# Determination of an Optimal Handrim Compliance

DETERMINATION OF AN OPTIMAL HANDRIM COMPLIANCE

W Mark Richter, PhD and Peter W Axelson, MSME
Beneficial Designs BioMobility Lab, Nashville TN USA

## PURPOSE

The impact spike seen during the beginning of the push phase of wheelchair propulsion bears some resemblance to the impact spike found at heel strike during running, which can be attenuated by adding compliance between the person and the ground. Adding compliance between the handrim and the wheel offers a simple approach to attenuating impact loading during wheelchair propulsion. The purpose of this study was to optimize the level of handrim compliance such that it is soft enough to attenuate impact loading but not too soft such that user acceptance is compromised.

## METHODS

A Variable Compliance Handrim Prototype (VCHP) was designed and built which did not affect handrim size or spacing from the wheel. Three linear response settings were developed to span a range of compliance, with values of 266 N/cm (C1), 191 N/cm (C2), and 124 N/cm (C3).

Seventeen (17) full-time wheelchair users with full use of their upper extremities participated in the study. Subjects used the VCHP to negotiate a propulsion activities of daily living test course in their own wheelchairs. Compliance was increased until subjects felt the compliance was too soft. Subjects then propelled their wheelchairs fitted with instrumented wheels on a wheelchair treadmill while handrim kinetics were sampled at 480 Hz. Each propulsion bout consisted of 15 pushes on each of four ramping conditions: 1) 2% grade at 0.94 m/s, 2) 4% grade at 0.49 m/s, 3) 6% grade at 0.31 m/s, and 4) 8% grade at 0.22 m/s. The three compliance levels and a rigid condition were randomly varied prior to each bout. Subjects were blinded from the compliance condition.

Impact was characterized using the peak and average rate of rise (pROR, aROR) of the resultant force. aROR was defined as the average of the positive force rate values over the push. Differences in propulsion outcomes were determined using a two-way ANOVA with repeated measures and Bonferroni post hoc t-tests.

## RESULTS

All of the subjects were tolerant of compliance at the C1 level, 71% at the C2 level, and 24% at the C3 level. In general, pROR increased, while aROR decreased from the 2% to 8% grades. pROR was found to be statistically reduced using the C1 handrim on the 6% and 8% grades and on the 8% grade using the C3 handrim. aROR was found to be statistically reduced for all the compliance levels on the 2%, 4%, and 6% grades.

## DISCUSSION

Many of the subjects commented that the compliant handrims felt more comfortable than the rigid handrim. Trends in pROR for the C2 and C3 levels suggest users may be adapting by pushing harder to compensate for the increased compliance. Use of aROR is believed to be a

good indicator of impact loading during propulsion.

CONCLUSIONS

An optimal compliance was identified at which impact loading is reduced while user acceptance is preserved. There do not appear to be any adverse side effects associated with the optimal handrim compliance. It is recommended that future handrim designs incorporate compliance as a means of reducing impact loading on the wheelchair user.