The Relationship Between Wheelchair Mobility Patterns and Community Participation Among Individuals With Spinal Cord Injury

Rory A. Cooper PhD a, Eliana Ferretti PhD b, Michelle Oyster MS c, Annmarie Kelleher MSOTR/LATP a & Rosemarie Cooper MPTATP a

a Human Engineering Research Laboratories, Rehabilitation Research and Development Service, Department of Veterans Affairs, and Department of Rehabilitation Science and Technology, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

b Human Engineering Research Laboratories, Rehabilitation Research and Development Service, Department of Veterans Affairs, Pittsburgh, Pennsylvania, USA

c Human Engineering Research Laboratories, Rehabilitation Research and Development Service, Department of Veterans Affairs, and Department of Physical Medicine & Rehabilitation, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

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The Relationship Between Wheelchair Mobility Patterns and Community Participation Among Individuals With Spinal Cord Injury

Rory A. Cooper, PhD,1 Eliana Ferretti, PhD,2 Michelle Oyster, MS,3 Annmarie Kelleher, MS, OTR/L, ATP,1 and Rosemarie Cooper, MPT, ATP1

1Human Engineering Research Laboratories, Rehabilitation Research and Development Service, Department of Veterans Affairs, and Department of Rehabilitation Science and Technology, University of Pittsburgh, Pittsburgh, Pennsylvania, USA
2Human Engineering Research Laboratories, Rehabilitation Research and Development Service, Department of Veterans Affairs, Pittsburgh, Pennsylvania, USA
3Human Engineering Research Laboratories, Rehabilitation Research and Development Service, Department of Veterans Affairs, and Department of Physical Medicine & Rehabilitation, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

ABSTRACT Participation is considered the most meaningful outcome of rehabilitation. The purpose of this study was to investigate whether there were correlations between wheelchair activity recorded with a data logger and community participation as measured by the Participation Survey/Mobility. Data from 16 participants were included in this study. Data collected during a two week period using a data logging device were analyzed to determine the mobility characteristics of participants. Among manual wheelchair users, significant positive correlations were found between average speed traveled and the community participation content areas of transportation ($r_s = .837$, $p = .019$) and socialization ($r_s = .772$, $p = .042$). In addition, for manual wheelchair users there was a trend toward a significant correlation between average speed traveled and total community participation score ($r_s = .714$, $p = .071$). Among power wheelchair users, there was a trend toward a significant negative correlation between average speed traveled and the community participation content area of leisure activity ($r_s = -.635$, $p = .066$). Understanding the relationship between wheelchair speed and community participation can be useful information to enable clinicians to recommend the most appropriate mobility devices designed to enhance community participation.

KEYWORDS activity, community participation, manual wheelchair, powered wheelchair, wheelchair

INTRODUCTION

The term community participation is used to refer to being active in family and community life, engaging in typical roles and responsibilities, and actively contributing to one’s social groups and society as a whole (Dijkers, 1999). A great deal of work has been done in developing tools to measure and document physiological impairment (or lack of ability to perform an activity)
(Noreau & Fougeyrollas, 2000). However, limited attempts have focused on the measurement and assessment of long-term participation. Participation has been considered the most meaningful outcome of rehabilitation (Cicerone, 2004); however, it is probably the most challenging to assess given the number of factors to measure since there are many things that contribute to a person’s level of participation.

Some participation measures primarily assess behaviors (e.g., number of hours of physical assistance, visits and communication with other people, and hours spent on activities), such as the Craig Handicap Assessment and Reporting Technique (CHART), while others assess perceptions of participation (individuals’ perspective about the impact of their health condition and problems they experienced when carrying out everyday activities), such as the Impact on Participation and Autonomy Questionnaire, the Reintegration to Normal Living Index, and the Canadian Occupational Performance Measure (Noreau, Fougeyrollas, Post, & Asano 2005). One measure, the Participation Survey/Mobility (PARTS/M), includes both aspects of participation (Miller et al., 2005).

The PARTS/M can be used to test personal limitations as well as the environmental factors that may restrict or facilitate participation. The PARTS/M also enables the collection of information on the individual’s perception of participation in major life activities (e.g., travel, parenting, intimacy, leisure, work). The PARTS/M domains and components of participation have been shown to have good internal consistency and stability (Gray, Hollingworth, Stark, & Morgan, 2006).

Several researchers have investigated the possibility of using electronic sensor technology to provide a more objective measure of the activity levels of adult manual wheelchair users (Fitzgerald et al., 2003; Ding et al., 2008; Tolerico et al., 2007) and power wheelchair users (Cooper et al., 2002; Sonenblum, Sprigle, Harris, & Maurer, 2008) in the community. The Human Engineering Research Laboratories (HERL) has developed a customized data logger that attaches to manual and power wheelchairs and records wheel rotation (Cooper et al., 2002, Tolerico et al., 2007; Grindle, 2007). From the wheel rotation data, mobility characteristics such as distance, speed, and number of minutes actively moving can be calculated. Using such technology eliminates the possibility of recall bias and misinterpretation of survey questions, which are commonly associated with self-report measures (Tudor-Locke & Myers, 2001). The data logger has been shown to be reliable and accurate and has been used to investigate the driving characteristics of wheelchair users in the community (Cooper et al., 2002; Fitzgerald et al., 2003; Tolerico et al., 2007; Ding et al., 2008).

The overall aim of this study was to investigate if there is a correlation between mobility characteristics (distance traveled, speed, number of stops, and drive time) and the frequency of participation in community activities of individuals with SCI as measured by the data logger device and the PARTS/M, respectively. Knowledge of this relationship has the potential to impact wheelchair prescription and training.

**RESEARCH DESIGN AND METHODS**

**Participants**

Thirty-one individuals were recruited into this study. The inclusion criteria included (a) having an SCI, (b) using a manual or power wheelchair as a primary source of mobility, (c) being 18 years of age or older, and (d) available to meet with study personnel to have the data logging device attached to their wheelchair. Six subjects did not return their questionnaire, 1 did not return the data logging device, and 2 did not return either the data logging device or the questionnaire. Of the 22 subjects who completed all portions of the study, data logging information from 6 subjects could not be used because of problems with instrumentation or subjects did not use their wheelchair for the entire study period. Therefore, data from 16 subjects were used for analysis in this study.

**Recruitment Procedures**

Subjects were recruited during the 27th annual National Veterans Wheelchair Games (NVWG) held in Milwaukee, Wisconsin, during June 2007. Subject recruitment was carried out by study personnel at the NVWG-sponsored exposition, which takes place each year during the opening day of the games. Individuals who expressed interest in this research completed the study during that time or set up an appointment to meet at a more convenient time.
Protocol

The VA Pittsburgh Healthcare System’s Institutional Review Board approved the study protocol before its initiation. The nature of the study was explained and written informed consent was obtained from all subjects before the start of data collection. A data logging device was attached to each subject’s wheelchair. In addition, the participants were asked to complete the PARTS/M questionnaire. At this time, subjects also received a packet that contained materials (i.e., a hex key, box with prepaid postage, packing wrap, and removal instructions for the instrumentation) to remove the data logging device at the end of the study period and send it back to the laboratory. Participants were also given the option to complete the questionnaire at another time and mail it back to the laboratory with the data logging device. The data logging device was placed in a location that did not obstruct the propulsion of the wheelchair or interfere with the subjects’ functioning. The device required little to no attention during the study period, so individuals were able to conduct their daily activities as normal. For all subjects, the data logging device monitored their wheelchair activities for 3 weeks (1 week during the NWVG and 2 weeks in their home environment). If the subjects did not return the data logging device as well as the questionnaire within 2 weeks of the removal date, subjects were called as an additional reminder.

Questionnaire

The PARTS/M is composed of 13 major life activities (Chaves, 2007), including both activities performed at home and in the community. For this study, only five content areas related to activity performance in the community were analyzed: (a) leaving the home (which included going into the community to shop or go to the doctors), (b) transportation (accessing and using different forms of transportation), (c) active recreation (which included sports or camping), (d) leisure activities (which included dining out, attending movies or concerts, and participating in a hobby), and (e) socializing (visiting friends or family at home, at the homes of others, or at social events). These specific definitions were written prior to each item in the questionnaire. For four of the five content areas, subjects were asked one multiple-choice question related to their perceived frequency of participating in community activities. Based on the structure of the questionnaire, the leisure activity area asked four separate multiple-choice questions specific to frequency of dining out, participating in a hobby, attending movies, and attending concerts. All of the questions were asked as “how often/frequently do you participate in [specific activity]?”

Data Logger

Custom designed data logging devices that easily attach to manual (Tolerico, 2007) and power wheelchairs (Grindle, 2007) were used to record movement activity. For manual wheelchairs, the data logging devices were attached to the spokes of the wheels (Tolerico, 2007). For power wheelchairs, the data logging devices replaced the caster wheels. Using onboard memory and a software program for data collection, the data logger recorded a time stamp every time the wheelchair wheel exceeded 120 degrees of rotation. The time stamp data were used to calculate speed, distance traveled, number of stops, and the amount of time in a day participants actively used their wheelchair (Tolerico, 2007).

Data Analysis

All data were examined for normalcy. Sex, race, type of SCI (paraplegia or tetraplegia), and type of wheelchair (manual or power) were described using frequency counts. Means and standard deviations were calculated for continuous data, including age, years since diagnosis, and mobility characteristics.

Data collected on the questionnaire were combined to produce a score for frequency of community participation. The total frequency of community participation score, which ranged from 0 to 19, was created from the following items: frequency of leaving home (subscore ranged from 0–4), frequency of using transportation (subscore ranged from 0–4), frequency of active recreation (subscore ranged from 0–4), frequency of socializing (subscore ranged from 0–3), and frequency of four leisure activities (dine out, attend movies, attend concerts, and hobby) (subscore ranged from 0–4). Since there were four items measuring leisure activity but only one item measuring the other content areas, leisure activities would be weighted more heavily than other types of community participation if the total score was created by simply summing all...
eight items. To avoid this unequal weighting, the average of the four leisure activity items was computed first to compute the leisure activity subscore. Then the subscores from the five content areas were summed to produce the total score.

For this study, only the data collected during the 2-week period in the home environment were used in the analyses to characterize the mobility characteristics of the subjects. The week of data collected at the NVWG was not included in the analysis because previous research has shown that mobility characteristics of wheelchair user differ significantly among the two environments (Tolerico et al., 2007). A complete description of the methods used to calculate the mobility characteristics variables can be found in Tolerico (2007). A stop was considered when there was no activity for 7 seconds.

Mobility characteristics were compared to the PARTS/M community participation scores using a Spearman rho correlation test. All statistical analyses were completed using SPSS 13.0 software. The significance level was set at $p < .05$.

**RESULTS**

Data from 16 subjects (15 men and 1 woman) collected over a 2-week period were used to describe the mobility patterns of individuals who used manual and power wheelchairs. The mean age of the participants was 49.13 years ($\pm$14.25). The majority ($n = 12$) of participants were White, 3 were Black, and 1 was Indian/Alaska Native. The average time post-injury was 18.94 years ($\pm$10.17). Nine individuals had tetraplegia and 7 had paraplegia. Seven subjects self-propelled a manual wheelchair and 9 subjects independently operated a power wheelchair.

Data from the data logging devices revealed that the 16 subjects traveled an average daily distance of 3,374.07 ($\pm$1,677.27) meters at a speed of 0.77 ($\pm$0.17) meters per second. The maximum average daily distance traveled by a subject was 5,905.80 meters. The average daily number of stops that occurred was 146.73 ($\pm$91.96). The subjects drove an average of 68.65 ($\pm$32.56) minutes per day during the 2-week period. The number of minutes the subjects drove ranged from 11 to 107. Among 14 subjects, total community participation scores ranged from 6.5 to 16.0, with an average score of 11.98 ($\pm$2.93). Only 14 subjects’ data were analyzed because 2 subjects did not answer at least one of the five content area questions. Table 1 provides a summary of the mobility characteristics and the total community participation scores for each subject.

Among manual wheelchair users, significant positive correlations were found between average speed traveled

<table>
<thead>
<tr>
<th>Subject</th>
<th>Level of injury</th>
<th>Distance (meters)</th>
<th>Speed (meters/second)</th>
<th>Number of stops</th>
<th>Drive time (minutes)</th>
<th>Community participation score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Wheelchair Users</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>T7</td>
<td>5851.45</td>
<td>1.08</td>
<td>95.86</td>
<td>91.25</td>
<td>15.33</td>
</tr>
<tr>
<td>2</td>
<td>C6</td>
<td>2352.99</td>
<td>0.86</td>
<td>201.53</td>
<td>46.01</td>
<td>16.00</td>
</tr>
<tr>
<td>3</td>
<td>T8</td>
<td>2793.25</td>
<td>0.65</td>
<td>164.97</td>
<td>72.11</td>
<td>10.75</td>
</tr>
<tr>
<td>4</td>
<td>T4</td>
<td>4539.19</td>
<td>0.79</td>
<td>114.94</td>
<td>93.73</td>
<td>14.50</td>
</tr>
<tr>
<td>5</td>
<td>L2</td>
<td>609.15</td>
<td>0.67</td>
<td>280.11</td>
<td>10.54</td>
<td>12.50</td>
</tr>
<tr>
<td>6</td>
<td>T5</td>
<td>4073.13</td>
<td>0.71</td>
<td>133.54</td>
<td>94.76</td>
<td>10.00</td>
</tr>
<tr>
<td>7</td>
<td>T9</td>
<td>875.87</td>
<td>0.88</td>
<td>180.00</td>
<td>15.72</td>
<td>13.25</td>
</tr>
<tr>
<td>Power Wheelchair Users</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>C4</td>
<td>1298.87</td>
<td>0.79</td>
<td>408.55</td>
<td>17.17</td>
<td>6.67</td>
</tr>
<tr>
<td>9</td>
<td>C7</td>
<td>5379.36</td>
<td>0.81</td>
<td>44.66</td>
<td>107.45</td>
<td>–</td>
</tr>
<tr>
<td>10</td>
<td>C4</td>
<td>4253.11</td>
<td>0.68</td>
<td>104.82</td>
<td>89.05</td>
<td>10.25</td>
</tr>
<tr>
<td>11</td>
<td>C4</td>
<td>5905.80</td>
<td>1.19</td>
<td>31.38</td>
<td>78.18</td>
<td>11.50</td>
</tr>
<tr>
<td>12</td>
<td>C3</td>
<td>3450.9</td>
<td>0.71</td>
<td>123.73</td>
<td>67.76</td>
<td>6.50</td>
</tr>
<tr>
<td>13</td>
<td>C5</td>
<td>2354.79</td>
<td>0.78</td>
<td>88.11</td>
<td>47.63</td>
<td>13.50</td>
</tr>
<tr>
<td>14</td>
<td>C5</td>
<td>4148.20</td>
<td>0.62</td>
<td>94.10</td>
<td>101.35</td>
<td>14.50</td>
</tr>
<tr>
<td>15</td>
<td>C5</td>
<td>2159.45</td>
<td>0.54</td>
<td>142.02</td>
<td>62.86</td>
<td>12.50</td>
</tr>
<tr>
<td>16</td>
<td>T7</td>
<td>3939.61</td>
<td>0.62</td>
<td>139.42</td>
<td>102.90</td>
<td>–</td>
</tr>
</tbody>
</table>

\[ \text{Total} \quad 3374.07 \pm 1677.27 \quad 0.77 \pm 0.17 \quad 146.73 \pm 91.96 \quad 68.65 \pm 32.56 \quad 11.98 \pm 2.93 \]
TABLE 2 Correlations between mobility characteristics and community participation content areas for manual and power wheelchair users

<table>
<thead>
<tr>
<th>User category and community participation content area</th>
<th>Mobility characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distance</td>
</tr>
<tr>
<td>Manual wheelchair users</td>
<td></td>
</tr>
<tr>
<td>Leaving home</td>
<td>-.289 (.530)</td>
</tr>
<tr>
<td>Transportation</td>
<td>.418 (.350)</td>
</tr>
<tr>
<td>Recreation</td>
<td>.018 (.969)</td>
</tr>
<tr>
<td>Socialization</td>
<td>-.077 (.869)</td>
</tr>
<tr>
<td>Leisure activities</td>
<td>.324 (.478)</td>
</tr>
<tr>
<td>Total score</td>
<td>.179 (.702)</td>
</tr>
<tr>
<td>Power wheelchair users</td>
<td></td>
</tr>
<tr>
<td>Leaving home</td>
<td>-.178 (.646)</td>
</tr>
<tr>
<td>Transportation</td>
<td>.103 (.808)</td>
</tr>
<tr>
<td>Recreation</td>
<td>.350 (.395)</td>
</tr>
<tr>
<td>Socialization</td>
<td>.098 (.802)</td>
</tr>
<tr>
<td>Leisure activities</td>
<td>-.270 (.483)</td>
</tr>
<tr>
<td>Total score</td>
<td>.107 (.819)</td>
</tr>
</tbody>
</table>

Note: Entries are \( r_s \) values with \( p \) values in parentheses.

\( ^* p < .05, \ ^{†} p < .10 \)

and the community participation content areas of transportation \( (r_s = .837, p = .019) \) and socialization \( (r_s = .772, p = .042) \). In addition, for manual wheelchair users there was a trend toward a significant correlation between average speed traveled and total community participation score \( (r_s = .714, p = .071) \). Among power wheelchair users, there was a trend toward a significant negative correlation between average speed traveled and the community participation content area of leisure activity \( (r_s = -.635, p = .066) \). For both manual and power wheelchair users, no significant differences were found among distance traveled and community participation. Table 2 provides a summary of correlations between mobility characteristics and the five community participation content areas and total community participation scores for both manual and power wheelchair users.

**DISCUSSION**

This study investigated the relationship between the mobility patterns and level of community participation of individuals with SCI. The data showed a trend among manual wheelchair users indicating that participants who on average traveled faster tended to have a higher level of community participation. The average maximum speed for the manual wheelchair users ranged from 0.65 to 1.08 meters per second, which is lower than the average walking speed. This is consistent with Tolerico et al.’s (2007) finding that manual wheelchair users traveled an average speed of 0.79 meters per second, which is slower than the previously reported average walking speed of 1.23 to 1.48 meters per second (Fisher & Gullickson, 1978; Blessey et al., 1976). In an ambulatory population, researchers have identified increased walking speed as a predictor for increased functional ability, health status and quality of life (Purser et al., 2005; Schmid et al., 2010; Hubertus, 2010). This relationship for individuals who use wheeled mobility devices is unknown; however, is likely to be relevant for wheelchair users. Being able to change and increase speeds is important in some daily circumstances, such as when crossing a street. If the traffic light changes and the person is still in the middle of the street, he or she might be in a dangerous situation.

When evaluating the specific content areas for manual wheelchair users, a significant positive correlation was found with increased speed and increased frequency of using transportation and socializing with others. The ability to effectively self-propel a manual wheelchair can facilitate a person’s ability to participate in community activities. Research has shown that properly fitted ultralight wheelchairs and the use of pushrim-activated power assist (PAPAW) systems could be considered as an option for individuals who want to propel their wheelchair.
more efficiently and faster (Koontz & Boninger, 2003; Boninger et al., 2000; Souza, 2007; Algood et al., 2004). The easier it is for a person to self propel their wheelchair, the more likely they may be willing to go more places and socialize with others.

For participants who used power wheelchairs, there were no significant differences noted between mobility patterns and the total community participation score or any of the individual content areas. This indicates that there are some differences in the relationship between the mobility characteristics and community participation variables evaluated with use of either a manual or power wheelchair. The data did show a trend toward a negative correlation between increased speed and decreased participation in leisure activities. It is possible that this can be explained based upon the leisure activities defined in the questionnaire. For example, this question specified leisure activities as dining out, attending movies, attending concerts, and participating in a hobby. Participants were asked to identify their hobby, and the responses were varied. The majority of these activities do not require speed. Some examples included gardening, playing a musical instrument, outdoor sportsmanship, and playing video games.

Participation is defined as being involved in life situations, such as taking care of oneself and participating productively in work and leisure (World Health Organization, 2001). Research has shown that for mobility, the physical and social environments are seen as the most important predictors of community participation (Miller et al., 2005; Scherer & Glueckauf, 2005). Other studies have revealed that severity of injury indirectly affects quality of life through its influence on community participation (Post et al., 1998; Dijkers, 1999). If the level of community participation valued by a person is not affected because of favorable conditions (e.g., appropriate environmental adaptations, social support), it is likely that subjective well-being will not be affected, regardless of severity of injury (Miller et al., 2005; Dijkers, 1997). Therefore, individuals with more favorable conditions might be able to accomplish all of their required activities throughout the day and consequently use their manual or power wheelchairs for a longer period of time and at faster speeds. Without the use of a mobility device, individuals who rely on a wheelchair for their primary means of mobility would be confined to a bed or chair.

Furthermore, having an appropriate mobility device can significantly influence how a person with a disability perceives life (Buning et al., 2000). This study found no relationship between distance and community participation, which might indicate that individuals travel most often within their local neighborhoods. This is consistent with Tolerico et al. (2007), who found that there are significant differences in the activity of manual wheelchair users within their home environment (average of 2457.0 ± 1195.7 meters) than during participation in the NVWG, which is a program developed to increase participation (average of 6745.3 ± 1937.9 meters).

There are several limitations to this study that need to be discussed. The sample size was small and primarily made up of male veterans who attended the NVWG, which limits the generalizability of the study. Obtaining a greater distribution of females and individuals from all age groups would provide a more comprehensive characterization of typical mobility patterns of manual and power wheelchair users. The study sample collected information on individuals who use manual and power wheelchairs. Obtaining information from individuals who use PAPAWs would provide a more comprehensive characterization of other typical mobility patterns. Future research should explore the relationship of the quality of different types of mobility devices to community participation. Understanding this relationship would be beneficial for clinicians to consider when recommending the most appropriate wheelchairs to facilitate community participation. The data logger device did not capture whether subjects where traveling in the home or out in the community. Hence, it would be interesting to explore the differences in mobility patterns of wheelchairs users in these two environments.

The data logger provides a means to quantify and understand the mobility characteristics of individuals who use wheelchairs. The PARTS/M quantified the level of community participation of individuals with SCI. Because of that, the relationship between mobility characteristics and community participation was identified in this study. The ability to objectively quantify the mobility patterns of a person may enable clinicians to try to enhance the way the person pushes a wheelchair through training and optimization of the wheelchair set-up. These factors can lead to increased speed or drive time or reduce the number of stops, which would enhance the community participation of other typical mobility patterns.
individuals who use wheelchairs as a primary means of mobility.

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