DIFFERENCES IN PROPULSION KINETICS BETWEEN WHEELCHAIR DEPENDENT AND NON-WHEELCHAIR DEPENDENT USERS

W. Mark Richter[1, 2], Peter W. Axelson[2], Rory A. Cooper[3]

[1]Stanford University, Stanford, CA (wrichter@stanford.edu) [2]Beneficial Designs, Inc., Minden, NV
[3]Human Engineering Research Laboratories, Highland Drive VA Medical Center, Pittsburgh, PA

INTRODUCTION

Investigation of handrim kinetics during manual wheelchair propulsion provides insight into the demands on the wheelchair user and may ultimately serve to prevent the development of overuse injuries of the upper extremity. Studies enlisting the participation of non-wheelchair dependent users risk drawing conclusions that are not relevant to the wheelchair user population.

In a comparison of the metabolic demand of wheelchair dependent (WD) users and non-wheelchair dependent (NWD) users, Brown et al. found that WD users used less metabolic energy to complete the same propulsion task. In a study comparing propulsion kinetics of WD and NWD users, Robertson et al. found WD users tended to have lower peak tangential and vertical forces as well as longer times to reach those peak values. The researchers concluded that WD users might have developed these propulsion techniques to reduce the stress on the upper extremity. This study reevaluates the kinetic differences between WD and NWD users.

METHODS

Five WD and five NWD subjects participated in the study. Subjects propelled a wheelchair on a stationary dynamometer at a steady state target velocity of 3 m/s. The resistance of the dynamometer was set to simulate propulsion up a 2% grade. WD subjects used their own wheelchair in an unaltered configuration. NWD subjects used a Quickie Carbon wheelchair (Quickie, Fresno, CA). Handrim kinetics were measured using a SMART^{Wheel} instrumented wheelchair wheel (Three Rivers Holdings, Scottsdale, AZ).

Kinetics during ten consecutive pushes from each trial were used in the analysis. Handrim forces were normalized by subject body weight (bw) to remove subject weight as a factor in the results. The force components in the plane of the wheel were transformed from an inertial lab frame to a wheel fixed frame such that the resulting components were radial (Fr), tangential (Ft), and axial (Fa). Peak force components over the entire push and the average rate of force application (dF/dt) over the first ten percent of each push were determined and averaged. Results for each subject group were compared using a two-tailed paired samples t-test and considered to be statistically significant for $p<0.05$.

RESULTS

Resulting values of peak force and initial rate of force application are given for the WD and NWD groups in Table 1. The general trend in the data suggests that the WD users tend to exhibit larger peak forces and a higher rate of force application than the NWD users. Statistically significant differences were seen in the rate of force application in the radial and axial directions. The WD users applied force components 101% and 115% faster than the NWD users in the radial and axial directions, respectively. While propulsion velocity tended to be less for the WD users, the difference was not statistically significant. Had the propulsion velocity been higher for the WD users, it would have provided a possible reason for the trend in increased force on the handrim.

Table 1: Propulsion kinetic characteristics for wheelchair dependent (WD) and non-wheelchair dependent (NWD) users

Parameters	WD	NWD	Significance (p)
Velocity (m/s)	2.68	3.09	0.053
Push Frequency (Hz)	1.15	1.09	0.697
Peak Fr (bw)	0.112	0.081	0.070
Peak Ft (bw)	0.072	0.064	0.435
Peak Fa (bw)	0.047	0.040	0.305
Avg Initial dFr/dt (bw/s)	2.070	1.030	**0.035***
Avg Initial dFt/dt (bw/s)	0.434	0.389	0.725
Avg Initial dFa/dt (bw/s)	1.012	0.470	**0.034***

DISCUSSION

While the results of this study appear to be in contradiction to those found by Robertson et al., the two studies are not directly comparable. The variation in results found by Robertson et al. may be explained by the use of non-body weight normalized forces. Body weight of WD users tends to be less than NWD users due to lower extremity atrophy, which would likely result in a reduced net force required propel the wheelchair.

The decreased rate of force application in the NWD users is believed to be the result an actively positioned and stabilized trunk. This conclusion may be supported by results of the Brown et al. study. Metabolic demand of NWD users would be expected to be greater than WD users due to the use of the large muscle groups of the trunk being used during propulsion. Results of this study indicate that kinetic propulsion characteristics of WD users are different than NWD users and as a result, future propulsion biomechanics studies should restrict participation to WD users.

REFERENCES

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