Effects of Wheelchair Type on Mobility Performance in Community and Home Environments

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INTRODUCTION

Elders with progressively declining abilities constitute the majority (56%) of community-dwelling wheelchair users (Gray, 2002). Most older wheelchair users are partially ambulatory (i.e., use a wheelchair some of the time) (Hoenig, Pieper, Zolkewitz, Schenkman, & Branch, 2002). Little is known about how elders actually use their mobility devices (Berg, Hines, & Allen, 2002). Few studies have examined use of different types of wheeled mobility devices in public environments (Fitzgerald et al., 2003; Koontz et al., 2005) and none included an elder cohort. Little is known about wheeled mobility performance and the impact of device type on wheelchair users.

There are a large number of wheeled mobility devices in use today, ranging from walkers and manual wheelchairs, to scooters and power wheelchairs, each which come with a variety of special features that produce documented benefits for some users. Power mobility devices may be helpful during longer bouts of mobility and the initiation of movement when greater forces are needed (Koontz, et al., 2007; Price, et al., 2007). There is little evidence to suggest that older people would benefit from the use of ultra light wheelchairs and there is scant evidence to support the use of a power mobility device (PMD) when a person can use a manual device. With the variety of wheeled mobility devices available, it is vital to determine the impacts of device on mobility performance in everyday environments to ensure the optimal device is provided to enhance performance and participation of community-dwelling older adults (Hoenig, Harris, Griffiths, Sanford, & Sprigle, 2008). This is dependent on having outcome measures that can successfully detect effects of specific mobility devices on mobility performance. The purpose of this study was to determine if speed was sensitive to detecting differences in the effect of specific types of wheeled mobility devices on mobility performance.

METHODS

Study Design

Repeated measures design was used. Subjects used three wheeled mobility devices, all of which had 4 wheels and a seat, each using a different method of propulsion (4-wheeled walker (WW) [Eco Wide DX], manual wheelchair (MW) [Sunrise/Quickie 2], power wheelchair (PW) [Invacare Pronto M91/SureStep]) to traverse two defined paths at the Durham VAMC; one reflecting a public environment and one a home environment. A variety of subjective and objective measures were collected including self report of factors such as exertion, pain, and device preference according to parameters (i.e., ease of use and maneuverability). Objective measures included time to traverse the path, heart rate, respiratory rate, and oxygen saturation. Each subject's physical functioning was assessed using measures of grip strength, functional reach, gait speed, 2-minute-walk distance and baseline metabolic measures.

A total of 59 subjects were recruited among veterans prescribed mobility aids in the preceding 3-12 months identified through the VA's electronic medical record.

Inclusion Criteria:

1. Mobility Aid: Prescribed WW, MW, or PW in last 3-12 months AND used the device or a cane in the last 2 weeks.
2. Medical: Chronic cardiopulmonary disease AND/OR arthritic disorder.
3. Functional: Active Drivers License AND/OR prescribed and using a power mobility device

Exclusion Criteria:

1. Medical: Neurological, myopathic, or cognitive disorder; poorly controlled hypertension AND/OR acute cardiac disease (unstable angina, heart attack or heart surgery in last 6 months) AND/OR major surgery on abdomen, chest, spine, or arm in last 6 months AND/OR weight >300 pounds AND/OR height >74 inches
2. Functional: Unable to walk and/or propel wheelchair across a small room independently AND/OR needs assistance to transfer AND/OR unable to sit on side of bed independently AND/OR shoulder pain with self care or wheelchair use.

The "community" mobility path involved travel to and from the parking lot in front of the hospital to the physical therapy clinic, which represents a comparable distance to mobility required in typical health care settings and other community mobility tasks. The path traversed was 1,120ft long and navigated through hospital hallways, elevators, lobbies, automatic doors, and over a covered brick walkway. The "home" mobility path navigated from the hallway of the physical therapy clinic into and through the ADL bathroom and bedroom. The spaces are more confined, representing what subjects might encounter in private home settings. The path was 128ft long and navigated through doorways, next to a bathtub and sink, and into a bedroom. Subjects traversed each path a total of 3 times, once with each mobility device.

To give patients a rest in between devices, the second device was always the PW and the first and third device used was randomly assigned as the WW or MW (28 persons = WW first, 28 persons = MW first). Time was determined by review of a digital video recording from a camera that was mounted to each mobility device, which was reviewed for person-environment interactions (e.g., stops/starts, path deviations). Subjects received training in the proper use of each device (propulsion, turns, opening/closing doors, etc). All subjects were taken through the paths before testing using a manual wheelchair propelled by the research assistant.

Statistical Analysis

Mixed regression models (Singer & Willett, 2003) were used to determine the effect of device type on average speed, and whether the impact of device type varied with period administered. Trial was treated as a random effect in these analyses. Seven subjects with incomplete records were excluded from the analyses, leaving a sample of 52 subjects for the "community" task. Nine subjects with incomplete records were excluded from the "home" task, leaving an analysis sample of 50.

RESULTS

The majority of the subjects were male (91.5%), white (66.1%), and high school graduates (81.4%), with a mean age of 71. A total of 52 (93%) persons completed the "community" course with all 3 devices. Among those who declined to attempt the "community" mobility path with one or more devices, 1 (14%) declined the MW, and 1 (14%) declined both the WW and the PW. Among those subjects who attempted the course, but did not complete the course in its entirety (n=7), 1 (14%) each were using the WW and the PW, and the majority were using the MW (71%). A total of 50 (89%) persons completed the "home" course with all 3 devices. One subject declined the "home" mobility path with both the WW and the PW. We had 3 subjects who completed the "home" course but whom we did not include in analysis due to corruption of video files.

Table 1 shows that average speed was greatest for the PW followed by the WW and the MW. It shows a significant treatment by trial interaction for the "community" task (p=0.03) where the WW showed increased speed at trial 3 compared to trial 1, both absolutely (155.7 vs 135.6), and relative to the MW and the PW.

Table 1: Speed for each device according to order in which device was used for "community" path

Outcome: Speed (ft/min)	WW Mean (SD)	MW Mean (SD)	PW Mean (SD)
Trial 1:	135.6 (43.1)	120.0 (36.9)	
Trial 2:			150.0 (33.7)
Trial 3:	155.7 (33.7)	120.8 (44.9)	
Overall:	145.6 (39.6)	120.4 (40.7)	150.0 (33.7)

Following standard practice for crossover designs when an interaction is present, we limited our comparisons to the trial 1-trial 2 data, which reduced our sample size for those analyses to n=28. The overall means (WW vs. MW vs. PW) were significantly different from one another (p<0.01). As seen in Table 2, with pairwise comparisons, mean speed for the MW was significantly less than for the PW (p<0.01). In Table 2, the regression effects are converted to "effect sizes", (device-based difference in mean speed)/(standard deviation of Y), as described in Cohen (1988). While only the MW vs. PW contrast is significant in Table 2, the effect sizes are substantial in magnitude. A power analysis indicated that a sample size of 60 would be sufficient to detect an effect size of .36 (p<0.05, 2-tailed) with 80% power.

Table 2: Standardized effect sizes for device-related differences in mean speed for "community" path

Comparison	Mean Difference (SD of difference)	P-Value	Effect Size
WW vs. MW	15.6 (11.12)	>0.05	0.39
WW vs. PW	-14.4 (9.65)	>0.05	-0.36
MW vs. PW	-30.0 (8.61)	<0.01	-0.75

Table 3 shows results for the "home" task, the column of which show that average speed was greatest for the WW, followed by the MW, then the PW. As was the case with the "community" task, the cells means suggest a treatment by trial interaction - there was a significant increase in speed for the WW from trial 1 to trial 3 (84.2-65.7, p<0.001) suggesting the presence of a learning effect. During trial 3, speed for the WW exceeded that of the PW by about 39.5ft/min (84.2-44.7), compared with 21ft/min (65.7-44.7) during trial 1.

Table 3: Speed for each device according to order in which device was used for "home" path

Outcome: Speed (ft/min)	WW Mean (SD)	MW Mean (SD)	PW Mean (SD)
Trial 1:	65.7 (13.1)	56.0 (13.3)	
Trial 2:			44.7 (12.4)
Trial 3:	84.2 (17.7)	53.0 (14.0)	
Overall:	74.6 (17.9)	54.5 (13.6)	44.7 (12.4)

Since an interaction effect with trial was present for the home task as for the community task, we again limited our comparisons to the trial 1-trial 2 data, which reduced our sample size for those analyses to n=28. The overall means (WW vs. MW vs. PW) were significantly different from one another ($p<0.001$). In Table 4, the regression effects from Table 3 are converted to "effect sizes" (Cohen, 1988) for the "home" task, just as we demonstrated in Table 2 for "community". Two contrasts, WW vs. PW and MW vs. PW, were significant at $p<0.01$. The third contrast, WW vs. MW was significant at $p<0.05$. The effect sizes for all 3 comparisons with the "home" task are significant.

Table 4: Standardized effect sizes for device-related differences in mean speed for "home" path

Comparison	Mean Difference (SD of difference)	P-Value	Effect Size
WW vs. MW	9.7 (3.74)	<0.05	0.49
WW vs. PW	21.0 (3.11)	<0.01	1.08
MW vs. PW	11.3 (3.19)	<0.01	0.50

CONCLUSIONS

Mobility speed was highly variable across participants for all devices. Nonetheless, statistically significant differences in performance for mobility tasks typical of community and home environments could be detected between diverse wheeled mobility devices according to speed with a small sample size. Course completion appeared sensitive to the effect of device for the longer "community" mobility task. The differential performance of WW by trial was a surprising finding, and may relate to the physical constraints of using a manual wheelchair, limiting the ability to increase speed with increasing familiarity with the course. The potential effects of learning on mobility performance should be considered by both researchers and clinicians.

In addition to the statistical significance of speed as an outcome measure in our study, the differences seen in our study likely are clinically significant. Comparing "community" speed with the average walking speed for elderly pedestrians (210ft/min [Fitzpatrick, Brewer, & Turner, 2006]), all devices were slower (PW was 28.6%, the WW was 30.7% and the MW was 42.7%). Thus, our findings imply that clinicians should consider limitations in physical capacity and need for speed in community environments when recommending particular assistive devices. Results of our study indicate that clinicians and researchers should consider the limitations that patients may encounter when using assistive devices in a home environment. The ease of maneuverability and smaller size of a WW is likely a reason subjects were able to complete the home task more quickly with that device than the MW or PW.

We conclude that speed of mobility in community and home settings is a statistically useful and clinically important outcome measure for wheeled mobility devices.

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