour shape. These results will be published in *IEEE Transactions on Rehabilitation Engineering* 1999.

Recommended Future Research

Our results should be viewed as preliminary and further investigation is necessary to establish appropriate transformation equations for particular subject groups. In particular, we did not find the same relationship between the flat pressure and contour data for both subject groups. We have not determined if the differences between subject groups reflect intrinsic differences in soft tissue properties; or were the result of the use of different thicknesses of foam cushions during the pressure measurement procedure (3" for the elderly and 4" for SCI); or were caused by other factors. Furthermore, the results may be dependent on the measurement techniques employed, including the type of foam used and the spring constantly used in the Electronic Shape Sensor (ESS).

This study revealed relationships between the interface pressure measured between the buttocks and a flat foam seat cushion and the contour measured using a force deflection contour gage. The result indicates that custom contoured seat cushions can be generated using interface pressure measurements without the need for a contour gage. Verification of the relationships is necessary to validate the method.

Publications

Brienza DM, Chung K-C, Brubaker CE, Wang J and Karg PE. A System for the Analysis of Seat Support Surfaces Using Surface Shape Control and Simultaneous Measurement of Applied Pressures. *IEEE Transactions on Rehabilitation Engineering* 1996, (4)2: 103-13.

Brienza DM, Karg PE, Brubaker CE. Seat Cushion Design for Elderly Wheelchair Users Based on Minimization of Soft Tissue Deformation Using Stiffness and Pressure Measurements. *IEEE Transactions on Rehabilitation Engineering* 1996, (4)4: 320-7.

Brienza DM and Karg PE. Seat cushion optimization: A comparison of interface pressure and tissue stiffness characteristics for spinal cord injured and elderly patients. *Archives of Physical Med. and Rehabil.* 1998;(79) April:388-394.

Brienza, DM, Chen-Tse Lin, and Patricia E. Karg. A method for custom contoured cushion design using interface pressure measurements *IEEE Transactions on Rehabilitation Engineering* 1999, (in press).

References

Sprigle SH, Chung K-C, Brubaker CE. Reduction of Seating Pressure with Custom Contoured Cushions. *J Rehabil Res Dev* 1990; 27(2): 135-40.