**FREE PAPER 4**

# Clinical Interpretation of ISO16840-2 Measurements for Wheelchair Seating Cushions

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## Summary

The ISO16840-2 standard defines a set of mechanical characteristics intended to differentiate cushion performance, but the clinical interpretation of these measures is not established. This study uses linear discriminant analysis to explore whether the measures may correspond with current knowledge on the clinical performance of 37 wheelchair seating cushions.

## Aims and Objectives

This study aims to explore the relationship between four sets of measures from the ISO16840-2 standard for the mechanical characteristics of wheelchair cushions and the clinical performance of the cushions, as judged by experienced clinicians. The objective of the study is to help with the clinical interpretation of the ISO measures by determining which measures are most relevant to pressure and stability performance.

## Background

Prescription of an appropriate wheelchair seating cushion is a critical factor to the function, comfort and tissue integrity of wheelchair users. Clinical selection of an optimum cushion however continues to be based on custom and practice, and the individual clinician's experience. The ISO16840-2 standard, published in 2007, attempts to address this by defining a set of tests for wheelchair seating cushions which are intended to differentiate performance characteristics. The standards however do not include clinical interpretation of the test data. This study therefore uses multivariate statistical techniques to explore the clinical potential of the ISO16840-2 standard.

Load Deflection and Hysteresis (section 9), Impact Damping (section 11), Recovery (section 12), and Loaded Contour Depth and Overload Deflection (section 13) measurements were made on 38 cushions according to ISO16840-2. The cushions were selected to represent a range of different designs, or cushions and foams in regular clinical use. The cushions tested were the Roho single valve, Roho Quadtro, Jay J2, J2 Deep Contour, Jay 3 with Roho, Jay Gel, Flo-tech Contour, Flo-tech Contour Visco, Flo-tech Plus, Flo-tech Solution, Flo-tech Lite, Flo-tech Lite Visco, Propad, Qbitus Mercury100, Qbitus Mercury200, Qbitus Mercury300, Qbitus Qbi-gel, Vicair Academy 6, Vicair Academy 10, Varilite Evolution, 2" Polyfoam, 3" Polyfoam, 2" CM60, 3" CM60, 2" CM35, 3" CM35, 2" RX39, 3" RX39, 2" Pink, 3"Pink, 2" Sunmate, 3" Sunmate, 2" 3lb chip, 3" 3lb chip, 2" 6lb chip, 3" 6lb chip, 1" Pink on 2" 3lb chip, and 1" Sunmate on 1" CM35 on 1" CM60

The cushions were also classified by two clinicians experienced in wheelchair seating cushion prescription for postural and tissue integrity management. Each cushion was classified as low, medium or high, according to its clinical appropriateness for pressure management, static, and dynamic postural stability. Impact damping could not be measured on the Varilite Evolution because the rigid cushion loading indenter rebounded clear of the cushion after the first impact. The remaining 37 cushions were therefore used

in the subsequent analysis.

Linear discriminant analysis (LDA) was used to explore whether the ISO measures could be used to produce the same classifications for pressure management and dynamic stability as the experienced clinicians. Three-fold cross-validation was used, in which the cushions were divided into three groups, and then two groups were used to train the LDA and the remaining group used to test. This was done three times such that each cushion was tested once.

For the pressure performance classifications, 29 cushions were correctly classified by the LDA, 8 were classified wrongly by one category and none were wrong by the maximum of two categories. For the static stability classifications 26 were correctly classified, 10 were wrong by one category and 1 was wrong by two categories. For the dynamic stability classifications 23 were correctly classified, 10 were wrong by one category and 4 were wrong by two categories. The Kappa statistic, which quantifies agreement while taking account of chance agreement, was 0.65 for the pressure classification, 0.30 for the static stability classification and 0.39 for the dynamic stability classification. This indicated that agreement of LDA with the original clinical classification was better than chance.

**Discussion**

Linear discriminant analysis is a multivariate statistical technique which establishes a set of equations intended to classify sets of input data into categories. In this study the input data sets were the sets of ISO measurements for each cushion, and the categories were the clinical performance categories for pressure and stability. The equations are developed using data for which the categories are already known, and in this study these were determined by the experienced clinicians. When successful, LDA can classify unknown data correctly, and by examining the coefficients of the equations the most relevant measures for the correct classification can be discovered.

This study has found that the ISO16840-2 measurements examined in the study can be used to classify some cushions into the same categories as experienced clinicians. It also showed that LDA was better when considering pressure relief characteristics than either static or dynamic stability and this may be a reflection of the ISO standard's intention to focus on the management of tissue integrity. The number of misclassified cushions does however mean that these ISO measures may not contain sufficient reliable information on the clinically relevant properties of any given cushion. It is acknowledged however that the clinical classification of the cushions was subjective and errors in this process would also have resulted in misclassifications.

**References**

BS ISO 16840-2:2007. Wheelchair seating - Part 2: Determination of physical and mechanical characteristics of devices intended to manage tissue integrity - Seat cushions

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