Measuring Usability of Assistive Technology From a Multicontextual Perspective: The Case of Power Wheelchairs

Sajay Arthanat, Susan M. Nochajski, James A. Lenker, Stephen M. Bauer, Yow Wu B. Wu

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- consumer satisfaction
- environment
- locomotion
- self-help devices
- wheelchairs

Assistive technology (AT) devices enable people with disabilities to function in multiple contexts and activities. The usability of such devices is fundamentally indicative of the user's level of participation in multiple roles and occupations. Seventy people who used power wheelchairs were interviewed using a novel tool, the Usability Scale for Assistive Technology (USAT). The USAT uses a human factors science framework to investigate the wheelchair user's perceived independence in mobility-related activities within home, workplace, community, and outdoors in accordance with the characteristics of the wheelchair, environmental factors, and abilities and skills of the user to operate the wheelchair. Descriptive analysis of the data revealed usability issues with the use of power wheelchairs in all contexts. Users confronted far more significant issues within the community and outdoor environment compared with those at home and in the workplace. These issues have been elucidated and applied to an intervention framework with relevance to a multitude of AT stakeholders.


Mobility is a multicontextual domain that affects all spheres of occupation. There has been a growing trend in the number of people using wheelchairs in the United States as a result of an increase in the population of people with mobility impairments and the growth of the wheeled mobility industry. According to the U.S. Census Bureau, the number of people ages 15 and older using wheelchairs rose from 2.1 million in 1997 (U.S. Census Bureau, 1997) to 2.7 million in 2002 (U.S. Census Bureau, 2002). In the case of powered mobility, nearly 155,000 people in the United States were using power wheelchairs (PWCs) by the year 2000 (Kaye, Kang, & LaPlante, 2000).

People using PWCs make up a highly heterogeneous population with wide-ranging mobility-related impairments and activity needs within the settings of home, workplace, school, or community. To address this diversity, technology developers and manufacturers continue to advance mobility products, resulting in a vast array of models and features available to consumers. Although the role of occupational therapy in the area of mobility and seating is clearly outlined (Lange, 2000; Pedersen & Taylor, 2004; Perr, 1998), the continuing growth of the wheelchair industry combined with the evolving concepts in intervention will potentially impose challenges in demonstrating the effectiveness of service delivery. One of the ways to validate the efficacy of seating and mobility intervention is to verify whether the right person was provided with the right wheelchair for the right purpose. Fundamentally, this question hinges on the concept of a person–technology–environment match (Scherer, 1998). In practice, the match is reflected by the
usability of the wheelchair. Usability, in this context, can be best described as how effectively and efficiently a user can interact with a wheelchair to accomplish an optimal level of mobility and seating integrity in a given environment.

We investigated participation of users of PWCs in multiple contexts of occupation as measured by the usability of their wheelchairs. Initially, we describe the concept of usability as it relates to the science of occupation and human participation to promote a clear understanding of this emerging research domain. The concept is then operationalized to wheeled mobility, and measurement approaches in research are reviewed. Subsequently, the Usability Scale for Assistive Technology–Wheeled Mobility (USAT–WM), the instrument used to capture and outline the findings, is described. The study’s findings are later applied to the instrument’s framework, which is designed to optimize wheeled mobility usability. In closing, we propose potential strategies to optimize PWC usability related to the various levels of the intervention framework.

Assistive Technology Usability

Measurement of an outcome domain requires a clear understanding of its definition, conceptual framework, and operational application to the field of study. Usability of a product has been theoretically defined as the effectiveness, efficiency, and satisfaction involved in using the product in specific activities and environments (International Organization for Standardization, 1999). Assistive devices, as products, are designed to enable function (Cook & Hussey, 2002), and their usability (from a real-world perspective) dictates both the quantity and quality of functioning of those that rely on the devices (Arthanat, Bauer, Lenker, Nocajaik, & Wu, 2007). The term quantity is a measure of effectiveness of the assistive technology (AT) device characterized by the variety and consistency with which specific activities can be performed by the AT user, whereas quality is analogous to the efficiency of the AT device reflected by the ease and comfort with which activities are carried out (Arthanat et al., 2007). Because change in function is a yardstick to validate occupational therapy service, usability of AT can be considered as a key outcome to demonstrate the efficacy of interventions that involve technologies and adaptations.

With its origins in human factors science and ergonomics, usability has been conceptualized as an outcome of the interaction between the user and a product to accomplish a task in a given context. Although this conceptualization has been operationalized to the field of AT (Cook & Hussey, 2002; Scherer, 1998), one must also recognize the inherent association of this concept with occupational therapy when considering it as an outcome of intervention.

Taking into account AT as a critical element in the environment, models that dynamically portray the person–occupation–environment transaction further our understanding of AT usability. As examples, the Model of Human Occupation (Kielhofner, 1997) and the Person–Environment–Occupational Performance (Law et al., 1997) are paradigms that facilitate conceptualization of AT usability from an occupational therapy perspective. These models exemplify some of the person factors that necessitate and motivate an individual to use AT, the abilities and skills that are needed to interact with AT, the roles and activities that need to be accomplished, and the environmental factors that influence use of the AT device within various occupational contexts.

Because mobility is inherent in multiple occupational contexts, usability of wheelchairs needs to be conceptualized and measured on the basis of the interaction of the user, the wheelchair, and the environment specific to activities performed in each context. Researchers have proposed a comprehensive assessment framework in the area of wheeled mobility. As critical elements in the evaluation, Hardy (2004) stressed the adoption of the Occupational Performance Model (Australia) to study the enablement of human performance through powered mobility by taking into account the impact of the environment, life roles, space and time, and individual component-level skills. On a parallel theme, Routhier, Vincent, Desrosiers, and Nadeau (2003) emphasized a framework that involves the consideration of the user’s profile, the functions and features of the device, the environment, the training obtained, and the activities. Although these approaches are crucial precedents to wheelchair recommendation, research that focuses on measurement of wheelchair usability demonstrates a departure from this framework. Moreover, research on the usability of PWCs within multiple contexts is essential to understanding the role of the physical, temporal, and social environments in promoting mobility and involvement in occupation.

Literature Review

Usability of wheeled mobility devices has been studied on the basis of several indicators, including, but not limited to, propulsion, driving, seating, pressure management, transportation, and safety. Although the merit of these research studies needs to be recognized, an exhaustive review is usually required to collectively understand the usability of wheelchairs. Exceptionally, a few studies have tested the performance characteristics of wheelchairs on a range of usability indicators.

Researchers have used the American National Standards Institute and RESNA (ANSI/RESNA) wheelchair standards to test and compare several performance characteristics of
wheelchairs in well-controlled laboratory settings (Cooper, Boninger, & Rentschler, 1999; Rentschler et al., 2004). In general, objective methods are helpful and valid in closely examining intricate facets of wheelchair usability. However, there are a few drawbacks to consider. Controlled testing of usability parameters of wheelchairs as per the proposed standards (such as ANSI/RESNA) requires specialized equipment and setup. Moreover, such tests merely examine the performance characteristics of the wheelchair in the absence of a user. In other words, examination of specific performance characteristics in controlled environments is not entirely indicative of the usability of the wheelchair from a consumer-oriented occupational perspective.

Evaluation of an AT device by the user was shown to be the most valid and effective method to address all aspects of its usability compared with other methods such as evaluation by experts, case study, and simulation of use (Wessels, Willems, & de Witte, 1996). In doing so, experts have observed user-reported measures of use or abandonment, user satisfaction, and well-being to be associated with AT usability (Lenker, Scherer, Fuhrer, Jutai, & DeRuyter, 2005). Researchers have already investigated users’ satisfaction with various mobility aids (Bergström & Samuelsson, 2006; Demers, Monette, Lapiere, Arnold, & Wolfson, 2002; Weiss-Lambrout, Tremblay, LeBlanc, Lacoste, & Dansereau, 1999). Nonetheless, an overall score of satisfaction does not distinctly convey users’ satisfaction with the mobility device in multiple contexts and environments. For example, users’ satisfaction with their wheelchairs was reported to vary considerably in different contexts, such as when the wheelchair is used indoors versus outdoors (Bergström & Samuelsson, 2006). As a result of these inadequacies, measurement of wheelchair usability must not only be consumer centered but also holistic by consideration of all activities and contexts.

Usability Scale for Assistive Technology: Wheeled Mobility

The USAT–WM was developed as a tool for people with mobility impairments to rate and report on the usability of their wheelchair as a property of (1) the perceived benefit of the wheelchair in terms of users’ participation in specific activities in specific contexts of mobility; (2) the ease of use, safety, and comfort associated with use of the wheelchair; (3) the abilities and skills of the user to interact with the wheelchair; and (4) the influence of environmental factors in specific contexts of mobility (Arthanat, 2007; Arthanat et al., 2007). The USAT–WM consists of 50 items categorized into seven subscales. The internal consistency scores of these subscales range from .77 to .91, and the instrument has a test–retest reliability correlation of .85 (Arthanat, 2007). The development process of the USAT has been described in detail in earlier articles (Arthanat, 2007; Arthanat et al., 2007).

Four subscales of the USAT–WM—Home Usability, Workplace/School Usability, Community Usability, and Outdoor Usability—reflect usability of the wheeled mobility device in four specific contexts. The other three subscales signify the user–wheelchair interaction, respectively, in terms of ease of use, seating, and safety of the wheelchair. The distribution of the items across seven distinctive subscales allows for the delineation of usability within specific contexts and on the basis of the user’s physical, sensory, and cognitive interaction with the wheelchair. In essence, each subscale is a short and valid component of the composite wheelchair usability.

The Home Usability subscale consists of 7 items pertaining to the user’s independence in home mobility, home accessibility, and the suitability of the wheelchair for home activities. The Workplace/School Usability subscale includes 6 items that highlight the user’s independence as a function of the individual’s mobility at work or school, physical accessibility, and social support for use of the wheelchair at workplace or school. The third subscale, Community Usability, involves 9 items that signify wheelchair usability in community-based activities where public accommodation or accessibility is required. Among these 9 items, the first 4 pertain to mobility while performing community and leisure activities, and the remaining 5 pertain to the wheelchair accessibility of the settings wherein these activities are performed. The Outdoor Usability subscale consists of 11 items that evaluate the usability of the wheeled mobility device in the outdoor context. The items basically focus on participation in outdoor activities, the performance and suitability of the wheelchair for outdoors, and the safety and accessibility of the outdoor environment.

The Ease of Use subscale includes seven items for the user to rate the demands of using the wheelchair and the adequacy of his or her abilities to use the wheelchair effectively and efficiently, such as while driving or propelling and negotiating spaces. In the Seating subscale, six items are associated with the user’s perception of the wheelchair’s seating effectiveness in terms of his or her posture, comfort, and pressure relief. The final subscale, Safety, consists of four items that represent the user’s awareness of safety issues with use of the wheelchair, the wheelchair’s stability, and the incidence of falls and accidents while using the wheelchair.

The USAT–WM uses 5-point Likert response scales that vary according to the content of the items. The instrument can be administered in 20 to 30 min as part of a structured interview or as a self-reported survey tool. The USAT–
WM can be used by practitioners from all disciplines, including occupational and physical therapists, AT technicians, vocational and rehabilitation counselors, and educators. The USAT–WM is intended for users of wheeled mobility devices who are already using their devices in daily life. The instrument can also be used to confirm the suitability of a wheelchair for an individual during a trial usage period. The scores obtained on the USAT–WM can be applied to an intervention framework with wide-ranging clinical and societal implications in the field of wheeled mobility and seating.

**Intervention Framework of the USAT–WM**

The composite score of the USAT–WM provides an overall perspective of a wheelchair’s usability. However, from an intervention standpoint, focus must be systematically scaled down to the subscale scores and subsequently to each item score of the USAT–WM. Because the seven subscales of the USAT–WM are in fact seven subconstructs of wheelchair usability, the subscale scores are more relevant and sensitive to convey usability issues specific to the interaction of the user with the wheelchair in a particular context. Any item that is scored 3 or below on the Likert scale is translated as an indication of moderate to very low usability and is therefore considered as a potential usability attribute requiring intervention. The intervention model proposed here can be considered as a comprehensive user-centered screening approach to delineate areas of wheelchair usability in which further assessment and intervention is required. Conceivably, wheeled mobility and seating practitioners may use objective methods as warranted to intricately probe each usability variable.

Figure 1 depicts the intervention framework of the USAT. The framework is structured around the subscales of

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**Figure 1. Intervention framework of the Usability Scale for Assistive Technology–Wheeled Mobility.**
the USAT–WM that evolved after the psychometric analysis of its items. On the basis of the USAT–WM scores, intervention can be directed contextually at primary, secondary, and tertiary levels. The primary and secondary interventions focus individually on the user, whereas the tertiary intervention needs to be conducted from a broader and societally perspective with the end-user population in mind.

At the primary level, the focus of the intervention must be directed toward improving the overall usability and the home usability of the wheelchair. The stakeholders involved at the primary intervention level are the user, his or her family, and the clinician or the technician with additional support from a funding agency. Intervention at this stage may involve home modification to increase wheelchair accessibility; training to enhance ease of use, comfort, and safety with use of the wheelchair; or repair or replacement of the wheelchair. Intervention at the secondary level is focused on optimizing wheelchair usability at the workplace or educational setting. At this point, the user and the clinician can collaborate with the employer or school personnel in identifying and resolving factors that are undermining wheelchair usability.

Tertiary intervention is population centered and requires the concerted effort of stakeholders, including researchers, technology developers, wheelchair manufacturers, and policymakers. Technology developers and manufacturers must recognize the unmet needs of consumers and strive to enhance the quality and features of their wheeled mobility devices in terms of their ease of use, user comfort, and safety. The current service delivery of wheeled mobility devices is dictated by a medical model that defines and funds wheelchairs as durable medical equipment for sole use within the home. A critical need for the provision of wheelchairs on the basis of their multicontextual functions still remains vastly unmet. Policymakers also need to acknowledge the collective voice of the consumers of wheeled mobility devices and advocate and implement measures to improve community and outdoor accessibility for use of wheelchairs. This study examines the usability of PWCs as measured by the USAT–WM and outlines the implications of the findings by applying them to the aforementioned intervention framework.

Research Objectives

The specific study objectives were to (1) examine the usability of PWCs, (2) identify factors associated with PWC usability in specific contexts (i.e., home, school or workplace, community, and outdoors), (3) identify issues with users’ interaction with the wheelchair, (4) map and describe the findings in reference to the aforementioned intervention framework, and (5) provide a descriptive guide to evaluation and intervention of the identified PWC usability issues.

Method

The study involved analysis of field test data collected for the psychometric evaluation of the USAT–WM. The findings in essence demonstrate the sensitivity of this instrument to capture usability issues with wheeled mobility devices.

Participants

Seventy people who used PWCs participated in this study. Residents in small towns and suburbs of western New York ages 18 to 65 were considered for the study. As an inclusion criterion, participants who used their wheelchairs outdoors and in the community were recruited so as to probe all contexts of wheelchair usability. Consequently, people residing in nursing homes or institutions were not considered for the study.

Data Collection

The field testing protocol for the USAT–WM was reviewed and approved by the Social Behavioral Sciences Institutional Review Board of the University at Buffalo. Among the 70 participants recruited for the study, 65 participants were contacted through the Western New York Independent Living Project consumer database and 5 participants were associated with an organization that serves children and adults with developmental disabilities. Participants were initially contacted by phone to obtain their verbal consent and to ensure that they fulfilled the inclusion criteria for the study. A written consent was obtained from all recruited participants before their involvement in the study.

The content and structure of the study instrument has been detailed in the background section of this article. The pilot version of the USAT–WM consisting of 71 items was used to collect data. Participants were given detailed information about the instrument, its purpose, and guidelines for responding to items. In addition, individual case notes concerning specific aspects of usability were documented for each participant. The participants were encouraged to comment on usability issues pertinent to items that they rated as ≤3 on the Likert scale. Each interview session was completed in approximately 45 min.

Data Analysis

Secondary analysis of the field test data was used in this study. The data were first analyzed by computing the mean scores of the USAT–WM subscales. To narrow the focus, frequency distribution of participants within a usability continuum—very low to low or below optimal usability, moderate or suboptimal usability, and high to very high or optimal usability—for each usability variable (item) of the USAT–WM subscales was analyzed. Collapsing the 5-point usability
Likert scale into this 3-point continuum seemed appropriate to summarize and interpret the findings from the study. Participant comments attributed to these usability variables were aggregated and reported. Finally, the findings were applied to the aforementioned intervention framework. A list of possible intervention strategies to address reported issues is suggested at each level of this framework.

Results

The demographic information on the 70 participants is presented in Table 1. Of the 70 participants, 42 were women and 28 were men. Their average age was 47.9 (standard deviation [SD] = 11.5) with a range of 20 to 65 years. The generalizability of the study’s findings was suggested by the similarity between the sample and demographic characteristics of the PWC user population. The two major mobility impairments of the participants were cerebral palsy and spinal cord injuries. According to disability statistics in the United States (Kaye et al., 2000), these are the two most common conditions necessitating use of a PWC. The employment rates of the study participants (18.5%) were also comparable to the 17.4% estimated among the wheelchair user population (Kaye et al., 2000). Also, note in Table 1 that the proportion of participants within the income strata decreased considerably with increasing levels of income, similar to trends reported in the PWC user population (Kaye et al., 2000). Additional demographical information relevant to this study is presented in Table 2 and includes the participant’s experience with use of PWCs and the characteristics of the wheelchairs in use.

The mean scores of the USAT–WM subscales are plotted in Figure 2. In all, the PWCs attained a high degree of usability with a mean score of 4.23 (SD = 0.83) and 4.32 (SD = 0.59, n = 27) at home and workplace or school, respectively. The mean scores for the community and outdoor usability of the PWCs ranged from moderate to high usability with corresponding values of 3.60 (SD = 0.77) and 3.74 (SD = 0.62). The overall usability mean scores associated with ease of use, seating, and safety of the PWCs ranged between high to very high usability at 4.25 (SD = 0.54), 4.36 (SD = 0.69), and 4.32 (SD = 0.56), respectively. Usability ratings specific to each subscale are discussed in detail as follows.

Home Usability

A majority of the participants (ranging from 61.4% to 88.4%) reported high to very high usability on all variables pertaining to usability of their PWCs at home (see Figure 3). Nonetheless, approximately 24% of the participants reported their house to be only somewhat organized and 14%...
Figure 2. Mean scores of Usability Scale for Assistive Technology–Wheeled Mobility subscales (N = 70).

Note. n = 27 for workplace/school usability; CI = confidence interval. Percentages may not add to 100 due to rounding.

Figure 3. Home usability of power wheelchairs.

Note. Percentages may not add to 100 due to rounding.
reported it to be cluttered to very cluttered for use of their wheelchair. In all, approximately 14% of the participants indicated that their house was inaccessible to very inaccessible in terms of the space available to use their PWCs.

**Workplace/School Usability**

Among the 27 participants who were employed or attending school, a majority (see Figure 4) reported high to very high usability of their PWCs in getting to the workplace or school (92.6%) and moving around workplace or school (88.9%). Notably, 85.2% acknowledged that their school or workplace was accessible to very accessible for mobility with their PWCs. By contrast, more than 50% indicated that their workstation or classroom was somewhat accessible (44.4%) to inaccessible and very inaccessible (7.4%).

**Community Usability**

In relation to home and workplace/school, the usability of PWCs in the community was rated lower by the users. As shown in Figure 5, approximately 40% to 50% of users rated their wheelchairs as having moderate and low to very low usability in activities such as shopping and going to restaurants, visiting public buildings, and attending events. As observed, nearly 30% of the respondents rated the places they shop as being somewhat accessible, whereas approximately 50% rated restaurants and public buildings to be somewhat to very inaccessible for use of their PWCs. Almost 31% of the PWC users rated public kiosks such as automatic teller machines, ticket counters, and vending machines to be inaccessible to very inaccessible.

**Outdoor Usability**

Usability issues with PWCs outdoors were as prominent as those found in the community (see Figure 6). More than 50% of the PWC users reported moderate (42%) and low to very low usability (11.6%) in driving through the streets with their PWCs. On the same note, approximately 32% of PWC users considered the sidewalks on streets to be inaccessible to very inaccessible. Moreover, approximately 70% of the respondents reported that they encountered barriers (such as uneven surface, muddy conditions, and snow) somewhat often (45.7%) and often to very often (24.3%) while driving their PWCs outdoors. Approximately 78% of users rated their PWCs as suitable to very suitable for outdoor use. However, some major concerns emerged in the area of outdoor usability.

### Figure 4. Workplace/school usability of power wheelchairs.

*Note. Percentages may not add to 100 due to rounding.*

<table>
<thead>
<tr>
<th>Activity</th>
<th>Very Low to Low Usability</th>
<th>Moderate Usability</th>
<th>High to Very High Usability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Getting to Work/School</td>
<td>3.7%</td>
<td>3.7%</td>
<td>92.6%</td>
</tr>
<tr>
<td>Moving Around Work/School</td>
<td>11.1%</td>
<td></td>
<td>88.9%</td>
</tr>
<tr>
<td>Workplace/School Access</td>
<td>3.7%</td>
<td>11.1%</td>
<td>85.2%</td>
</tr>
<tr>
<td>Workstation/Classroom Access</td>
<td>7.4%</td>
<td>44.4%</td>
<td>48.2%</td>
</tr>
<tr>
<td>Employer/School Admin. Support</td>
<td>3.7%</td>
<td>14.8%</td>
<td>81.5%</td>
</tr>
<tr>
<td>Coworker/Peer Support*</td>
<td>7.7%</td>
<td></td>
<td>92.3%</td>
</tr>
</tbody>
</table>
Figure 5. Community usability of power wheelchairs.

Note. Percentages may not add to 100 due to rounding.

Figure 6. Outdoor usability of power wheelchairs.

Note. Percentages may not add to 100 due to rounding.
With respect to driving on rough terrain (such as cracked sidewalks, mud, and snow), 36.2% of the participants reported that their PWCs were only somewhat effective in overcoming surface barriers. Regrettably, only 18.6% of participants perceived that their PWCs were effective to very effective for use in adverse climatic conditions such as rain, extreme cold, or snow, and 48.6% of the participants were concerned that their PWCs were ineffective to very ineffective for use in unpleasant climatic conditions. For travel with their wheelchair, >23% of PWC users rated the size and weight of their wheelchairs as bulky to very bulky for use in transportation. In addition, more than one-third of respondents reported concerns with both transportation availability and accessibility. Also, among the 28 respondents who had traveled by air, 9 revealed that air travel was only somewhat accessible, and 13 participants reported it as inaccessible to very inaccessible. The two major problems reported with air travel were travel delays and damages to wheelchairs during transit.

Usability

As seen in Figure 7, the majority of the participants rated the usability of their wheelchairs as high to very high on most variables of ease of use, seating, and safety. The majority of participants rated their PWCs as easy and very easy to drive (95.7%), to maneuver (92.9%), and to turn around (82.9%) in terms of the fine motor control (78.6%) required to operate the controller. A significant proportion of the participants rated their postural control (28%) and reach (44%) as only somewhat adequate to very inadequate during use of their PWC. A majority of participants reported high to very high usability on variables including comfort, suitability to body posture, and pressure relief. Nonetheless, approximately 37% of participants experienced moderate and severe to very severe pain in at least one anatomical region of the body. Further inquiry pointed out that pain was mostly localized in the lower back, followed by the hip and a lower extremity.

In terms of safety, a majority of participants (52.8%) stated that they have experienced accidents involving a fall or collision of their wheelchair that resulted in injury. Twenty percent of the participants had experienced two accidents, and 14.3% had experienced three or more accidents. On the basis of the respondent’s descriptions, 42% of all accidents involved an error in human judgment, 32.2% were attributed to hazards in the environment, nearly 10% were attributed to a fault with the wheelchair, and 16% were considered to be caused by a combination of these factors.

![Figure 7. Usability of power wheelchairs.](http://ajot.aota.org/pdfaccess.ashx?url=/data/journals/ajot/930101/ on 06/18/2017 Terms of Use: http://AOTA.org/terms)

*Note. Percentages may not add to 100 due to rounding. Percentages less than 4.0% are not reported.*
Table 3. Usability Issues Applicable to the Usability Scale for Assistive Technology—Wheelchair Mobility Intervention Framework

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Usability Issues</th>
<th>Reported Problems</th>
<th>Possible Intervention</th>
<th>Stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home Usability</td>
<td>• Indoor mobility • Home arrangement • Space • Wheelchair suitability • Exit and entry</td>
<td>• Clutter • Organization • Narrow space in kitchen and bathroom • Narrow entrance • Wheelchair damages the house</td>
<td>• Home modification • Reduce clutter • Widen doorways • Pad wheelchairs to reduce impact</td>
<td>• User • Clinician • Technician • Home owner/family</td>
</tr>
<tr>
<td>Workplace/School Usability</td>
<td>• Access to classrooms and workstation • Device safety • Seating • User awareness</td>
<td>• Wheelchair does not fit with the table • Narrow aisles in classroom • Problems reaching the table</td>
<td>• Provision of adjustable workstations • Ensure ADA compliance • Intervene through Individualized Education Program</td>
<td>• User • Clinician • Employer or school admin</td>
</tr>
<tr>
<td>Community Usability</td>
<td>• Shopping • User awareness • Seating • Disease • Learning disabilities</td>
<td>• Narrow aisles • Obstacles • Problems with reach • Restrooms inaccessible • Streets inaccessible</td>
<td>• Ensure ADA compliance • Encourage use of reachers • Intervene through Individualized Education Program</td>
<td>• Community • Store manager • End users • Architects • Policy advocates</td>
</tr>
<tr>
<td>Outdoor Usability</td>
<td>• Going to restaurants • Access to sidewalks • Environmental hazards • Parking</td>
<td>• Narrow aisles • Restrooms inaccessible • Seating problems • Wheelchair mobility • Environmental hazards</td>
<td>• Ensure ADA compliance • Encourage use of reachers • Intervene through Individualized Education Program</td>
<td>• Community • Policy advocates • Manufacturers • Technology developers • Researchers</td>
</tr>
<tr>
<td>Usability: Ease of Use</td>
<td>• Limited reach • Postural interventions • Difficulty performing tasks • User awareness</td>
<td>• Difficulty performing tasks such as picking up objects and accessing work surface • User awareness</td>
<td>• Postural interventions • Consider use of a reacher • Intervene through Individualized Education Program</td>
<td>• User • Clinician • Technician</td>
</tr>
<tr>
<td>Usability: Seating</td>
<td>• High incidence of pain in lower back, hips, and shoulders • Seating • User awareness</td>
<td>• Pain when sitting for a long time • User awareness • Postural interventions • Difficulty performing tasks</td>
<td>• Periodical seating evaluation and intervention • User training • Intervene through Individualized Education Program</td>
<td>• User • Clinician • Technician</td>
</tr>
<tr>
<td>Usability: Safety</td>
<td>• High incidence of falls and accidents • Seating • Environmental hazards • User awareness</td>
<td>• Environmental hazards • Device safety • User awareness • Postural interventions • Difficulty performing tasks</td>
<td>• User training • Clinician/technician training • Intervene through Individualized Education Program</td>
<td>• User • Clinician • Technician • Researchers</td>
</tr>
</tbody>
</table>

Note. ADA = Americans With Disabilities Act; PWC = power wheelchair.

The usability issues captured by the USAT–WM are listed in the second column of Table 3. The qualitative information related to these issues recorded as case notes from participants is presented in the third column. The table also lists common problems reported by respondents in reference to usability of their wheelchairs specific to each subscale of the USAT–WM.

Discussion

Usability of AT devices must be examined specific to the type of technology and must exclusively take into account all occupational contexts. Using this approach, this study demonstrated the measurement of AT usability within one of its key segments, wheeled mobility, and seating. Human mobility is inherently central to well-being and occupational performance, and evaluating and optimizing usability of a wheelchair has direct implications on user participation.

Past research has suggested that PWCs give users a sense of self-direction and empowerment in fulfilling day-to-day roles (Miles-Tapping & MacDonald, 1994), and those people transitioning from manual mobility to powered mobility have reported noticeable improvement in occupational performance and psychosocial status (Buning, Angelo, & Schmeler, 2001). Nonetheless, users of wheelchairs may consider their wheelchairs to be the most limiting factor to participation when they confront issues with mobility ranging from an inadequacy with the technology to the existence...
of physical barriers (Chaves et al., 2004). Findings from this study demonstrate the continued efforts needed in enhancing the occupational performance of PWC users while in their day-to-day activities, community involvement, and social participation.

Participants in this study used their PWCs at home and in the workplace optimally in relation to major attributes of usability. Nevertheless, issues with space and accessibility reportedly undermined their participation in these contexts. The need to organize and modify the space for use of wheelchairs is a vital strategy to enhance PWC mobility within the home environment. One of the key concerns with use of PWCs indoors was the extent of damage caused to property because of problems with drivability and restricted space. Because most participants resided in rental properties, the mounting damages potentially posed a future liability issue for them.

With respect to the workplace/school usability of PWCs, accessibility of workstations or classrooms is an area warranting attention. In addition, most of the participants were unemployed and the usability of their wheelchairs was therefore not accountable in the area of work- or school-related activities. This problem may be directly attributed to factors associated with unemployment in the disability population and may require intervention external to the usability framework applied here.

In the case of community and outdoor usability of PWCs, the issues were far more apparent than those in other contexts. Participation in community activities such as shopping, going to public buildings, and eating in restaurants was restricted for a notable proportion of users of PWCs owing to specific accessibility problems in these places. For example, problems reported in going to restaurants included lack of space with seating and inaccessible restrooms. With regard to shopping, participants expressed problems with narrow aisles, difficulty reaching for items, and encountering frequent obstacles. On this note, participants stated that legislation concerning public accommodations for wheelchairs is not rightfully implemented in many public places according to mandated standards. Previous reports from wheelchair users have indicated that lack of accessible and safe physical environments considerably undermines their community and social participation (Chaves et al., 2004).

As intervention, the involved policymakers must establish stringent criteria in ensuring that public buildings and facilities are designed, constructed, and maintained within the norms of accessibility standards. Architectural experts must continue to research and resolve problems that limit accessibility of wheelchairs in public places. In terms of wheelchair drivability, outdoor usability of PWCs was undermined in the activity of driving through the streets, most possibly because of the problem in accessing sidewalks. Because research has shown that PWC users may travel on average approximately 8 km (5 miles) per day (Cooper et al., 2002), issues with outdoor accessibility must be continually identified and resolved. Civic authorities (especially in inner-city neighborhoods) must take note that a major portion of the PWC users in this study voiced concern that sidewalks in their locality were uneven and unsafe to drive on, prompting them to drive with traffic on streets. Taking into account consumer needs, PWC manufacturers must continually focus on improving the capability of wheelchairs to overcome rough terrain and the resistance of PWCs to withstand adverse weather conditions.

For travel, guidelines for using various forms of wheelchair transportation are documented. These include educating wheelchair users with information on options available for private and public transportation and evaluation and training to ensure competence in using these options (Welch, 2007). Even so, transportation authorities must persistently strive to improve the availability and accessibility of various modes of transportation for people using PWCs.

The findings also substantiate the need for continued seating and postural interventions for users of PWCs. Earlier research has indicated that nearly 41% of reported problems with wheelchair use are associated with inappropriate seating alignment (Mann, Hurren, Charvet, & Tomita, 1996), and discomfort related to seating was perceived by wheelchair users to be a significant impediment to their participation (Chaves et al., 2004).

Occupational therapists who conduct seating interventions for wheelchair users must continually direct their expertise on issues related to posture, reach, and safety. A significant number of respondents reported moderate to low postural control and moderate to severe pain while seated in their wheelchairs. To optimize the usability of PWCs, improving the user’s reach for performing tasks is an area requiring intervention. Postural interventions and use of assistive devices such as reachers are strategies to consider.

Studies examining wheelchair safety have indicated that nonfatal but serious injuries from wheelchair accidents are very prevalent (Kirby & Ackroyd-Stolarz, 1995) and commonly result in fractures, concussions, dislocations, amputations, and head and spinal injuries (Kirby, Ackroyd-Stolarz, Brown, Kirkland, & MacLeod, 1994). Consequences of such accidents may include direct (medical) costs, indirect costs from work absence, and functional costs of caretaking and dependence. Taking into account the high incidence of reported accidents in this study, the intervening therapists and technicians may need to intensively train their clients during the service delivery process in safe use of PWCs within all contexts.
Limitations

Although a large sample was preferable, the study’s findings are reasonably generalizable considering that the sample characteristics represent that of the population. Some salient limitations of the study were apparent. The results of this study were derived from secondary analysis of data collected to field test an instrument. As a result, the original objective of the study was not investigative but methodological. In the process, the sample recruitment was not premeditated for examining PWC usability. Tracking the usage of PWCs specific to each participant across time may perhaps lend a better picture of their longitudinal usability.

Implications

The study provides a general overview of PWC usability within multiple contexts of occupation from both a mobility and a seating standpoint. On the basis of the findings, intervening therapists may need to further investigate specific aspects of PWC usability more elaborately. As shown in Table 3, the findings have been applied to the proposed intervention framework with a (nonexhaustive) list of possible interventions and stakeholder involvement. The framework can seemingly be applied to other wheeled mobility devices such as manual wheelchairs, push-rim activated power-assisted wheelchairs, and scooters.

Wheeled mobility and seating are continually advancing as one of the specialties in the field of occupational therapy. Even so, all therapists who work with wheelchair users need to acquire a general know-how in resolving common usability issues with mobility devices and must advocate toward alleviating some of the broader contextual issues. Above all, a collective effort from other stakeholders including technology developers, manufacturers, researchers, and policymakers is required to address the issues with wheelchair usability.

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References


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