Comparing Satisfaction with Occupational Performance Using a Pushrim-Activated Power-Assisted Wheelchair and a Power Wheelchair among Task-Specific Power Wheelchair Users

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ABSTRACT

Wheelchairs provide a valuable method of mobility for individuals whose ambulation is compromised by physical impairment. Manual wheelchairs (MWC) are light, maneuverable, and portable, but are also physically demanding to use. Power wheelchairs (PWC) provide a less physically taxing alternative but face more environmental and social barriers. Consequently, some individuals choose to use these two devices – a MWC and a PWC – for different activities. A pushrim-activated, power-assisted wheelchair (PPW) may provide an alternative to the PWC for these users, reducing the physical demands of propulsion while still offering the benefits of a MWC configuration.

This study utilized a two-phase, mixed methods design, comparing the performance and satisfaction of wheelchair users carrying out self-selected activities with their current PWC and with a PPW. During phase one, four tools were used to gather quantitative data on occupational and functional performance, satisfaction, and impact on quality of life (COPM, FEW, QUEST, and PIADS). In phase two, a focus group format was used to gather qualitative data regarding the participants' experiences with each device, facilitating interpretation and explanation of the quantitative results.

Participants identified relative benefits and barriers with each wheelchair device. There was no statistically significant difference in the outcome measures between the PWC and PPW (with the exception of the Self Esteem subscale on the PIADS); however, many participants reported a preference for the PWC when the physical environment was conducive to its use. Less accessible environments, particularly when traveling or transporting a wheelchair, were identified as opportunities for PPW use. Rather than

replacing the PWC for all of their identified activities, participants indicated the PPW improved upon the MWC by retaining its advantages and compensating for its shortcomings. As a result, participants expressed a willingness to try more (and new) activities, including some that might have been previously performed with the PWC.

The process by which participants evaluate (and ultimately choose) a wheelchair is a highly complex one and reflects more than comparing attributes of one device over another. The performance of the device within the actual context of use, and the subjective experience of the user in performing those occupations, are carefully measured against expectations. The evaluative process is an iterative one, requiring both adjustment of the device to the user and user to the device. Furthermore, this process requires sufficient expertise in the prescriber and adequate time to accurately evaluate the outcome.

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DEFINITIONS

Community participation. Participation, as defined in the *International Classification of Functioning, Disability and Health*, is “involvement in a life situation” (World Health Organization, 2001, p. 10). More specifically, it refers to the ability of an individual to function within a social context, with successful role performance. Community participation is considered to be performing “the actions and tasks required to engage in organized social life outside the family, in community, social and civic areas of life” (World Health Organization, 2001, p. 168). This definition includes activities associated with recreation and leisure, arts and culture, sports, hobbies, socializing and activities related to practicing spirituality and religion.

Dual users. Manual and power wheelchairs each have unique attributes that can operate as both enablers and barriers to successful occupational performance. Some individuals will employ both types of mobility devices, depending upon the particular activity or environment in which they plan to participate. Individuals who utilize both a power and a manual wheelchair, each used for specific activities and purposes, will be considered dual users.

Focus Group: “A semi-structured group session, moderated by a group leader, held in an informal setting, with the purpose of collecting information on a designated topic” (Carey, 1994, p. 226).

Manual wheelchair. This term refers to an independently propelled mobility system (Kreutz & Johnson-Taylor, 2002; Cook & Hussey, 2002). While some wheelchair designs allow for a care-giver to provide propulsion, these will not be considered for the purposes of this research study. The manual wheelchair device is comprised of two large wheels at the rear and two smaller wheels in the front. The user propels the wheelchair independently with his or her upper extremities, lower extremities, or some combination of the two (Kreutz & Johnson-Taylor, 2002; Cook & Hussey, 2002).

Occupation: "Occupation refers to groups of activities and tasks of everyday life, which are named, organized, and given value and meaning by individuals and a culture. Occupation is everything people do to occupy themselves, including looking after themselves (self-care), enjoying life (leisure), and contributing to the social and economic fabric of their communities (productivity)" (Townsend, 2004, p. 3).

Occupational Performance: "Occupational performance refers to the ability to choose, organize, and satisfactorily perform meaningful occupations that are culturally defined and age appropriate for looking after one's self, enjoying life, and contributing to the social and economic fabric of a community" (Townsend, 2004, p. 30). Occupational performance is the outcome that "results from the dynamic relationship between people, their occupations and roles, and the environments in which they live, work and play" (Law et al., 1996, p. 9).

Power wheelchair. This term refers to an independently operated power mobility system (Cook & Hussey, 2002; Kreutz & Johnson-Taylor, 2002). The device is electrically powered, and includes a power source (i.e., batteries), a drive motor to the wheels, and a control interface for the user to operate the system (Cook & Hussey, 2002). Another alternative configuration is a scooter. The scooter includes the same components, but the control interface is limited to a tiller mechanism with separate controls for steering and speed.

Pushrim-activated power-assisted wheelchair. This term refers to an independently propelled mobility system, consisting of a manual wheelchair and a pair of rear wheels with direct-drive in-wheel motors. The wheels incorporate both a power source (battery) and a drive motor. As the user advances the wheel pushrims, the motors temporarily engage and provide additional propulsion (Cook & Hussey, 2002). The power to these wheels can be turned off or they can be exchanged with the standard, non-powered wheels to convert to purely manual operation (See Appendix A). In some literature, PAPAW has been used as an abbreviation; however, PPW is used in this thesis to provide consistency with the PWC and MWC acronyms.

1.0 INTRODUCTION

1.1 Statement of the problem

For most people in our society, personal mobility is achieved through ambulation. When the ability to walk is compromised by physical impairment, a wheelchair may serve as a means to maintain mobility (Brandt, Iwarsson, & Stahle, 2004; Hoenig, Landerman, Shipp, & George, 2003; Arva et al., 2000). Mobility via a wheelchair enables continued participation in activities related to independence, work, and social engagement (Algood et al., 2003; Field, 1999). When the physical demands of using a manual wheelchair (MWC) interfere with performance of occupation, individuals must often decide whether to continue using a MWC or convert to using a power wheelchair (PWC) – often reluctantly because of the implications of accessibility and perceived social stigma (Buning & Schmeler, 1999). A PWC is much heavier and presents limitations to portability, often requiring use of a specialty (handicap accessible) transit or van, rather than smaller, more economical vehicles. They are typically larger and wider than a MWC, creating accessibility issues particularly within the home environment (Leonard, 1992). A PWC may be perceived by the user as creating a more disabled image, and appear more obvious than a MWC (Buning & Schmeler, 1999). Some individuals prefer to use a MWC to maintain their physical status and fear a transition to a PWC may diminish their health (Leonard, 1992).

While all of these reasons might discourage individuals from moving from a MWC to a PWC, the demands for successful occupational performance (both individual and environmental) may ultimately compel them to change their mode of mobility. Some individuals choose to use both methods – PWC for specific occupations and environments that require it, and MWC for others. Using two different wheelchairs for different occupations can prove to be complicated and costly. Up until recently, individuals who experienced difficulty propelling a MWC had only three options: continue using a MWC with difficulty; have an attendant push their MWC; or transition to using a PWC. The pushrim-activated, power-assisted wheelchair (PPW) was developed as another alternative to these existing options, particularly for those individuals who have difficulty propelling a MWC but may not want to use a PWC (Algood, Cooper, Fitzgerald, Cooper, & Boninger, 2004; Arva, Fitzgerald, Cooper, & Boninger, 2001; Cooper et al., 2002a; Cooper & Cooper, 2003; Corfman, Cooper, Boninger, Koontz, & Fitzgerald, 2003; Levy et al., 2004). The PPW may present an alternative to the PWC for specific occupations – delaying or eliminating the need for a PWC. However, little research has occurred in the area of occupational performance using a PPW and virtually no investigation has been made comparing PWC and PPW performance.

1.2 Significance of the study

For persons with disabilities, the decision to use a MWC or a PWC may be a difficult one, and there is a paucity of information available for making such decisions (Buning, Angelo, & Schmeler, 2001; Miles-Tapping & MacDonald, 1994; Bates, Spencer, Young, & Rintala, 1993; Cooper et al., 2002b). Occupational therapists must consider many factors when recommending a MWC or PWC, and require evidence to advocate for their recommendations to third-party payers (Leonard, 1992; Warren, 1990). Even more challenging is finding evidence to support *alternatives* to the traditional manual and power wheelchair. Very little research is available with regard to PWC alternatives (including PPW), particularly around the impact this wheeled mobility device has on occupational performance.

If the PPW proves to be a viable alternative to PWC for some individuals, this information may benefit a number of stakeholders. For users, they could potentially own a single wheelchair and use it in either manual or PPW configuration, simply by exchanging the standard wheels with the power-assisted wheels. If PPW could be used (to the satisfaction of the user) for occupations with which they currently employ a PWC, it may be able to replace a PWC, or delay the transition to a PWC. This could provide flexibility for the user, while reducing costs (i.e., not having to own two wheelchairs). It would also potentially address the barriers to community access that the use of a PWC inherently creates. For occupational therapists, the data collected to investigate the use of PPW as an alternative to a PWC will supplement the evidence base for clinical practice and decision-making. For funding agencies, it will provide evidence to justify prescription of PPW for appropriate individuals. For researchers in the field of rehabilitation medicine, the data will contribute to an emerging area of practice and help direct larger research studies.

2.0 REVIEW OF THE LITERATURE

2.1 Summary of the Literature

2.1.1 Alternatives in Manual Wheelchair Mobility

Overview of Hand-rim Propulsion

The hand-rim (or push-rim) propelled MWC is the most common form of wheeled mobility device, estimated to be used by 90% of all wheelchair users (van der Woude, Dallmeijer, Janssen, & Veeger, 2001a). Despite the widespread popularity of this design, the hand-rim is a relatively inefficient and physically taxing method of propulsion (Boninger, Baldwin, Cooper, Koontz, & Chan, 2000; van der Woude, Veeger, Dallmeijer, Janssen, & Rozendaal, 2001b). Several factors contribute to this degree of inefficiency. In order to generate continuous movement, the user must alternately engage and release his or her hands from the hand-rim. This process of coupling and uncoupling between hand and rim must occur rapidly and demands considerable coordination (Boninger et al., 2002; van der Woude et al., 2001a; van der Woude et al., 2001b). During this coupling and uncoupling action, it is difficult for the user to match his/her arm speed precisely with the speed of the handrim as it passes by; consequently, a negative force (or braking effect) caused by this speed differential between hand and rim, is incurred before the individual can again provide an effective push. This braking effect is accentuated when users experience impairment in sensation, coordination, or motor control (Fay & Boninger, 2002).

During the push phase of propulsion (when the hands are coupled with the rim), the user must generate a significant peak force over a very short time period, roughly one-half second. The upper extremities are placed in a less-than-optimal position mechanically, and considerable joint stabilization is required at the shoulder and scapula, as well as the wrist and hand (Boninger, Cooper, Shimada, & Rudy, 1998; van der Woude et al., 2001a; van der Woude et al., 2001b). Furthermore, the most mechanically advantageous application of force is tangential to the handrim. The shoulder anatomy, and subsequently the orientation of the upper extremity to the wheel, does not promote an optimal push (i.e., tangential force application). Consequently, hand-rim users self-select a push stroke that balances the anatomical and mechanical efficiencies (Aissaoui, Arabi, Lacoste, Zalzal, & Dansereau, 2002; van der Woude et al., 2001a; van der Woude et al., 2001b). In summary, the anatomical configuration of the upper extremities is poorly matched as a substitute for the lower extremities in the task of repetitive, high-force, high-impact ambulation. Van der Woude (2001b) identifies three strategies to compensate for the inefficiencies of hand-rim wheelchair propulsion: maximize the wheelchair performance and user-technology interface; improve the physiological structure and performance of the individual; or adapt the task by changing the propulsion method. The last alternative will be explored in more detail.

Alternative Methods of Propulsion

Several options have been developed to adapt the propulsion method. One common strategy is to convert the source of power from the individual to an electric motor. The PWC and the PPW are two examples that either eliminate or reduce the physical demands of propulsion. However, there are other innovations in manual wheelchair design that provide an alternative to traditional hand-rim propulsion – specifically crank and lever systems.

Hub-crank Propulsion

Crank propulsion systems operate like a bicycle, with pedals extending from an axle. Two types of crank systems have been examined: hub-crank and arm-crank. The hub-crank design has the pedals connected directly to the wheelchair axle and the user positions his or her arms similarly to the hand-rim design. Each pedal articulates on the crankshaft as the user propels the wheelchair, allowing the hands to remain in contact with the wheel continuously and positioning the hand-wrist in an efficient orientation. This design also allows use of both the upper extremity flexor and extensor muscle groups during propulsion.

A small number of research studies have investigated the benefits of using a hub-crank wheelchairs over hand-rim propulsion. Two studies (van der Woude, van Kranen, Ariens, Rozendal, & Veeger, 1995; van der Woude, Mass, & Rozendal, 1995) identified decreased oxygen uptake and heart rate using a hub-crank wheelchair, as well as increased gross mechanical efficiency (12.9% compared to 9.1%). Both studies employed a motor-driven treadmill, rather than a natural setting. In addition, participation was limited to non-wheelchair users in the former study and wheelchair athletes in the latter. Several disadvantages have been identified with the hub-crank design. Steering and braking are difficult for the user, the location of the crank increases the overall width of the chair significantly (i.e., increased by 15 cm), and larger front wheels contribute to an increased overall length. These limitations likely contribute to the small number of research studies, and the fact that hub-crank wheelchairs have been used predominantly in racing applications.

Arm-crank Propulsion

The second design, the arm-crank, situates the crank immediately in front of the seated user. The individual operates the crank with their arms, in the same manner used to pedal a bicycle. The crank is connected to the rear drive wheels using a sprocket-and-chain mechanism, as with a bicycle. This design allows the use of gears for a variety of environments and conditions (van der Woude et al., 2001b). Arm-crank operated wheelchairs are more common than the hub-crank design. The arm-crank has been used for exercise purposes, particularly among individuals with spinal cord injury.

Research measuring mechanical efficiency suggests that the arm-crank is superior to hand-rim wheelchair propulsion, although most studies measure efficiency with an ergometer rather than an arm-crank operated wheelchair (Martel, Noreau, & Jobin, 1991; Glaser, Sawka, Brune, & Wilde, 1980; McConnell, Horvat, Beutel-Horvat, & Golding, 1989; Sedlock, Knowlton, & Fitzgerald, 1990). The demand of operating an arm-crank wheelchair, measured by energy cost and heart rate, is lower than hand-rim propulsion and power output is higher (van der Woude, de Groot, Hollander, van Ingen Schenau, & Rozendal, 1986; Engel & Hildebrandt, 1974). A few studies have compared arm-crank and hand-rim propulsion in natural settings (Engel & Hildebrandt, 1974; Oertel, Brundig, & Henze, 1999; van der Woude et al., 1986). Oertel (1999) found a decrease in physiological demands (i.e., heart rate and caloric expenditure) and superior performance was identified (i.e., improved speed and endurance). Van der Woude (2001a) identified several advantages to the arm-crank configuration. The arms are situated in a mechanically- and anatomically-advantageous position, and hand-coupling occurs in a more natural position without the need for de-coupling. Large muscles in the flexor and extensor groups of the upper extremities are engaged, and operation occurs within the user's visual field, creating less demand for intact coordination and sensation.

Lever-driven Propulsion

The lever system also situates the propulsion mechanism in front of the user, but rather than using a circular motion, the arms push and pull two levers in either a synchronous or asynchronous direction. The levers connect to the drive wheel and generate torque around the axle, similar to an old-style locomotive. Propulsion occurs in a rhythmic motion in the sagittal plane, with the arms moving in either the same or alternating directions (van der Woude et al., 2001a). This mechanism shares similar mechanical and anatomical advantages with the arm-crank method, as discussed previously.

Very little research exists that evaluates lever-driven wheelchairs, particularly in comparison to the hand-rim configuration. Improvement in mechanical advantage has been suggested (van der Woude & Botden, 1997) as well as decreased energy expenditure (Engel & Hildebrandt, 1974; van der Woude et al., 1986; van der Woude, Veeger, de, & Rozendal, 1993). Lever-driven wheelchairs have not made a significant appearance in the commercial market to date, and research remains largely prototypical. Several limitations in the design have contributed to this situation: difficulty integrating reverse and free-wheeling modes; awkward steering; and poor maneuverability particularly in confined areas (van der Woude et al., 2001a).

Summary

Alternative designs of wheelchair propulsion systems do appear to provide a mechanical advantage over the traditional pushrim, resulting in decreased physiological demands for the user. However, the drawbacks inherent in these modifications, including increased size, cost, and complexity of the device, contribute to their poor application in typical daily activities resulting in limited consumer demand. Virtually no research has explored use of alternative propulsion designs in the natural living environment of the user. While these prototypic options show promise, the feasibility of individuals adopting them for daily use is still minimal and requires additional investigation (Corfman et al., 2003; Cooper et al., 2002a; Somers & Wlodarczyk, 2003; Arva et al., 2001; Algood et al., 2002).

2.1.2 Pushrim-Activated Power-Assisted Wheelchair (PPW)

PPW Overview

The PPW is a relatively new technology. Historically, individuals who had difficulty with or were unable to propel a MWC independently, had to choose between using a PWC and having an attendant push them in a MWC. The PPW was developed as an alternative to these existing options (Algood et al., 2004; Arva et al., 2001; Cooper et al., 2002a; Cooper & Cooper, 2003; Corfman et al., 2003; Levy et al., 2004). It is estimated that, in the United States in 2003, there were approximately 5,000 individuals using PPW devices; this number is expected to grow rapidly in the near future (Cooper & Cooper, 2003). The PPW is a manual wheelchair with electrically powered motors located in the hubs of the rear wheels. When the user applies torque to the pushrim (i.e., manually propels the wheelchair), the motors are temporarily engaged. The motors briefly supplement the manual push, proportional to the user's input of force on the pushrim (Levy & Chow, 2004; Algood et al., 2004; Cooper et al., 2001; Cooper & Cooper, 2003). The user continues to propel as they would with a traditional MWC;

however, the push requires less effort and produces a larger result, suggesting propulsion should be easier (Levy et al., 2004; Somers & Wlodarczyk, 2003; Levy & Chow, 2004; Algood et al., 2002). Propelling on uneven terrain or up an incline requires less effort (Best, Kirby, & Smith, 2003; Cooper et al., 2001; Levy & Chow, 2004; Medvescek, 2003; Algood et al., 2004; Smith, 2004; Somers & Wlodarczyk, 2003).

Several PPW products have been produced commercially. In Canada, two devices are currently available. While the principle of operation is similar, there are some variations in performance and features between the products. The PPW wheels used in this study are designed to fit the axles of most adjustable lightweight wheelchairs (i.e., those with quick-release axles to easily remove the rear wheels), with the addition of specialized brackets mounted on the axle plate. The user can alternate between PPW and manual wheels by using the quick-release mechanism to exchange wheels, depending upon which configuration he or she wants to employ. Furthermore, the wheelchair seating equipment and positioning remains largely unchanged, regardless of which configuration is used. Each wheel (including the battery) weighs approximately 12 kg. This additional weight goes unnoticed by the user during power-assisted operation; however, if the motors are turned off or the batteries lose their charge, there is a noticeable increase in effort to propel the wheelchair manually. In addition, the weight of the wheels can create an increased challenge for some users (e.g., dismantling the wheelchair to exchange manual and PPW wheels or to load into a vehicle for transport), and some users may require assistance for these types of activities (Cooper et al., 2001; Corfman et al., 2003). The cost of one set of PPW wheels is approximately $6500 (in 2006 Canadian dollars).

Physiological and Mechanical Advantages

PPW research, to this point, has focused primarily on the physical demands of propelling the wheelchair, and the physiological benefits derived from using power-assisted rather than manual propulsion (Arva et al., 2000). Compared with use of a manual wheelchair, the PPW reduces the metabolic demands of propulsion, resulting in lower heart rate (Levy et al., 2004), oxygen consumption (Cooper et al., 2001; Arva et al., 2001), and ventilation rate (Algood et al., 2004). Biomechanically, joint range of motion and stroke frequency during propulsion are also reduced (Algood et al., 2004; Cooper et al., 2002a). Some studies have used subjective rating scales to evaluate ease of use (Levy et al., 2004; Cooper et al., 2001) and perceived exertion (Levy et al., 2004), and report users respond more favourably with the PPW than their MWC on both variables. Corfman et al. (2003) found that in a group of ten participants with spinal cord injury, the use of PPW resulted in a significant reduction in required shoulder, elbow and wrist range of motion during propulsion compared with traditional MWC propulsion. The authors suggested that this improvement may reduce the likelihood of upper extremity injury and neuropathy that is common in long-term wheelchair use, but these results have yet to be confirmed. Mechanical efficiency is reported to increase up to 80%, particularly at higher speeds, and less torque is required to propel the wheelchair (Arva et al., 2001; Cooper et al., 2002a) with reduced muscle activation demands (Levy et al., 2004; Chow et al., 2002).

Potential Users

Most PPW studies have included adult participants with spinal cord injury, including those with paraplegia (Arva et al., 2000; Arva et al., 2001; Cooper et al., 2001; Cooper et al., 2002a) and tetraplegia (Algood et al., 2003; Algood et al., 2004; Somers &

Wlodarczyk, 2003). While this is a group that often benefits from use of PPW, there are certainly other populations for whom the benefits should be researched, including people with Multiple Sclerosis, Cerebral Palsy and Cerebral Vascular Accident (CVA). One study included elderly users, but these participants also had specific neurological or orthopaedic diagnoses (Levy et al., 2004).

Performance in Functional Activity

A small number of studies comparing PPW and MWC have included performance of functional activities as an outcome measure; however, investigation of occupational performance in a community setting has not yet been undertaken. One study had a group of 30 able-bodied participants perform a series of standardized tasks (i.e., the Wheelchair Skills Test) in a clinical setting using PPW and a traditional light weight MWC (Best et al., 2003). No statistical difference was found in performance on the test, although 85% of participants indicated a preference for the PPW. A second study, using ten wheelchair users, incorporated a standardized driving course as part of a comparison between MWC and PPW devices (Cooper et al., 2001). The course provided a variety of common driving conditions and obstacles (e.g., carpet, tile, door threshold, 5º ramp, speed bumps), as well as several tasks (e.g., open and close a door, transfer into a simulated car, disassemble the wheelchair and load it into the simulated car after transferring). Participants used a Likert rating scale (scored from 1 to 10) developed by the authors. A significant difference was reported between participants' rating of ergonomics, comfort, and appearance of the two devices. Transportability of the PPW, in and out of a vehicle for example, was identified as a particularly relevant consideration as it relates to community participation. Cooper et al. (2001) reported five of the ten participants in their study were unable to fully complete the car transfer portion of the ADL course, due to the awkwardness and weight of the PPW wheels. Levy et al. (2004) investigated differences in ease of wheeling PPW and MWC over various surfaces with eleven elderly wheelchair users. The authors indicated that ten participants self-reported propulsion to be easier with the PPW on level or inclined terrain, and nine reported likewise on carpeted surfaces. After comparing the two devices, seven of the eleven participants reported a strong willingness to exchange their MWC for a PPW. However, this study took place within a controlled laboratory setting, and not in the participants' natural environment.

Areas Requiring Further Investigation

The majority of research to date has taken place within a controlled laboratory setting; typically measured physiological function; and compared PPW and MWC operation. Various authors have identified a pressing need for further investigation into additional areas, including: time spent in the wheelchair, locations visited, distance covered, and users' perception of satisfaction (Algood et al., 2003; Levy et al., 2004). Little work has been done exploring the benefits of adjustability within the programming of the PPW, such as the ability to compensate for unequal strength between upper limbs or to encourage "forced use" of the more affected limb in CVA (Cooper et al., 2002a). No investigation to date has been made comparing performance of the PPW with traditional powered mobility and this research has been strongly recommended by several investigators (Levy et al., 2004; Arva et al., 2001; Cooper et al., 2001). Evaluation of PPW performance in the users' natural environment is identified as a high priority, as well as having participants evaluate the benefits incurred, particularly on quality of life, satisfaction, independence, community participation and integration, and affect (Algood et al., 2002; Algood et al., 2004; Arva et al., 2001; Corfman et al., 2003; Levy et al., 2004; Somers & Wlodarczyk, 2003).

2.1.3 Conceptual Model

This study is conceived under the broad framework of the Canadian Model of Occupation Performance (Townsend, 2004). Within this framework, users of mobility devices base their selection of equipment on enablement of successful occupational performance (Buning & Schmeler, 1999). The selection of a manual or power wheelchair may be influenced by factors related to the person (e.g., fatigue prevents effective use of a manual wheelchair); by the environment (e.g., existence of ramps may elicit use of PWC while restrictive spaces may preclude it); and by the task itself (e.g., one hand is required to hold an object, leaving only one hand available to operate the wheelchair). The choice of specific technologies for specific occupations is dependent upon how the user evaluates the interaction of these factors (i.e., client-centred) and the measurement of successful occupational performance. These choices represent the individual's ability to participate in occupations and roles that are meaningful and influence how the individual perceives him/herself and their life experience (Buning & Schmeler, 1999). This study is designed to measure the outcomes of participants' experiences using the PWC, and identify whether an alternative technology (i.e., PPW) provides a comparable degree of satisfaction with respect to performance, community participation, and psychosocial impact. The study used quantitative outcome measurement tools to evaluate performance and satisfaction, and qualitative information gathered through focus groups to explain and interpret these results.

2.1.4 Assistive Technology Theoretical Framework

Occupational therapists seek to optimize their clients' ability to perform meaningful occupations and fulfill important life roles (Crepeau & Boyt Schell, 2003). The focus of their intervention is generally on mediating the *consequences* of a health condition, rather than ameliorating the condition itself (Barrett & Kielhofner, 2003). Consequently, success for the client is measured in their ability to overcome barriers to activity, and perform occupations in a satisfactory manner. Assistive technology (AT) is used frequently as an intervention in the field of rehabilitation to achieve this outcome. Alice Seidel describes rehabilitation as "the process of restoring an individual's capacity to participate in functional activities when this capacity has been altered or limited by a physical or mental impairment" (2003, p. 235). A rehabilitation model aims to compensate for impairment, through modification of the environment or task and through the use of assistive technologies (Seidel, 2003). Motivation of the individual is critical, and flows from the development of client-centred goals and a collaborative approach to intervention. Results may not be immediate, and success may come over time as the client's skills, abilities, and attitudes evolve. Furthermore, client needs may change over time as their goals, abilities and environments change, and interventions may need revision or replacement. Individuals are complex and unique beings, and their behaviour is influenced through a dynamic relationship with their environment (Burke, 2003). In particular, the environment of use must be a primary consideration in the intervention process.

Occupational therapists strive to be evidence-based in their provision of rehabilitative services. They must understand which interventions are most likely to be effective in optimizing occupational performance, and why those interventions succeed, in order to facilitate appropriate decision-making. Furthermore, there is an increasing demand for accountability in their choice of interventions and recommendations (Depoy & Gitlow, 2001). More specifically, occupational therapists develop solutions using a clinical reasoning process, based in part on previous experience. Clinicians may recognize a familiar situation and suggest a device, without conscious awareness of why it is or is not effective. For clinicians, understanding the application of assistive technology to occupational performance requires a consideration of the underlying theoretical framework.

The Need for a Conceptual Model

A theoretical framework provides direction to AT procurement; expedites exploration of solutions based on a rationale for success; and provides clarity in justification for the user and other potential stakeholders. Lenker and Paquet (2003) argue that theoretical development for AT in rehabilitation has largely focused on individual results – what worked with this client in this situation – rather than trying to establish causal relationships and generalizable principles. Clinicians observe the obvious benefits of AT use, and that the impact of a specific device is self-evident. Prescribers tend to rely on their own and others' anecdotal experience (Lenker & Paquet, 2003).

Given that expertise in AT prescription is difficult to find, funders have been reticent to demand evidence from practitioners (Lenker & Paquet, 2003). There is a general consensus among researchers in the field of AT that a theoretical model is critical to understanding the relationship between treatment and outcome, and for explaining why a particular solution is effective (Ragnarsson, 1990; Scherer & Galvin, 1996; Watts, O'Brian, & Wojcik, 2004). Reid et al. contend “without theory, conceptual direction is ambiguous, and atheoretical data does not help to advance the knowledge base” (2002, p. 265). Utilizing a model would facilitate both descriptive and predictive functions, improving the prescription process and addressing the needs of a broad range of stakeholders (Day, Jutai, & Campbell, 2002).

Focus for Evaluating Conceptual Models

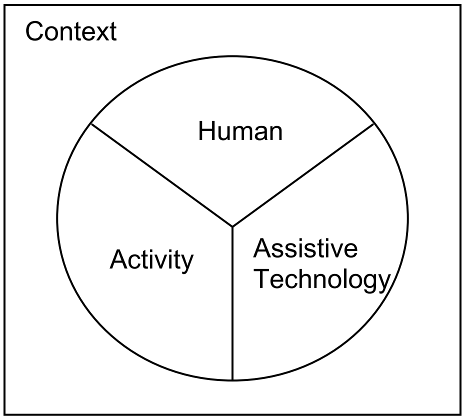
This review will consider conceptual models that provide discussion around the factors that relate to successful implementation of AT (beyond listing strategies or protocols for intervention) and expand on these conceptual factors enough to evoke some predictive direction. Such models will facilitate an exploration of outcome measures that relate directly to causal variables, in addition to functional outcomes. In addition, the models should be consistent with the values and perspectives of occupational therapy. Specifically, the model should support a client-centred approach in which the user defines what the outcomes should be, and plays a primary role in evaluation of these outcomes. The outcome should reflect occupational performance, where fulfillment of a task or role is the central focus. Occupational performance is a systemic outcome that reflects consideration of the attributes of the individual, the task itself, and the environmental context within which the task takes place (Christiansen & Baum, 1997). Finally, the models should be acknowledged within the AT literature, and not limited to a specific area of practice (e.g., only applicable to the field of education).

Current Models of Assistive Technology

Everett Rogers (1995) proposed a model, the *Diffusion of Innovations*, to explain acceptance or rejection of new technologies. As a social scientist, his foci are the global processes by which new ideas or products (i.e., innovations) are integrated into society and the variables that contribute to individual differences in acquisition (i.e., diffusion). Some researchers have applied this social theory specifically to the field of assistive technology and rehabilitation (Riemer-Reiss, 1999; Riemer-Reiss & Wacker, 2000). Rogers identifies the Innovation-Decision Process – a series of stages through which individuals progress in their determination of accepting a new device (Carr, 2004). Individuals gain awareness of a potential product and soon thereafter develop an attitude, either positive or negative, towards the innovation. The result of this is a decision to accept or reject the technology on a short-term basis. If accepted, the innovation is implemented into their life for a period of time, and ultimately they make a long-term decision to either maintain or abandon use of the product. This decision is based on the perceived benefits of the product, as well as personal characteristics of the individual (Carr, 2004; Rogers, 1995).

Cook and Hussey (2002) have proposed the *Human Activity Assistive Technology (HAAT)* model as a framework for prescribing assistive technologies (see Figure 1).

Figure 1. HAAT model.



Note. From "Assistive technologies: Principles and practice (2nd ed.)," by A. M. Cook & S. M. Hussey, 2002, St. Louis: Mosby, Inc. Copyright 2002 by Elsevier. Adapted with permission from Elsevier.

Human performance depends upon an *interaction* between the individual, the activity, and the environment. The role of AT is to improve function in specific activities (Edyburn, 2001). Consequently, this model considers AT *system performance*, rather than strictly human or device performance (Lenker & Paquet, 2003). The relationship between the individual and the device, or the *human/technology interface*, is a reciprocal one. Selection of a device depends upon its ability to bridge the gap between the environmental and task demands, and the intrinsic enablers of the system. Human perception of the technology is integral to occupational performance. Since the introduction of an AT device is identified as a systemic gestalt, it must be adopted by users as an extension of themselves. Therefore, the extent to which they appreciate or perceive the device as satisfactory must be related to the ultimate success of the system (Cook & Hussey, 2002). Perception of self and what others think of self (i.e., environmental context and interface) is critical to effective performance of the system. Consequently, evaluation of the intrapersonal component is important when considering which device is optimal within the AT system.

The *Matching Person and Technology* (MPT) model identifies three components that contribute to successful application of AT to activity performance. These elements reflect the characteristics of the milieu, the person, and the technology itself (Lenker & Paquet, 2003; Scherer & Galvin, 1996; Scherer & Craddock, 2002; Bromley, 2001). The milieu refers to the physical and psychosocial environment or setting within which the technology is used. The person component incorporates all factors relating to the user, including physical abilities, needs, expectations, motivation and temperament (Scherer & Galvin, 1996). Finally, the characteristics of the technology/device itself are integral, such as physical, sensory and cognitive demands for use; esthetics; durability/reliability; and functional performance (Lenker & Paquet, 2003). The user is identified as central to the process (Scherer & Galvin, 1996), as the authors believe that the basis of dissatisfaction and abandonment in AT “is the failure to consider user opinions and preferences in device selection” (Scherer & Craddock, 2002, p. 4). A collaborative approach to AT decision-making is incorporated. The MPT model promotes a developmental or sequential perspective, considering potential changes over time related to progression of impairment and anticipated future performance needs (Scherer & Galvin, 1996). The model also integrates the ideas of successful role performance, as espoused by the profession of occupational therapy.

Gitlin proposed a *Career Path* model that considers use of AT over a longitudinal perspective, identifying a “career” that users pursue with respect to device adoption (Lenker & Paquet, 2003). The career is composed of four “phases that represent periods of relative constancy between major life events” (Lenker & Paquet, 2003, p. 8). These include the novice user, the early user (immediately post-discharge from hospital), the advanced user (6-12 months post-discharge) and the expert user (beyond 12 months). At these points in time, individuals make significant choices about whether they will discard or continue to use a particular technology. During each career period, several variables are proposed as contributing to this decision process. The model implies the user has suffered a traumatic event, and centres around a hospital-based intervention process.

Several models of AT provision have been proposed using the International Classification of Functioning, Disability and Health (ICF) model of human function (Cooper et al., 2001). Most notably, Lenker and Jutai (2002) modified the existing schema to incorporate the components of AT provision, including devices, reimbursement models, and measurement tools. Fuhrer, Jutai, Scherer & DeRuyter (2003) identified the need for an over-arching AT conceptual model applicable to a wide variety of device-specific models. Their intention was to provide a context for AT use and non-use, including descriptions of terms and relevant elements, and to develop a "causal sequence connecting the procurement of devices to specific outcomes" (p. 1244). Within this framework, adoption of any device is a sequential or developmental process with two distinct phases; *procurement* and *adoption*. Evaluation encompasses subjective and objective variables – relating the experience as well as the performance of the user (Fuhrer, Jutai, Scherer, & DeRuyter, 2003). Consumers of AT devices are active members in the procurement process, and performance goals are important and implicit to the user. Personal control and self-efficacy are crucial constructs of evaluation (Frank, Ward, Orwell, McCullagh, & Belcher, 2000). Continuation and discontinuation of technology use are the two alternative outcomes that are ultimately measurable. Variables that contribute to successful AT introduction, both at the short- and long-term level, include: efficiency, effectiveness, user satisfaction, psychological functioning, and subjective well-being.

Synopsis of Themes in Current Conceptual Models

When existing conceptual models of AT are considered, several common threads are apparent. Essentially all models incorporate an *Ecological* (or Systems) approach to the application of AT (Watts et al., 2004; Lenker & Paquet, 2003; Shone, Ryan, Rigby, & Jutai, 2002). From this perspective, any outcome (e.g., occupational performance) is the result of a complex interaction between various factors, all of which are interdependent. Therefore, assessment of the *interaction* between components, rather than just assessment of the components individually, is required. Furthermore, virtually all models incorporate at least three attributes in this ecological relationship: the individual, the environment (or context), and the assistive technology. Some models differentiate the *task* being performed as a unique and separate entity with *performance* of the task as the outcome of this interaction (e.g., HAAT), while other models see the task itself as the result (e.g., MPT, Career Model). Rogers' Diffusion theory is less explicit in identifying these components, but highlights the influence of the individual as well as their context, particularly the social and societal influences on acceptance of technology. The connection between these components is best met when the technology promotes occupational performance. This search for optimal function is often referred to as congruence, fit, or match in the literature (Lenker & Paquet, 2003). While these models utilize a Systems approach, there is a de facto assumption that AT is employed as a *compensatory* strategy to replace and/or compensate for individual or environmental limitations.

Another common theme among these conceptual models is the *developmental* process in adopting technology. Fuhrer et al (2003) identifies this as adaptation theory, while Bain (1997) refers to it as an acquisitional frame of reference. Potential users must develop skills and aptitude in using AT devices, and develop competence in different environments of use. When considering the success of a particular AT intervention, it is important to recognize that the immediate and long-term results may differ. Skill development, expediency, and familiarity with a device can potentially increase user satisfaction, which may not be immediately apparent when the device is first presented. The process of introducing an AT device should recognize this time-dependency, and this information may need to be communicated to the user (e.g., use of this device will become easier as you become more proficient). This is closely linked to the idea of user expectations. Users of AT may have unrealistic expectations of the performance of their AT device initially (often due to the marketing effect of technology suppliers and media). As a result, initial use may be unsatisfactory (Rogers, 1995). Over time, the user may develop more reasonable expectations and, particularly with increased competence, achieve greater congruence between expectation and satisfaction (Fuhrer et al., 2003; Riemer-Reiss, 1999). In this research study, an intervention period of three weeks was selected to provide sufficient time for the participants to accommodate to the new device and arrive at a realistic appreciation of its benefits.

Client-centredness is a recurrent theme in many conceptual models of AT. Many of the theories identify the importance of user-defined goals and evaluation. Each model indicates a need for collaboration between stakeholders, but the role of the user varies between perspectives. Clinically, acceptance of a device appears to be strongly related to motivation and involvement in the prescription process. Incorporating outcome measures that solicit subjective feedback from the user, and inquire about user preference, are critical to obtaining an optimal fit.

Many of the major conceptual models focus on a *systematic process* for obtaining the appropriate match and the need to formalize this procedure, including documentation. The HAAT model describes the process in a more generic sense, identifying the traditional process of referral, evaluation, recommendation, implementation, and follow-up (Cook & Hussey, 2002). Evaluation focuses on the elements described in the model (i.e., human, context, activity and assistive technology) using traditional measurement of performance components consistent with ICF and the Person-Environment-Occupational Performance Model proposed by Christiansen and Baum (1997).

There are some differences in perspective on the roles of individuals in the process of AT discernment. HAAT describes a collaborative approach where each partner (i.e., AT user and provider) brings both opinion and expertise (Cook & Hussey, 2002). The role of the provider is to contribute sufficient information so that the AT user can make an informed decision, without being unduly influenced, using an *educational* model (rather than using expert or consumer-driven models). The MPT model also places the AT user at the centre of the process, identifying the expertise that they bring to the situation. Fuhrer's ICF model highlights the importance of a collaborative approach, specifically including "multiple stakeholder perspectives including those of users' family members, friends, and co-workers, ATD service providers, manufacturers, vendors, payers, researchers, and policy analysts" (2003, p. 1248-1249).

Summary

Conceptual models provide a framework for understanding the process of procurement for assistive technologies users, and for understanding the relationships between factors that contribute to successful implementation of AT. A cogent appreciation of variables that relate to positive outcomes will assist clinicians in providing service in an expeditious and efficacious manner. It also provides direction for research design and identification of relevant outcomes to measure. Ultimately, confirmation through research will provide justification and validation for clinical recommendations, benefiting both clinician and client.

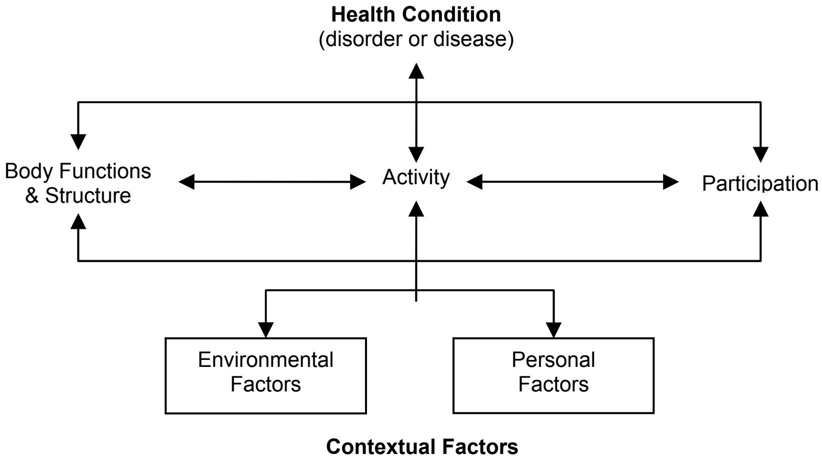
This research study uses the HAAT model as a theoretical framework. The HAAT model provides clear definitions of the individual model components, and uses concepts and terminology consistent with an occupational therapy perspective. This includes the importance of fulfilling life roles in the performance areas of self-care, work, and leisure. This connection facilitates the use of outcome measures that are based on an Occupational Therapy perspective, such as the Canadian Occupational Performance Measure. The HAAT model integrates social and cultural variables into the environment, highlighting the perception of the AT user within this context. Therefore, measures of participation and Quality of Life (e.g. Psychosocial Impact of Assistive Devices Scale) are consistent with this model. The HAAT model seeks to identify which variables within the person, activity, environment, and assistive technology contribute to or restrict occupational performance. This approach facilitates the descriptive and predictive functions that are critical to research outcomes.

2.1.5 Community Participation and Wheelchair Use

ICF Framework

The *International Classification of Functioning, Disability and Health*, or ICF, is a framework developed by the World Health Organization to "provide a common understanding of health and function" (World Health Organization, 2002, p. 11). Within the ICF framework, individual performance results from the interaction between the health conditions of the person and the context in which they live. Injury or illness can compromise the structure or function of the body, creating *impairment* within the individual that can impact function. If the life context does not adequately accommodate this impairment in the completion of daily tasks, Activity performance is restricted. The ability to perform activities within the situations that life normally presents is a measure of Participation (World Health Organization, 2002). The diagram below provides a graphic representation of the ICF model (see Figure 2). Intrapersonal impairment and contextual attributes can both influence participation, which is "the extent of a person's involvement in life situations" (World Health Organization, 2002, p. 10). Contextual factors can relate to the environment (external) and the individual (internal). The environmental context has physical, social, and attitudinal subsets. The physical environment encompasses natural and synthetic architecture, equipment, and climate, as well as policies and programmes within the larger societal structure. The social environment considers relationships and support received from other people within the individual's social network. The attitudinal environment refers to the manner in which people in society relate and behave towards the individual. The individual context incorporates demographic variables and characteristics of the person, independent of their health condition (World Health Organization, 2002). Individuals experience disability when they are unable to participate

Figure 2. ICF model.



From "Towards a Common Language for Functioning, Disability and Health: ICF," by the World Health Organization, 2002, p. 9. Copyright 2002 by the World Health Organization. Reprinted with permission of the author.

in activities of life as a result of this incongruence between health conditions and contextual factors.

In measuring participation, the ICF considers a broad spectrum of activities within life (e.g., communication, mobility, self care, etc.). One specific context of performance identified is community, social, and civic life. This involves activities associated with recreation and leisure, arts and culture, sports, hobbies, socializing, and activities related to practicing spirituality and religion.

Relevance of Community Participation

Occupational therapists seek to enable people in performing their chosen activities, or occupations, in the environments in which they live (Townsend, 2004). Occupational therapists contend that active engagement in occupation and participation in society promotes health and well-being, consistent with the ICF framework. Contextual factors can create barriers to participation, resulting in ill-health. When participation is restricted, individuals lose their connection with community and social life. It has been suggested that involvement with friends and family, and in social activities in the community increases integration in, and solidarity with, the larger societal structure (Arva et al., 2003). Access to the geographical and social community represents a critical part of the life experience for individuals with mobility impairment. When this access is compromised, there may be a substantial change in the person's social, financial, and emotional status (McClain, Medrano, Marcum, & Schukar, 2000). Interruption in community participation can lead people to feel dissatisfied, unmotivated, and isolated (Hoenig et al., 2003; Levins, Redenbach, & Dyck, 2004). Miles-Tapping reported individuals with a mobility impairment felt a "burst of energy" when they suddenly regained access to their community through the new acquisition and use of a PWC, after experiencing contextual barriers previously with their MWC (1996, p. 140).

An important tenet in the profession of occupational therapy is the value placed on one's ability to participate in the community (or society at the local level). Participation in community activity enables an individual to fulfill important roles and occupations. This ability to engage in valued roles creates a sense of independence and increases self-esteem, suggesting an improvement in overall well-being (Shechtman, Locklear, MacKinnon, & Hanson, 2003). When impaired mobility prevents role fulfillment, and/or individuals become confined within their own residence, they can become segregated from society (Carlson & Myklebust, 2002). It has been reported that home confinement increases the risk of nutritional deficiencies, dysthymia and depression; decreases satisfaction with life; and compromises access to health care (Hoenig et al., 2003).

Even commonly performed community-based activities outside the home can play a critical role in healthy living. A 2004 study of powered wheelchair users found the most frequently reported activities were going for a ride in the wheelchair, shopping, and visiting friends and family (Brandt et al.). The authors identify that fresh air and sunlight are essential ingredients of physical and mental health, supporting the value of getting outdoors. Furthermore, there is evidence that participation in socializing activities is linked with higher survival rates (Glass, de Leon, Marottoli, & Berkman, 1999).

Community Participation and Wheelchair Use

Wheelchairs and ambulation aids provide an alternative form of mobility for individuals who experience physical impairment (Brandt et al., 2004; Hoenig et al., 2003;

Shechtman et al., 2003). By using a wheelchair, these individuals are able to continue to participate in activities related to independence, work and social engagement (Reid, Laliberte-Rudman, & Hebert, 2002; Field, 1999). However, individuals who depend upon these assistive devices still experience lower levels of participation in social activities than those who are ambulatory (Carlson & Myklebust, 2002). In large part, this is related to contextual factors that create barriers to community participation – factors which do not typically impede individuals without a mobility impairment.

The National Organization on Disability (NOD) conducted a survey in 2000 concerning community participation among individuals with a disability. The results of this survey, which included 535 adults who self-identified having a disability and 614 adults who did not, indicated that the former group was less involved in their community (National Organization on Disability, 2001a). Specifically, people with disabilities were less likely to attend community service organizations, religious services, cultural events (e.g., library, theatre, ballet, etc.), outdoor community places (e.g., beach, park), and recreational events (e.g., movies, sporting events). However, there was no significant difference reported between the two groups with regard to socializing with friends, attending community events (e.g., parades), and volunteering. Even among those individuals who reported higher community involvement, people with disabilities indicated the quality of their experience was compromised because of the contextual obstacles that persist (National Organization on Disability, 2001a).

Social interaction is one component of community participation. While persons with mobility impairment generally experience restriction in social activities, this phenomenon is magnified among wheelchair users. One survey compared the social activities of 202,560 individuals living in the community, including 24,218 identifying themselves as having a disability. The authors found that 71.9% of respondents with a disability (excluding wheelchair users) got together with friends, while only 61.1% of wheelchair users were engaged in this activity (Carlson & Myklebust, 2002). In another study, 13 wheelchair users (who had sustained a spinal cord injury) had a significantly lower degree of community integration, as measured by the Craig Handicap Assessment and Reporting Technique (CHART), compared with 13 matched able-bodied control participants (Shechtman et al., 2003). Brandt et al. (2004) reported one quarter of their study participants identified some limitation in their ability to participate in prioritized activities using their powered wheelchair. Carlson (2002) reported results from an unpublished study using data from the 1994-1995 National Health Interview Survey on Disability. Wheelchair users identified very low participation in community-related activities during a two week period: 68.3% did not attend church/temple, 72.9% did not go to a movie/theatre, and 49.8% did not eat at a restaurant. This survey only considered a two week window for participation in these activities. It may be that a longer period would have found higher rates of participation, and the authors did not provide a comparison of participation rates for individuals who did not use a wheelchair. The authors did report that nearly half of the respondents identified a desire to do more.

Contextual Factors

According to the ICF framework, decreased participation in community activity is a result of the incongruence between an individual's health condition (e.g., impairment to ambulatory function) and the context in which they live. The literature provides some explanation of these contextual factors, both external and internal, that contribute to lower participation among wheelchair users.

External Environmental Factors

The Wheelchair: A Two-Edged Sword

The wheelchair itself can be both a facilitator and barrier to participation. Wheelchairs provide an alternative means to gain access to the physical environment and afford the opportunity to engage in activities outside of the home, when health conditions impede ambulation. They are a human-made technology, developed to compensate for changes to body function and structure. However, the use of the wheelchair itself presents new barriers to the user (Reid et al., 2002). Propelling a MWC places physical demands on the individual, particularly in challenging environments and conditions (e.g., grass, snow, or gravel; overcoming inclines, curbs, or steps). The upper extremities are not designed to provide this type of function, and current wheelchair design offers a relatively low level of biomechanical efficiency to propel (Boninger et al., 2000; van der Woude et al., 2001b). An alternative to manual propulsion is a powered wheelchair or scooter. While this type of device places fewer physical demands on the user, it also creates additional issues because of its dimensions, weight, and battery charging requirements. A study among manual and power wheelchair users found that the central limitation to access outside the home, as well as to using transportation, was the wheelchair itself (Chaves et al., 2004). Users of wheelchairs were more likely to blame the physical properties of the wheelchair than the environment for this inaccessibility, and believe a better wheelchair design might eliminate some of these environmental restrictions. Consequently, while many users perceive the wheelchair to be a tool to enable occupational performance (Hoenig et al., 2003), others may see it as a barrier in preventing optimal participation.

The Physical Environment

Barriers in the physical environment are perhaps the most salient components restricting participation in the community (Reid et al., 2002; Hoenig et al., 2003). Facilities are not universally accessible, and wheelchair users often find varying degrees of impediment within the same environment (Reid et al., 2002). For example, a shopping mall may provide an accessible entrance, but individual stores within the complex restrict access because of a narrow entrance or steps. Richards et al. (1999) studied 650 participants with spinal cord injury, comparing environmental accessibility (as measured by the CHART mobility subscale) and satisfaction with life (as measured by the Satisfaction With Life Scale – SWLS). The authors identified that as the level of environmental accessibility increased, so did the SWLS score, suggesting an association between these variables. Similarly, the authors found that participants who were better able to participate in relevant occupations including work, school, leisure, and volunteering (as measured by the CHART occupation subscale) also recorded higher measures of life satisfaction. Brandt et al. (2004) found that physical barriers were more significant in restricting social activity with friends and family than they were for shopping. The author suggests that this may reflect a behavioural change in the user, rather than the environment. Friends and family typically have a limited ability to alter their homes for accessibility, and people generally do not select their friends based on the design of their home. Conversely, wheelchair users can often choose to shop at accessible locations and avoid businesses with poor ingress. A group of users of PWC confirmed this explanation, indicating accessibility affected which businesses they patronized, although they also acknowledged the frequency and location of social interaction with friends and family was also impacted (Hoenig et al., 2003; Miles-Tapping, 1996).

Seasonal Differences

Climate presents a particular environmental challenge to wheelchair users (Reid et al., 2002). Safety, comfort, and mobility can all be confounded by extremes in temperature and precipitation. For individuals living in snowy locations, access to the community in winter months can be significantly impacted because of weather. One study, looking at older persons' use of PWC in Denmark, found a significant shift in usage patterns between seasons (Brandt et al., 2004). In summer, 96% of participants used their power wheelchair in the community at least once a week, and nearly two-thirds used it daily. In winter, however, only 64% ventured out on a weekly basis, with less than a quarter going out daily. In fact, 13% discontinued use of the wheelchair outside the home until summer returned. Temperature alone was rarely identified by participants as a significant barrier (less than 5%) for those who were unable to participate in activities in the community. Accumulation of snow and ice, as well as road/sidewalk conditions, might play a more substantial role in this regard. Winter temperatures in Denmark are relatively mild (average is around 0° Celsius in January) and the typical snowfall is approximately 6 centimeters annually. It is conceivable that individuals living in locations with colder and snowier winters might experience even greater barriers to participation.

The types of activities chosen by PWC users also differ, depending upon the season. In one study, the most frequently identified activities in summer were: going for a ride, shopping, and visiting, respectively (Brandt et al., 2004). In winter, all three types of activities were performed less often, and in particular ‘going for a ride’ dropped below shopping in frequency. It may be that as barriers increase in the physical environment, wheelchair users begin to give lower priority to their social interactions and perform those activities that are deemed more essential and address basic needs, such as shopping or attending religious services.

Issues of Transportation

Transportation, particularly public transit, has consistently emerged as a major barrier to gaining access to the community (McClain et al., 2000; Whiteneck et al., 2004; Meyers, Anderson, Miller, Shipp, & Hoenig, 2002; Noreau, Fougeyrollas, & Vincent, 2002). When users of wheelchairs have difficulty accessing public transit, activity levels drop dramatically (Carlson & Myklebust, 2002). Use of a vehicle appears to contribute significantly to community participation. Carlson and Myklebust found that users of wheelchairs who had access to a personal vehicle, and were able to drive, had higher involvement in social activities. They suggest that access to a vehicle for personal use represents an important variable related to independence and social involvement as people age and their mobility decreases.

Attitudes of Others

Social attitudes can also contribute to decreased participation (Reid et al., 2002; Richards et al., 1999). Negative attitudes among other members of society may present sanctions for the user if they do choose to participate in social functions. Pierce (1998) conducted a phenomenological study exploring the qualitative experience of nine wheelchair users, and their frustration with community accessibility. Two significant themes identified were “frustration with others’ attitudes toward people with disabilities” and their “lack of understanding of the situation of people with disabilities” (Pierce, 1998, p. 123). Participants reported being treated like a child (e.g., asking where her mother lived and if she was home), assumptions made around independence and competence (e.g., someone using a wheelchair would not own a credit card), and lack of awareness about accessibility (e.g., business owners assuming a handicap placard means a washroom is truly accessible). Results from the 2000 NOD survey also confirm the importance of social attitudes, identifying that among those with significant impairment, 64% report a lack of encouragement from organizations in their community as the primary barrier to participation (National Organization on Disability, 2001b). A study of 70 individuals with spinal cord injury living in Pittsburgh and St. Louis also identified that public and family attitudes were factors that restricted participation outside of the home (Chaves et al., 2004). The magnitude of this phenomenon differed between locations, suggesting that these attitudes may vary and are perhaps amenable to change.

Internal Personal Factors

Physical and Psychological Characteristics

Effective use of a wheelchair is not restricted to propulsion; users must also transfer in and out of the wheelchair, either independently or with assistance. For certain activities, this may be a required or desired component (e.g., using the bathroom while visiting; using a taxi en route to a concert; riding a rollercoaster at an amusement park; sitting in a chair in a fancy restaurant). The inability to perform transfers independently can decrease the likelihood of wheelchair users choosing to participate in community-related activities (Brandt et al., 2004). Additionally, Shechtman et al. (2003) found that, among wheelchair users with a spinal cord injury, poor grip strength was correlated with a lower measure of community integration and speculates this relates to both wheeling and transferring skills.

Some users of wheelchairs may feel conspicuous or self-conscious and choose not to venture out into social venues. Chaves (2004) found that a low self concept can be a barrier to participation. Miles-Tapping (1996; Miles-Tapping & MacDonald, 1994) describes the experience of transitioning from ambulation to wheelchair use as a psychological barrier. She indicates this decision may be perceived as giving in to impairment and adopting a label of disability. This process can result in a period of depression, contributing to further activity restriction. Individuals may struggle with redefining their own self-identity after injury and the need for a wheelchair as a mobility aid (Levins et al., 2004). Some wheelchair users described lowering their personal expectations of others and the environment, to minimize disappointment (McClain et al., 2000).

Demographic Characteristics

A number of demographic variables have been identified as potentially contributing to lower levels of community participation. Increasing age correlates with decreased social participation generally; this is particularly evident among wheelchair users (Carlson & Myklebust, 2002). Brandt et al. (2004) found that participants over 76 were 3-4 times *less* likely to use their PWC frequently outside of the home than those aged 76 and younger. Schechtman et al. (2003) reported that pain during wheelchair use increases with age, resulting in restricted community participation.

Lower levels of education appear to relate to lower participation in the community (Carlson & Myklebust, 2002). A more advanced level of education may enable individuals to reintegrate themselves into the community more quickly after injury (during the transition from ambulation to wheeled mobility), particularly in the area of employment (Carlson & Myklebust, 2002). Employment provides a venue outside the home for social exchange and increased exposure to social and community-related activities. Furthermore, employment provides the financial means to participate in many community related activities. Higher income is consistent with higher levels of social activity, but this is also true among individuals without disability (Carlson & Myklebust, 2002). Disability, particularly when mobility is impaired, relates significantly to lower rates of employment (National Organization on Disability, 2001a). Carlson and Myklebust (2002) reinforces this trend of low rates of social participation among wheelchair users who were unable to work, which proved to be significantly less than individuals without disability who were unable to work.

Gender and race have also been suggested as variables influencing community accessibility among wheelchair users. Richards et al. (1999) found that males were 1.7 times more likely than females to score higher on the CHART measure of access to the environment. The same authors found that individuals of African American and Hispanic descent were less likely to score higher on the same accessibility measure than their Caucasian counterparts (.65 and .59 times, respectively).

Manual vs. Powered Wheelchair Use

Many individuals with mobility impairment must decide between using a manual or a powered wheelchair. Manual wheelchairs are typically smaller, lighter, and more maneuverable, and can be transported more easily in a vehicle. Power wheelchairs decrease the physical demands of propulsion, allowing the user to go a further distance and potentially increase tolerance for greater activity involvement. Consequently, while some barriers to participation are common to both manual and power wheelchairs (e.g., steps, inaccessible bathrooms), others impact to a greater or lesser degree for each (e.g., manual wheelchairs are impacted *less* by transportation issues but *more* by changes in elevation; power wheelchairs may present a greater social stigma of disability but are easier to use in rough terrain and inclement weather).

As a result of these different assets and limitations, some individuals will use a MWC in some contexts (e.g., at home, where space and maneuverability is paramount) and a PWC in other environments (e.g., to go shopping or see a show, where distance and fatigue are of greater concern). For these individuals, MWCs do not necessarily provide sufficient independent mobility to engage in occupations of choice outside of the home. In fact, even PWCs can be inadequate, if not specifically designed for outdoor use. The National Health Service in England initiated a pilot program in 1996 to provide some consumers with power wheelchairs capable of performing in outdoor environments. For users of this new service, 88% indicated their independent mobility outside the home was improved “a great deal” or “quite a lot”, and when asked about the subsequent improvement in their quality of life 87.9% also indicated “a great deal” or “quite a lot” (NHS Executive and Department of Health, 2000). However, many respondents identified barriers in the community because they had difficulty climbing curbs, and only about 70% used a vehicle or transit system to transport their power wheelchair to community activities. A subsequent study (Evans, 2000) investigated the qualitative experience of eight of these users, and concluded that power wheelchairs increased independence and control in performance of occupation, as well as facilitated social participation. This increased opportunity for community participation was linked to improved health and well-being. This linkage, however, is somewhat tenuous. In a larger quantitative study of 97 outdoor power wheelchair users in England, similar results were identified (Frank et al., 2000). Participants had a mixed history of wheelchair use: 20% had previously used an outdoor power wheelchair, 45% had used an indoor-only power wheelchair, and 35% had used only a manual wheelchair. Half of the participants undertook new activities, including shopping, visiting outside the home, enjoying the outdoors, participating in religious or sporting activities, and attending work or school. Users identified the positive effect of independence, especially outside of the home, and the freedom to participate in community activities on their own time schedule. Conversely, a third study investigating users of the NHS program (Davies, De Souza, & Frank, 2003) found mobility and quality of life had improved for those who were provided with power wheelchairs, but perceived independence and improvement in their social life (measured using a visual analog scale) did not demonstrate a significant change, a finding that appears inconsistent with the aforementioned studies. Limitations in the precision of outcome measures, as well as insufficient time to adjust to the new technology (i.e., 3 months), may have prevented the researchers from identifying a significant difference that might have existed (i.e., β error).

An “entire shift in lifestyle” (Miles-Tapping & MacDonald, 1994, p. 36) has been reported when individuals made the transition from manual to power mobility. These individuals identified a new freedom to participate in employment, education, leisure, and social pursuits, as well as experience the independence of scheduling activities at their own discretion. Fitzgerald et al. (2003) found that MWC users reported they were more likely to participate in community-related activities when they were introduced to a power-assisted manual wheelchair than when they used their regular MWC. Respondents indicated the ease of use (i.e., decreased physical demands), ease of climbing hills, and the perceived increase in distance and speed available were significant variables in this decision. However, the objective measurement of outing frequency and distance traveled was not found to be different between the two wheelchair situations. The authors identified some study limitations including a small sample size and the brief duration of time participants used the power-assisted wheelchair (i.e., two weeks), which may have reduced the ability to find a difference in these objective measures.

In contrast, some evidence suggests that, when using power mobility, more barriers are apparent in the community. In a study conducted by Brandt et al. (2004), only 35% of older adults studied used their power wheelchair to travel longer distances. Transporting a PWC is often difficult for individuals wanting to travel further away from their home. In the same study, less than 10% of users transported their PWC in a private automobile and 5% used a bus or train. Special transportation (e.g., Handitransit) was used by 24% of the respondents. A PWC may prove to be undesirable, since the physical dimensions make transporting it much more difficult than a MWC. It is often impossible to drive the wheelchair directly to many community activities, either because of the limited range of the wheelchair or time/efficiency/safety issues of travel. Brandt et al. (2004) found that, among those older adults who were not able to access community activities with their PWC, over 40% chose to abandon the activity altogether, and a further 40% had a friend or family member drive them to the activity. One study of pediatric users (Wiart, Darrah, Cook, Hollis, & May, 2003) found that 47 out of 66 survey respondents identified that transportation of a PWC, in a personal vehicle or using accessible public transportation, was a barrier to community participation.

Summary

Successful community participation is partly a result of the interaction between an individual's health condition and the context in which they live. There is evidence to suggest that participation in meaningful activities within one's community, and the freedom to fulfill relevant roles within society, are contributors to health and well-being. When independent mobility impedes participation outside of the home, a wheelchair can enable continued or even new involvement. Clearly, community participation is compromised for individuals with mobility impairment, compared with the general population. In particular, those using a wheelchair report greater restriction in social activities and experience additional barriers that compromise accessibility. These barriers include external environmental factors, such as the characteristics of the wheelchair itself, physical structures, climate, transportation issues, and social attitudes, as well as internal personal factors such as self image and characteristics of the individual user.

Manual and power wheelchairs each provide certain benefits and limitations to community access. Users must decide which technology provides the optimal balance of accessibility and performance. There is little evidence available to compare outcomes between these two options. Several studies report on the benefits identified by users who transitioned from manual to powered mobility, but these are generally restricted to individuals who are no longer able to adequately propel their manual wheelchair. The process of transition from manual to power mobility requires further evaluation. Further investigation into the consideration of various alternatives to a power wheelchair (e.g., scooters, power-assisted wheelchairs, Segway technology, etc.) with people who are also able to operate a manual wheelchair is needed. It may be that these wheeled mobility options could adequately ameliorate the environmental barriers to community participation, without incurring the barriers inherent in the PWC. More research is required regarding assistive devices that might delay or prevent the transition from manual to power wheelchair use.

Policy and social change have improved some aspects of accessibility, such as the physical environment and transportation. Other issues that impact accessibility are less amenable to change through legislation, such as social attitudes, and merit further study to gauge whether they too are improving with time and what interventions are best suited. Still others, such as climate, require study to identify what interventions temper their effect. Continued investigation into the experiences of wheelchair users, and consequences of different contextual factors influencing community participation, is warranted. This research study explored whether a specific PWC alternative, a pushrim-activated power-assisted wheelchair, was able to provide the same degree of satisfactory performance for current dual-users in performing activities of community participation, and explored their experiences using the PPW in their communities.

2.2 Purpose of the Study

The purpose of this study was to identify occupations that participants performed using their PWC, and compare user satisfaction between performance of these occupations using a Pushrim-Activated Power-Assisted Wheelchair (PPW) and performance using their PWC. The data collected from each participant was used to determine whether the PPW would serve as a satisfactory alternative to a PWC.

Participants' subjective experiences with each wheeled mobility device was explored through a focus group data collection process, which was used to explain and interpret the quantitative results. The information gathered in this study provides some preliminary evidence regarding comparison between PPW and PWC use, as well as performance of community-based occupations using PPW.

2.3 Objectives of the Study

The following were objectives of the study:

1. To evaluate the impact of PPW and PWC on occupational performance, satisfaction, community participation, and quality of life quantitatively and qualitatively.
2. To explore user experience with PPW in the context of their normal living environment.
3. To contribute to the collection of evidence regarding the impact of PPW on users, to assist occupational therapists in prescribing and justifying recommendation of PPW.

2.4 Hypotheses

H_0 – There will be no difference in satisfaction with occupational performance of user-identified tasks for individuals using PPW or PWC as measured using the QUEST, PIADS, COPM and FEW.

H_0 – There will be no difference in measurable occupational performance for individuals using PPW or PWC as measured using COPM and FEW.

2.5 Limitations

The current study was designed to include eight participants, drawn from a variety of sources. A sample size of eight provided preliminary data and suggested trends, rather than obtaining generalizable results. The small sample size impacted on the power of this study, increasing the likelihood of a Type II error (i.e., not finding a difference that might actually exist). The gathering of qualitative data provided some mitigation of this risk, allowing comparison between participant perceptions and quantitative study results. The population pool available (as outlined in the inclusion criteria – Section 3.1) is small, and the response rate from within that pool suggested that eight was a reasonable number. Comparable studies in the literature have used a similar number of participants (Arva et al., 2000; Arva et al., 2001; Arva et al., 2003; Cooper et al., 2001; Cooper et al., 2002b; Levy et al., 2004). The small sample size presented a challenge to obtaining a normal distribution of results; therefore, nonparametric data analysis techniques were used.

Given the relatively small number of potential participants and the close network that exists between the identified client groups within Winnipeg and the surrounding area, it was not inconceivable that participants might come in contact with each other during the course of this study. Although there was some risk that interaction and discussion between participants might influence their opinions, and subsequently their responses on the outcome measurement tools, it was anticipated that participant perception of individual occupational performance and satisfaction would remain intact, and that the integrity and reliability of the tools would control for this influence. It has been reported that power wheelchair usage patterns and purposes differ in summer and winter (Brandt et al., 2004). It was anticipated that winter temperatures and precipitation in Manitoba would have a significant negative effect on performance and satisfaction with the PPW (Noreau, Fougeyrollas, & Boschen, 2002). Since the intention of this study is to gather preliminary information, data gathering occurred during non-winter months to provide an optimal environment for success. Future studies may consider performance in a wider range of seasonal conditions.

2.6 Delimitations

This study only considered individuals who use both a MWC and PWC in their activities of daily living, not those who use one device exclusively. Evaluation of overall levels of community participation or involvement in specific activities was not undertaken; only activities the participants were currently engaged in were considered. No control mechanism was in place for potential variability between participants (e.g., age, diagnosis, functional ability, proportion of activities/time using power versus manual wheelchair, number of years/experience using power/manual wheelchair); however, descriptive analysis was completed to acknowledge these variables.

3.0 METHODOLOGY

3.1 Participants

The primary inclusion criterion was a self-identified use of both manual and power mobility. Exclusion criteria were: individuals unable to participate in the outcome measurement tools (e.g., due to language or cognitive barriers); those living further than 75 kilometres from Winnipeg (due to practicality of equipment set-up/administration of outcome measures and lack of budget for researcher travel); and individuals with a self-identified unstable medical status (i.e., creating sufficient fluctuation in performance that measurement between the two research phases would be confounded). Approval of the study was obtained from the Health Research Ethics Board (University of Manitoba – Bannatyne Campus) (see Appendix B).

3.1.1 Sample Selection

Two agencies were approached and agreed to assist in distributing study information and contacting potential research participants: the Canadian Paraplegic Association (Manitoba) Inc. and the Society for Manitobans with Disabilities Inc. (Wheelchair Services). The two agencies reviewed their client/member records and identified individuals who met the inclusion criteria. A member of each agency contacted these individuals, briefly explaining the purpose of the study and asking permission for the investigator to contact them. If the potential participant gave permission, the investigator subsequently contacted them, either by telephone or in person. At that time, a full explanation was provided and consent was obtained prior to enrolment in the study (see Information and Consent Form – Appendix C). Enrolment also occurred through advertisement in relevant newsletters and recruitment posters (see Appendix D). Eight individuals met the inclusion criteria and completed participation in the study. The investigator met with two additional individuals who signed consent forms and identified relevant occupations using the COPM, but were unable to participate in the study due to health reasons (i.e., both individuals were on bedrest and could not use a wheelchair). Participants were reimbursed an equivalent of fifty dollars ($50), in the form of gift certificates to a store or restaurant of their choice. This was pro-rated over the course of the study: twenty dollars ($20) after each of the 2 three-week data collection periods and ten dollars ($10) after the focus group. In addition, costs associated with attending the focus group (e.g., taxi fare or parking) were reimbursed and refreshments were provided.

3.2 Research Design

The research design used a concurrent mixed methods procedure, utilizing a two-phase sequential explanatory strategy (Creswell, 2003). Phase one focused on collection of descriptive quantitative data using a *repeated measures crossover method*. When there are multiple treatments (e.g., PPW and PWC), “one group of subjects is tested under all conditions and each subject acts as his own control” (Portney & Watkins, 2000, p. 187). This allowed for some control over individual differences between individuals, particularly given the anticipated heterogeneity of participants. This method is well-accepted in research studies comparing PPW and MWC use. Corfman et al. (2003) used a similar repeated-measures crossover design. The authors evaluated ten participants with spinal cord injury, comparing range of motion and stroke frequency differences using PPW and MWC. Others studies investigating PPW and MWC performance (using wheelchair users as participants) have also employed a repeated measures crossover approach (Algood et al., 2002; Algood et al., 2004; Arva et al., 2001; Cooper et al., 2001;

Cooper et al., 2002a; Levy et al., 2004). The crossover component was also incorporated to minimize the potential bias from the sequence in which the mobility devices were introduced (Portney & Watkins, 2000). A random process was used to assign half of the participants to begin the study using PPW and the other half to begin the study using their PWC. Each of the previously mentioned studies referenced also used a crossover design.

Phase two of the study utilized a focus group approach to collect qualitative data regarding participants' experience using each type of wheeled mobility device. Data was collected through the investigator making field notes and transcription of the audiotaped focus groups. The data was reviewed and collated into categories using an iterative strategy. The results were validated through a member-checking process. The content analysis of the qualitative data was used to help interpret and explain the quantitative study results (Creswell, 2003).

3.3 Instrumentation

This research study was developed using the HAAT model as a theoretical framework for understanding the impact of assistive technology on occupational performance. The HAAT model identifies four components – the Human, the Activity, the Assistive Technology, and the Context – that interact to produce an outcome (i.e., System Performance). The four outcome measures used in this study were specifically selected to explore interactions between individual system components, as well as System Performance as a whole. The QUEST focuses primarily on the user's satisfaction with the assistive technology device and its attributes (i.e., Human ↔ Assistive Technology), while the FEW places the emphasis on the user's ability to perform activities and address activity needs (i.e., Human ↔ Activity). The PIADS targets the user's perception of self and disability, within the physical and social environment (i.e., Human ↔ Context). Finally, the COPM aims to measure the user's evaluation of occupational performance and satisfaction (i.e., System Performance). Clearly, it would be inaccurate, and inappropriate, to suggest that any of these tools does not incorporate all four HAAT components to some degree. However, for the purposes of this study, they lend themselves to focus on different aspects of the system and are used accordingly, acknowledging the complexity and richness of each measure.

3.3.1 Quebec User Evaluation of Satisfaction with assistive Technology (QUEST)

The QUEST (Demers, Weiss-Lambrou, & Ska, 2000b) is a standardized outcome measure designed to evaluate user satisfaction with assistive devices, and the services related to their provision. It consists of a self-report questionnaire with twelve items, each scored on a five-point Likert scale, with 1 being "not satisfied at all" and 5 being "very satisfied" (see Appendix E). Eight questions relate to the assistive device itself and four to service delivery. In addition, the user identifies three items from the list of twelve that are most important to him/her. The QUEST can be administered by a clinician, or self-administered by the participant.

The QUEST was selected for this study because it provides a comprehensive evaluation of the attributes of each device. It has been used extensively in the field of rehabilitation and assistive technology, particularly for comparison between devices (Shone et al., 2002; Brandt, Iwarsson, & Stahle, 2003; Jedeloo, De Witte, Linssen, & Schrijvers, 2002; Routhier, Vincent, Morissette, & Desaulniers, 2001; Stickel, Ryan, Rigby, & Jutai, 2002; Trefler, Fitzgerald, Hobson, Bursick, & Joseph, 2004; Vincent, Drouin, & Routhier, 2002; Wressle & Samuelsson, 2004).

Test-retest reliability, as measured using intraclass correlation coefficient (ICC), has been reported as .82 and .91 for the Devices subscale and the total QUEST scores respectively (Demers, Monette, Lapierre, Arnold, & Wolfson, 2002), suggesting good reliability (Portney & Watkins, 2000). The same study found good reliability, whether the form was completed independently by the user or together with the evaluator, reporting alternate-form equivalence ICC results of .89 and .91. Another study, involving 85 participants who used a wheelchair or lower limb prosthesis, found internal consistency between QUEST items to be acceptable, with Cronbach's Alpha scores of .80 and .82 (Demers, Weiss-Lambrou, & Ska, 2000a).

The QUEST version 2.0 (used in this study) is based on changes made to the original version resulting from validity testing with researchers and clinicians (Demers, Wessels, Weiss-Lambrou, Ska, & De Witte, 1999) as well as stakeholders and users of assistive technology (Demers, Weiss-Lambrou, & Ska, 1996). In a cross-validation study with the PIADS tool (Day & Jutai, 1996a), fair to moderate correlation was found for both the Devices subscale and the total QUEST score, reporting a Pearson correlation coefficient of .34 to .45 (Demers, Weiss-Lambrou, & Ska, 2002). The authors argue that both the QUEST and PIADS reflect the subjective experience of the individual and device satisfaction is related to experiential, behavioural, and lifestyle factors; however, each of the two measures employs a unique evaluative perspective, and consequently some difference in scores (as reflected in a lower ICC) would be expected (Demers et al., 2002).

3.3.2 Functioning Everyday with a Wheelchair (FEW)

The other outcome measures employed in this study represent an evaluation of the assistive technology devices from the user's perspective. Fuhrer (2001) identified the need to include external measures of performance, especially when there are multiple stakeholders involved in decision-making (e.g., third party payers). There is a paucity of outcome measurement tools available that evaluate wheelchair usage and performance, particularly in a community setting. The FEW (Mills et al., 2002b) is a standardized tool that can be used to measure the quality of an individual's wheelchair operation. The FEW includes both a user evaluation and a clinician evaluation of performance (see Appendix F). The user portion (section 1) poses ten statements about the ability of the wheelchair to address the user's personal needs or activity demands. Each statement is scored on a six-point Likert scale from "completely agree" to "completely disagree", and also includes a "does not apply" option. There is no neutral response option provided.

The second section of the tool (section 2: FEW-P) has the clinician score the wheelchair user on their performance in a series of activities or tasks. Three aspects of performance are rated on an ordinal scale of 0 – 3: Independence, Safety, and Quality. The first series of criterion-referenced tasks includes retrieving and placing an object from a variety of heights and distances. The second series includes performing two transfers from the wheelchair to another surface; an easier transfer and a more complex transfer. Tasks are performed in the participant's natural environment, using equipment that is available at hand. Performance of these activities is scored with regard to specific criteria included with the tool. A score of 3 represents full independence/safety/quality, and scores of 2, 1, or 0 represent increasing levels of assistance or risk (Holm, 2004).

During initial development of the FEW, 20 study participants were interviewed using the COPM, identifying occupational performance issues that were relevant to their wheelchair/seating system. These items were consolidated into the ten current categories of the FEW, suggesting validity of content. The authors also suggest the FEW categories demonstrate item-construct fit within the Matching Person and Technology theoretical framework (Mills et al., 2002b). In testing with 30 wheelchair users, test-retest reliability was measured after 4-7 days. The results produced an ICC of .94 (Mills et al., 2002a). For inter-rater reliability testing, the FEW-C was administered by 32 individuals observing 9 MWC and PWC users, and an ICC of 0.98 was reported (Holm, 2005).

3.3.3 Psychosocial Impact of Assistive Devices Scale (PIADS)

The PIADS is described by the authors as "an easy to use self-rating scale designed to measure the impact of rehabilitation products on the quality of life of the users of these products" (Day & Jutai, 1996b, p.1). According to the authors, "intrapersonal factors are the core dimensions of psychological well being … in our experience, they are essential components of how assistive technology users define the impact of their devices on their quality of life" (Day & Jutai, 1996b, p. 7). The authors indicate the PIADS measures quality of life using three component subscales (i.e., Adaptability, Competence, and Self-esteem) as well as a composite Total score. The tool lists twenty-six words or phrases (e.g., competence, happiness, sense of power), and the user identifies whether the assistive device increases, decreases, or has no effect on their experience vis-à-vis these variables (see Appendix G). The user scores their response on a seven point Likert scale, from -3 (decreases) through 0 (neutral) to +3 (increases). The authors suggest it can be completed in five to ten minutes.

The PIADS was selected for this study because it offers a measure of how each device impacts on the user's life experience. Individuals consider many variables in deciding whether to use a PWC or MWC. The choice to use one or the other may not rest solely on the performance of the device, but also on the user's experience using the device, particularly in the social context. Use of assistive technology has been linked to improvement in quality of life, and a comparison of PWC and PPW relative to this variable is appropriate. The PIADS has been used in other studies considering the effect of assistive technology on the lives of individuals with disability (Buning et al., 2001; Day, Jutai, Woolrich, & Strong, 2001; Jutai & Day, 2002; Ripat & Strock, 2004; Devitt, Chau, & Jutai, 2003; Stickel et al., 2002).

The reliability of the PIADS measure has been evaluated in a study of 307 individuals who were prescribed eye wear (Day & Jutai, 1996a). Internal consistency was measured using Cronbach's Alpha values. The Total PIADS score value was .95, while the three subscales ranged from .87 to .92 (Jutai & Day, 2002). The same study measured test-retest reliability and found the tool to be stable over time, with none of the *t test* values reaching significance (Jutai & Day, 2002). Jutai and Day (2002) report construct validity was confirmed using a Principal Component Analysis of the three subscales, and that this was further supported in two subsequent studies (Day & Jutai, 1996b; Jutai, 1999).

3.3.4 Canadian Occupational Performance Measure (COPM).

The COPM is described by the authors as “an individualized measure designed for use by occupational therapists to detect change in a client’s self-perception of occupational performance over time” (Law et al., 1998, p. 1). The tool uses a semi-structured interview format to identify areas of occupational performance that the client perceives to be problematic (i.e., occupational performance issues or OPIs). The client prioritizes these OPIs on a Likert scale from one to ten, indicating how important it is to be able to do the activity. Up to five activities are chosen, based on the highest ranking from this process. The activities on this list are confirmed with the client, who may chose to retain all items or replace any of them with an activity they deem more important in retrospect.

Each OPI is then rated by the client on Performance as well as Satisfaction, using a Likert scale from one to ten. In measuring Performance, the rater asks “How would you rate the way you do this activity now?” where a score of one indicates “not able to do at all” and ten indicates “able to do it extremely well” (Law et al., 1998, p. 41). In measuring Satisfaction, the rater asks “How satisfied are you with the way you do this activity now?” where a score of one indicates “not satisfied at all” and ten indicates “extremely satisfied” (Law et al., 1998, p. 41). The Performance scores for all OPIs are summed and the result is divided by the number of OPIs to provide an overall score for Performance. This process is repeated with the Satisfaction scores. The COPM can be readministered and used to measure change in the client’s perception of Performance and Satisfaction over a period of time/intervention, or between situations.

The COPM was selected for this study because it allows participants to self-identify activities specific to them for which they use their PWC, and evaluate Performance and Satisfaction with activity involvement using each wheelchair device. It has been used previously with assistive technology device prescription and has been recommended for this purpose (Fuhrer, 2001; Bottos, Bolcati, Sciuto, Ruggeri, & Feliciangeli, 2001; Reid, Rigby, & Ryan, 1999; Tam, Reid, Naumann, & O'Keefe, 2002).

Carswell et al. (2004) have suggested that, since the COPM clearly addresses the three domains of occupation – self-care, productivity, and leisure – it is deemed to have content and face validity. Construct validity has been supported through comparison of COPM Satisfaction scores with three other measures (Satisfaction with Performance Scaled Questionnaire, Reintegration to Normal Living Index, and Life Satisfaction Scale), demonstrating a high degree of correlation (McColl, Paterson, Davies, Doubt, & Law, 2000). Criterion validity has also been supported by McColl et al. (2000), indicating the ability of the COPM to generate issues relevant to occupational performance for individuals.

Reliability studies of the COPM have found acceptable test-retest reliability scores for measurement of Performance and Satisfaction components. Sanford et al. (1994) reported ICC scores of .63 and .84; Law and Stewart (1996) reported .79 and .75; and Bosch (1995) reported .80 and .89, all respectively. More recently, a study of 26 individuals with CVA found ICC scores of .89 and .88 with Performance and Satisfaction ratings, respectively (Cup, Scholte op Reimer, Thijssen, & van Kuyk-Minis, 2003), while a study of 141 Taiwanese with a mental health disability found similar results of .84 and .85 (Pan, Chung, & Hsin-Hwei, 2003). Further details about psychometric testing of the COPM can be found in the 4th edition of the user’s manual (Law et al., 2005).

3.3.5 Focus Groups

3.3.5.1 Purpose

Two focus groups were used to obtain insight into the experience of the participants. This type of information is difficult to draw from the four quantitative outcome measures. Focus groups have been used successfully to gather qualitative information in other research contexts (Krueger & Casey, 2000; Madriz, 2000; Speziale & Rinaldi Carpenter, 2003). The quantitative tools used do not lend themselves to answering the question of *why* participants were or were not satisfied with their performance. The focus groups were used to elicit this information, as well as identify common themes among the participants. The information gathered from the focus groups was not intended for statistical analysis (Morgan, 1998). A number of studies investigating wheelchair use and community participation have also used similar qualitative research methods, although typically through individual interviews rather than a focus group (Levins et al., 2004; Miles-Tapping & MacDonald, 1994; Miles-Tapping, 1996; Pierce, 1998). Other studies have employed focus groups to gather information on the lived experience of wheelchair users (Bauer, Lane, Stone, & Unnikrishnan, 1998; Abraham-Murali, Kane, & Staples, 2001; Manns & Chad, 2001; Routhier, Desrosiers, Vincent, & Nadeau, 2005). The participants in this study all share the common experience of being dual-users of a PWC and MWC – a key element in using a focus group approach (Krueger & Casey, 2000; Speziale & Rinaldi Carpenter, 2003). The investigator has had previous experience facilitating a series of focus groups in the area of assistive technology and disability (Ripat & Booth, 2005), as well as clinical training and experience in group work. This facilitation experience, with both content and process, is advocated for in the literature (Krueger & Casey, 2000).

3.3.5.2 Size

Focus group size is suggested to be between six and ten participants (Krueger & Casey, 2000; Speziale & Rinaldi Carpenter, 2003); however, it was felt that a 90 minute session would not allow sufficient time for all participants to contribute to the discussion. Several individuals identified fatigue as an issue when approached about involvement in the focus group, and indicated that a session longer than 90 minutes would present a barrier to effective participation. Consequently, two smaller focus groups (comprising four participants in each) were planned.

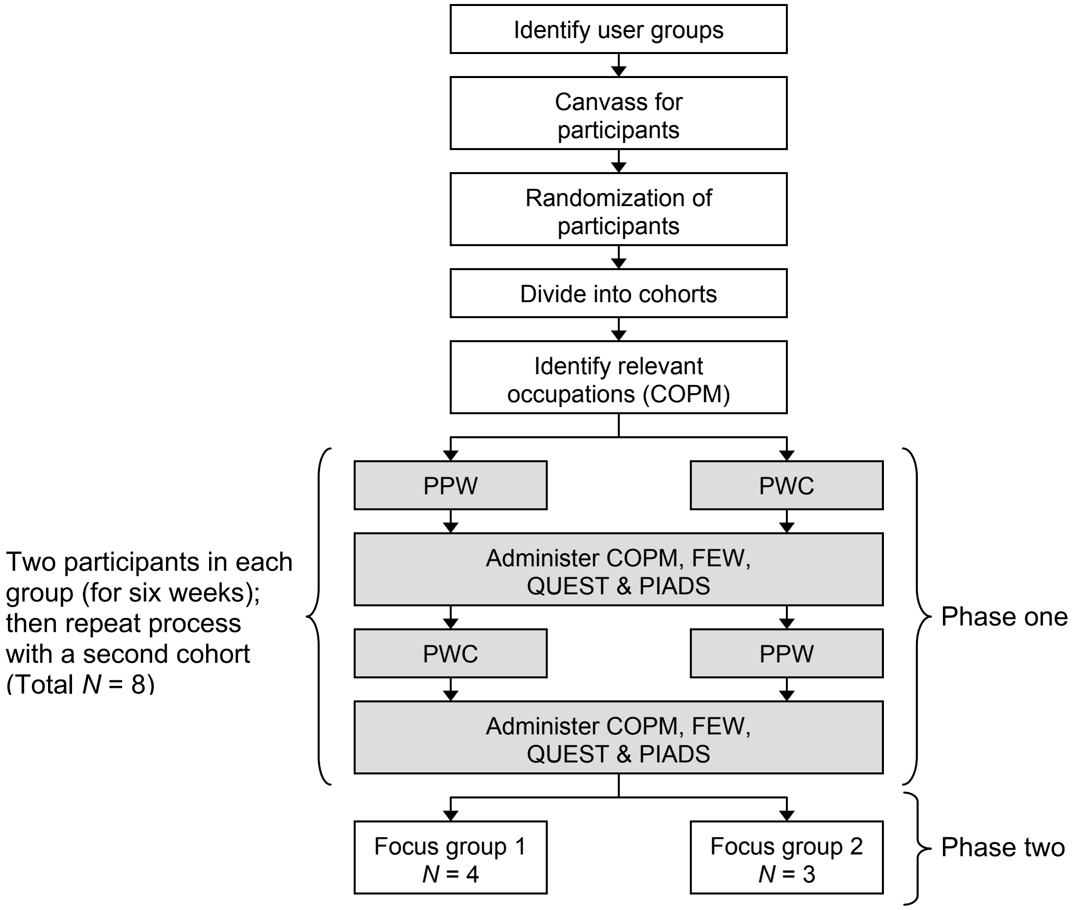
3.3.5.3 Questions

Question development is critical to the success of a focus group. The questions identified for this study were constructed using guidelines from a number of resources, as recommended (Clifford, 2002; Krueger & Casey, 2000; McNamara, 1999). A review of literature regarding wheeled mobility and community participation was used to identify issues of relevance, and a draft question list was developed. After completion of the initial descriptive portion of the study, a preliminary analysis of the quantitative data was performed. The focus group questions were revised to address areas of interest and uncertainty based on this preliminary analysis. The revised question list was reviewed by several researchers experienced in focus group analysis. Minor revisions were made based on these reviews, and a final version was set (see Appendix H). The question outline included primary questions, framed in an open-ended format to allow participants latitude in identifying issues and experience of relevance. Follow-up questions were prepared to facilitate in-depth discussion, if the participants required prompting. The questions were reviewed subsequent to completion of the first focus group to identify any omissions or issues before proceeding to the second focus group. No revisions were required based on this review.

3.4 Procedure

A detailed protocol of the procedures used in this study is included in Appendix I. Figure 3 provides a visual outline of the study components. The investigator met with each participant at his or her home, or another location where desired (e.g., at the MS society building following the participant's appointment there). The consent form was reviewed with the participant and signed. The investigator completed the Research Study Participant Cover Sheet (see Appendix J), and assigned a participant number. The COPM was used to identify activities the participant accomplished with their PWC, and was willing to attempt using the PPW during the study. A maximum of five activities were selected. The participant was

Figure 3. Study components.



informed about which device to begin with (i.e., PWC or PPW), based on random assignment (i.e., crossover design). The participants spent three weeks performing the identified tasks using their assigned mobility device. After three weeks, data was collected using the four quantitative outcome measures. Subsequently, the participant began using the second wheelchair device for the identified activities for a three-week period. Participants were free to use their MWC, PPW, or PWC for all other activities not identified using the COPM. Participants were also informed that, while they were encouraged to use the PPW for identified occupations, they were not obliged to do so if they felt this would be unsafe or presented undue difficulty.

The study was designed to involve eight participants - four participants during each of two six-week blocks of time. Only two sets of PPW wheels were available for this study; therefore, a blocking method was used to allow up to four participants to move through the study at any one time. Within each six week block, two participants would begin with the PPW and after three weeks switch to the PWC, while the remaining two participants would begin with the PWC and finish with the PPW. Participants were assigned to each group by the investigator, using a randomized process (i.e., ABAB). It was not anticipated that a cumulative effect would occur, and consequently no washout period between the treatment applications was required. Due to recruitment issues and participants' schedules, there were several occasions when less than four individuals were involved in the study at one time. Consequently, this portion of the study was completed over 20 weeks to include all eight participants.

At the beginning of the PPW segment of the study, the investigator installed the required equipment on the participant's own wheelchair (i.e., axle plate bracket) and provided training in use of the PPW until the participant indicated they were sufficiently familiar with its operation. Adjustments were made to the PPW settings where required, and modified until the participant indicated the best available option had been achieved. A user's manual, developed by the investigator, was left with the participant for reference (see Appendix K). Since all participants were already performing manual propulsion of a wheelchair, it was anticipated that the PPW learning period would be relatively short. The investigator ensured that there were anti-tippers on the participant's MWC for safety reasons. The investigator provided contact information (i.e., telephone number & email address) so that any issues around equipment or usage could be resolved quickly, with the investigator attending to the participant's residence to provide any follow-up services. At the conclusion of each PPW segment of the study, the investigator removed any study equipment from the participant's MWC and ensured it was returned to the original configuration prior to the study. Participants who owned a MWC without removable rear wheels were provided with a lightweight MWC (i.e., Quickie® 2) already configured with the PPW wheels, and adjustments were made as described above.

The four quantitative outcome measurement tools (i.e., COPM, QUEST, PIADS, and FEW) were administered at the end of each treatment period (at 3 and 6 weeks) in each participant's home, or other location if desired. The participants were given $20 gift certificates after completing the outcome measures in each of the two treatment periods.

Once the quantitative data collection was completed, the investigator made arrangements for participants to attend a 90 minute focus group. Two focus groups were used to allow each individual sufficient time and opportunity to share their experience and opinion. Participants were initially contacted by telephone to confirm that the time, date, and location was acceptable. A follow-up letter was mailed to each participant, reviewing the purpose of the focus group; providing directions to the location; and confirming that expenses for parking and transportation would be reimbursed. A checklist was developed to ensure consistency between groups (see Appendix L). Two tape recorders were used to audiotape the focus groups. To ensure no data would be missed, a second researcher was present to operate the recording devices and make field notes. A question template was provided to facilitate this note-taking and allow the second researcher to participate more fully in the data analysis process. At the conclusion of each focus group, participants were reimbursed for parking and transportation and given their final $10 gift certificate. The investigator facilitated both focus groups, including taking field notes. Immediately following the focus group, the investigator made notes relevant to the content and process to ensure retention of this information during data analysis.

The investigator transcribed the first focus group in full, using a dictation machine and word processing program on a personal computer. The transcription was edited to include line numbering for referencing specific participant responses. All identifying information (e.g., names and locations) was removed and replaced with descriptors. This process was repeated with the second focus group. A summary of the results of this data analysis process was compiled and mailed to all focus group participants, as a method of member checking to ensure accuracy (Creswell, 2003). Participants were asked to respond to the investigator and were provided with contact information if they identified issues with the accuracy of the data summary. All data was stored in a locked filing cabinet in the investigator's office, located in R028 – 771 McDermot Avenue, Winnipeg, Manitoba, R3E 0T6.

3.5 Data Analysis

3.5.1 QUEST

The QUEST provides ordinal ranking scores from 1 to 5 for participant satisfaction with eight different attributes of the wheelchair device, as well as a composite score representing the mean average of these individual scores. Participants rated their Satisfaction with each device (i.e., PPW and PWC). Differences in mean composite scores between PPW and PWC were compared. The QUEST tool also incorporates a four item section that rates Services. Since the study participants were not rating the services related device prescription, this section of the QUEST was not used. The QUEST tool also asks the user to identify three of the twelve Device/Service items as most important to them. In this study, only Device items were listed in this section.

3.5.2 FEW

The FEW provides an ordinal ranking of the participants' evaluation of ten device attributes on function (section one). Item rankings were converted into numerical scores, ranging from 1 (completely disagree) to 6 (completely agree), and a composite mean score was calculated. Participants scored each device using the FEW, and differences in composite mean scores between PPW and PWC were compared. The FEW also involved a clinical observer evaluation of seven tasks (section two): three standardized reaching activities and two transfers (from wheelchair to surface and then surface to wheelchair). These tasks are scored on three arrays: Independence, Safety, and Quality. Individual task scores range from 0 – 3. Scores for each array were totalled using the seven task results, and differences in scores between performance in PPW and PWC were analyzed.

3.5.3 PIADS

The PIADS provided a numerical score, from -3 to +3, for device impact on the participants' quality of life. Twenty-six individual item scores were generated by participants for each device (i.e., PPW and PWC). These item scores were then used to calculate a Total score, as well as three subscale scores: Competence, Adaptability, and Self Esteem. Differences between PPW and PWC scores for each subscale, as well as the Total score, were compared.

3.5.4 COPM

The COPM provided individual numerical scores for Performance and Satisfaction with each of the identified Occupational Performance Issues (OPIs), using ordinal ranking from 1 to 10. Total scores for Performance and Satisfaction are obtained by averaging the individual scores. Participants provided scoring data for Performance and Satisfaction with each device (i.e., PPW and PWC). Differences in mean scores between PPW and PWC were compared, for both Performance and Satisfaction with OPIs.

3.5.5 Focus Group

After the first focus group had been transcribed and identifying information removed, an analysis process was undertaken. The investigator read through the transcription several times to gain insight into the content as a whole, before beginning an iterative process of separating content into themes for comparison and summary (Creswell, 1998). The transcript was reviewed line by line, identifying 255 independent concepts (i.e. short phrases or sentences) and marking each one in the margin. Simultaneously, a second researcher also reviewed the transcript, writing their concept descriptors in the margin. The investigator compared the two transcript reviews. There was substantial consistency between the descriptive phrases used by each reviewer, and the transcript content indicated by these descriptors. These concepts were then compiled into a grid, organized by the focus group questions. The concepts were then reviewed again, using field notes and comments to identify commonalities. After several iterations, 42 categories were identified that subsumed all identified concepts. These categories were coded, and the original transcription adapted to incorporate these codes in the margins.

After completing this process, the second focus group was transcribed. The investigator reviewed this transcript in a similar fashion, identifying each independent concept and marking this in the margin. The categories identified in the first focus group were used in reviewing this second group transcript. Any concepts which did not fit into an identified category were indicated. All new concepts were then reviewed and additional categories were developed incorporating this new content. The transcript of the first focus group was reviewed again, looking for content that was consistent with these new categories.

The investigator then revisited both original transcripts and reviewed the categories identified, looking for overarching themes that would incorporate this content. Several iterations were developed and discussed in concert with the investigators advisors. Ultimately, a framework was developed that provided an appropriate explanation and incorporation of the qualitative data. A descriptive summary of the qualitative data was written identifying the common themes, without reference to specific participants. This summary was mailed to each focus group participant as a method of member checking (see Appendix M), to support confidence and verification of accuracy in the data analysis process (Creswell, 2003). No participants identified disagreement or conflict with the results presented in this summary. In addition, the investigator met individually with one participant who was unable to attend either focus group. The summary was presented to this participant and an extended discussion confirmed consistency with this individual's study experience, as well as providing increased insight for the investigator into many of the themes identified.

3.6 Statistical Analysis

The quantitative data collected (i.e., COPM, QUEST, PIADS, and FEW) was in the form of paired values – each participants' score using PPW was be compared with their score using PWC. The small sample size precluded a normal distribution of results, and consequently nonparametric data analysis was used. The Wilcoxon signed rank sum test was used to identify a significant overall difference between PPW and PWC scores by ranking the magnitude of each individual difference and the direction, positive or negative (Hassard, 1991). The investigator consulted with the Biostatistical Consulting Unit in the Community Health Sciences department of the Faculty of Medicine during analysis of this data.

The qualitative information (i.e., focus group themes and participant experience) was used to explain and interpret the quantitative data. Individual and common experiences were used to highlight results generated through the quantitative outcome measures, and were helpful in explaining any unexpected results (Creswell, 2003). This information was also helpful in exploring similarity and diversity in participants' experiences.

4.0 RESULTS

4.1 Quantitative Data

4.1.1 Demographics

The eight individuals who participated in this study included 6 males and 2 females, and represented a variety of health conditions. The first four participants listed used the PWC first and PPW second, the last four participants listed used the PPW first and PWC second (see Table 1). There was consistency in demographic information between the two study streams (PWC first vs. PPW first, respectively) including age (*M* = 51 years, range 40 – 63; *M* = 46 years, range 33-60), sex (3 male, 1 female for each), years in MWC (*M* = 7 years, range 5-8; *M* = 9.8 years, range 4-17), and years in PWC (*M* = 6.9 years, range 4 – 9.5; *M* = 11 years, range 3 – 27).

Table 1. Demographics of Study Participants

Sex	Age	Diagnosis	Years in MWC*	Years in PWC*	Focus Group
M	40	SCI C4/5 (quadriplegia)	7	9.5	N/A
M	63	Spinal cord stenosis (quadriplegia)	8	6	2
M	58	Multiple Sclerosis	8	8	1
F	42	Multiple Sclerosis	5	4	1
M	53	SCI C5/6 (quadriplegia)	17	27	1
F	39	Hereditary spastic paraparesis	8	3	2
M	33	SCI C5/6 (quadriplegia)	10	10	2
M	60	Polymyositis	4	4	2

* Some participants had used a PWC prior to using a MWC and vice versa.

Participants each identified up to five occupations to evaluate during the study (range 1-5; *M* = 3.88; *SD* = 1.46). These occupations included productivity activities, such as going to work; self care activities, such as home management; and leisure activities, such as visiting (see Table 2).

Table 2. Occupations Identified by Participants for Evaluation (Frequency of Response)

Occupation Identified (OI)	Selected at study outset	Included in evaluation*
Shopping	5	3
Going out to a restaurant	3	3
Going for a ‘wheel’/stroll	3	3
Doing laundry/housekeeping/cooking	3	3
Going to work	2	2
Attending support/self help group	2	1
Visiting/socializing	2	1
Attending community social events	2	1
Watching TV	1	1
Exercising	1	1
Walking the dog	1	1
Going to the library	1	1
Performing self-care/hygiene	1	1
Attending medical appointments	1	0
Going to see a movie	1	0
Playing outside with daughter	1	0

* Some participants did not have the opportunity to perform certain OI in both the PWC and PPW (see Table 3); these OI were excluded from the data analysis.

In some cases, participants were not able to participate in all of these occupations with both wheelchair configurations (PPW and PWC), and consequently these occupations were not included in the COPM data analysis (see Table 3). Participants reported that lack of opportunity was the only reason the PPW was not used for identified occupations; neither safety nor difficulty played a factor. The number of identified occupations participants were able to complete during the study period ranged from 1 to 5 (*M* = 2.75; *SD* = 1.16).

Table 3. Number of Occupations Identified and Included (by Participant)

Participant	001	002	003	004	005	006	007	008	Total
Identified	5	1	3	3	4	4	5	5	30
Included	5	1	3	3	2	2	3	3	22

4.1.2 Reported Hours of Use

The investigator contacted participants by telephone once per week to identify the number of hours they had spent in their wheelchairs during that week (see Appendix N). This data was collated for each 3-week study block.

Average Hours in Wheelchair

Participants reported the *average* number of hours *per day* spent using their PWC or PPW, and the number of hours spent using any type of wheelchair – manual or powered (see Table 4). The mean number of hours spent in the PPW or PWC on a daily basis was 5.5 hours (*SD* = 3.63) and 6.1 hours (*SD* = 5.36) respectively, and was not significantly different (t(7) = -0.33, p = .75 (two tailed)). The mean number of hours spent in any wheelchair (manual or powered) on a daily basis was 8.83 (*SD* = 5.34) and 9.17 (*SD* = 5.83) respectively for the PPW and PWC blocks, and also did not represent a statistically significant difference (t(7) = -0.54, p = .60 (two-tailed)).

Table 4. Mean Hours per Day Spent in a Wheelchair

Participant	PPW Study Stream		PWC Study Stream	
	PPW*	Total**	PWC*	Total**
001	2.50	13.50	13.50	13.83
002	7.50	12.00	6.00	10.50
003	6.83	6.83	1.67	4.67
004	8.17	9.50	8.50	10.00
005	7.67	14.33	3.00	15.00
006	0.50	0.50	1.33	1.33
007	1.00	1.67	1.00	2.00
008	10.00	12.33	14.00	16.00
M	5.52	8.83	6.13	9.17
SD	3.63	5.34	5.36	5.83

* Mean hours per day spent in powered wheelchair (PPW or PWC) during each study stream
** Mean hours per day spend in any wheelchair (manual and powered wheelchairs combined)

Hours Spent in Identified Occupations

During the weekly telephone contacts, participants also reported the *total* number of hours *per week* they spent participating in their identified occupations (see Table 5). Study participants spent a relatively equal number of hours participating in their identified occupations during each study block, with no statistically significant difference indicated (t(7) = -0.33, p = .75 (two-tailed)). Consideration was given to the fact that not all study participants selected the same number of identified occupations, and this could result in some bias. The mean hours spent in IOs was modified for each participant by dividing the total hours by the number of occupations identified (i.e., hours per IO). However, this did not result in any significant difference between the two study streams (*M* = 18.03, *SD* = 16.74 for PPW; *M* = 17.94, *SD* = 8.30 for PWC; t(7) = 0.02, p = .99 (two-tailed)). Consideration was also given to the fact that some participants had spent more time participating in IO, and consequently might have had a better opportunity to accurately evaluate each wheelchair device. Preliminary data analysis was completed with participants' outcome measure scores weighted according to the number of hours

Table 5. Hours Spent Performing IO Using PPW and PWC (by Study Stream)

Participant	Total hours in IO*	
	PPW	PWC
001	31.50	93.00
002	6.00	26.00
003	164.50	42.00
004	58.00	58.00
005	83.00	102.00
006	18.50	27.00
007	15.00	19.00
008	72.00	135.00
M	56.06	62.75
SD	52.03	42.55

* Total cumulative hours over 3 weeks (study block period)

spent in each wheelchair (relative to the other participants). This analysis did not demonstrate any substantial change to the reported results.

4.1.3 Sequence of Wheelchair Device Evaluation

A repeated measures cross-over design was used in this study. It was necessary to rule out any order effect that might have occurred, based on which wheelchair device was used first (i.e. study stream). The difference in outcome measure score between PPW and PWC evaluation for each participant was used, and separated into two groups (i.e., PWC first/PPW second *N* = 4; PPW first/PWC second *N* = 4). The group results were compared using an Independent t-test (see Table 6). No statistically significant differences were obtained.

Table 6. Values for Order Effect in Outcome Measure Differential

Outcome measure	PWC first		PPW first		
	M Δ	*SD*	*M* Δ	*SD*	*p* value
COPM					
Performance	-3.08	1.13	0.13	3.32	.117
Satisfaction	-3.12	2.92	0.96	3.64	.131
QUEST	-0.16	0.89	0.34	1.05	.496
FEW	-0.05	1.93	0.70	2.25	.629
PIADS					
Adaptability	-13.00	16.15	-0.5	22.22	.398
Competence	-2.75	11.18	-4	6.16	.851
Self-esteem	-6.25	5.91	-6.5	7.77	.961
Total	-22.00	32.42	-1.5	44.43	.484
Hours in wheelchair					
Total hrs PPW	8.96	5.88	8.71	5.64	.953
Total hrs PWC	10.29	6.47	8.04	5.84	.624
Difference PPW-PWC	-1.33	1.57	0.67	1.38	.107
Total hrs in IO PPW	62.88	49.99	67.13	73.46	.927
Total hrs in IO PWC	78.25	46.46	47.25	37.75	.340
Difference PPW-PWC	-33.25	33.67	19.88	68.81	.215
Hrs per IO PPW	14.72	8.33	21.33	23.57	.616
Hrs per IO PWC	17.92	8.36	17.96	9.53	.995
Difference PPW-PWC	-3.20	6.47	3.38	26.15	.643

4.1.4 Quebec User Evaluation of Satisfaction with assistive Technology (QUEST)

Participants rated eight attributes of their wheelchair devices on a Likert scale from 1 (indicating ‘not satisfied at all’) to 5 (indicating ‘very satisfied’). These items were summed, and an average rating was obtained for each device (see Table 7).

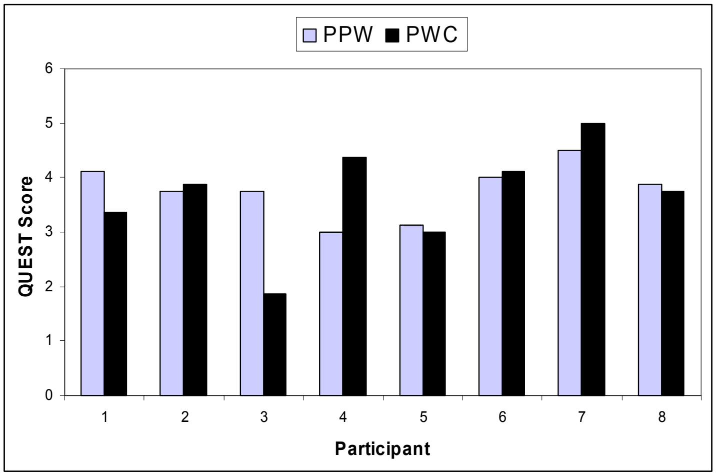
Table 7. QUEST Raw Scores

Participant	PPW	PWC	Δ*
001	4.1	3.4	0.7
002	3.8	3.9	-0.1
003	3.8	1.9	1.9
004	3.0	4.4	-1.4
005	3.1	3.0	0.1
006	4.0	4.1	-0.1
007	4.5	5.0	-0.5
008	3.9	3.8	0.1
M	3.8	3.7	0.1
SD	0.5	0.9	0.9

* Δ indicates the difference between PPW and PWC scores

Statistical analysis was performed on the difference between each participant’s mean PPW and PWC QUEST score. A Wilcoxon signed rank sum test did not reveal a statistically significant difference (W = -2.0, T+ = 17.0, T- = -19.0, p = .945). Graphing the participant scores of device satisfaction for the PPW and the PWC also suggested an equitable distribution (see Figure 4).

Figure 4. QUEST scores (graphed).



The mean scores for individual QUEST test items are summarized in Table 8. Participants scored four items higher for the PPW (i.e., Weight, Comfort, Dimensions, and Ease in adjusting) and four items higher for the PWC (i.e., Durability, Ease of use, Safe and secure, and Effectiveness).

Table 8. Individual Item Mean Scores for QUEST

Test Item	PPW	PWC	Δ*
Weight	3.8	2.6	1.2
Comfortable	4.0	3.4	0.6
Dimension	4.0	3.6	0.4
Ease in adjusting	3.5	3.3	0.2
Durability	3.9	4.4	-0.5
Easy to use	3.9	4.4	-0.5
Safe & secure	3.3	3.6	-0.3
Effective	3.9	4.1	-0.2

* Δ indicates the difference between PPW and PWC scores

Participants were also asked to identify which three individual test items were the most important to them. Participants did not always choose the same three test items in the PPW and PWC study streams (see Table 9). Safe and secure, Easy to use, and Effectiveness had the highest frequency of responses overall, and these items were all scored higher for the PWC device.

Table 9. QUEST Items Identified as "Most Important" (by Study Stream)

Test item	PWC*	PPW**	Total
Dimensions	2	2	4
Weight	0	3	3
Adjustments	0	0	0
Safety	6	4	10
Durability	2	2	4
Easy to use	5	5	10
Comfort	3	4	7
Effectiveness	6	4	10

Note. Frequency of responses as one of the three most important items when completing QUEST

* Items identified during the PWC portion of the study

** Items identified during the PPW portion of the study

4.1.5 Functioning Everyday with a Wheelchair (FEW)

The FEW contains two sections: one scored by the participant and one scored by the investigator. In the first section, ten statements are listed describing appropriateness of the wheelchair for different functional activities and needs of the user. Participants chose one of six options in response to the statement, ranging from “completely agree” (scored as 6) to “completely disagree” (scored as 1), or alternately “does not apply” (not included in calculations). The scores were summed and a mean was calculated based on the number of applicable responses (see Table 10).

Table 10. FEW (Section One) Mean Scores

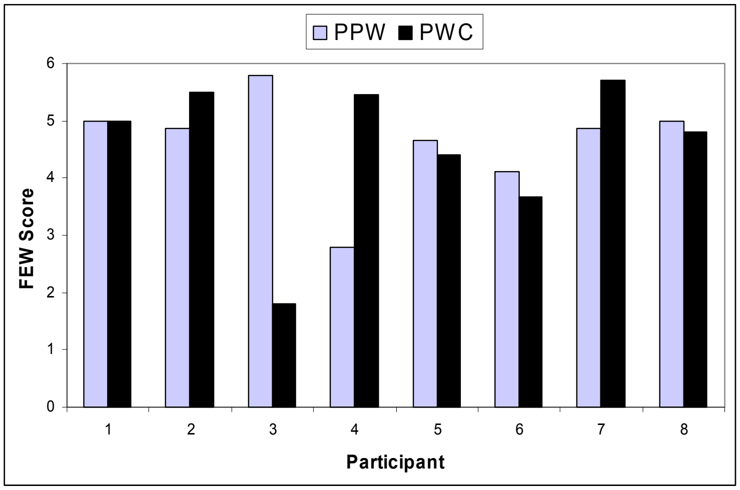
Participant	PPW	PWC	Δ*
001	5.0	5.0	0.0
002	4.9	5.5	-0.6
003	5.8	1.8	4.0
004	2.8	5.4	-2.6
005	4.7	4.4	0.3
006	4.1	3.7	0.4
007	4.9	5.7	-0.8
008	5.0	4.8	0.2
M	4.6	4.5	0.1
SD	0.9	1.3	1.9

* Δ indicates the difference between PPW and PWC scores

The mean scores for PPW and PWC were compared using the Wilcoxon signed rank sum test, and no statistically significant difference was found (W = 2.0, T+ = 15.0, T- = -13.0, p = .938). A graphic representation of mean scores also suggests very similar scoring for both wheelchair devices (see Figure 5).

The second section of the FEW involved an external evaluator with clinical experience (i.e., the Investigator) scoring study participants’ ability to perform a prescribed set of transfer and functional reaching tasks. Performance was scored on a

Figure 5. FEW participant mean scores (graphed).



four-point scale from 0 (i.e., total assistance/severe risk/unacceptable) to 3 (i.e., no assistance/safe/acceptable) using set criteria. Three performance components were evaluated for each transfer and reaching task: Independence, Safety, and Quality. All study participants were experienced users of manual and power mobility devices, so many scored “3” for most items, unless they required a complete assist for transfers, in which case they scored “0”. The component scores were combined to arrive at a total score for each wheelchair device (see Table 11). The difference between PPW and PWC scores was not statistically significant (W= -1.0, T+ = 0.0, T- = -1.0, P = 1.00).

Table 11. FEW (Section Two) Composite Scores

Participant	PPW	PWC	Δ*
001	18	18	0
002	19	19	0
003	57	52	5
004	34	34	0
005	27	27	0
006	63	63	0
007	63	63	0
008	63	63	0
M	43.0	42.4	0.6
SD	20.5	20.1	1.8

* Δ indicates the difference between PPW and PWC scores

4.1.6 Psychosocial Impact of Assistive Devices Scale (PIADS)

The PIADS presents 26 words or phrases relating to psychosocial experience, and asks participants to rate how each device affects them. A seven-point Likert scale presents “0” as no effect. The scale indicates “decreases” on one side (ranging from “-1” to “-3”) and “increases” on the other side (ranging from “+1” to “+3”). The PIADS incorporates 3 subscales (Competence, Adaptability, and Self Esteem) as well as a Total composite score. The difference in scores (PPW – PWC, see Table 12) was evaluated using the Wilcoxon signed rank sum test. No statistically significant difference was found for Total score (W = 16.0, T+ = 26.0, T- = -10.0, p = .313), for the Competence subscale (W = 16.0, T+ = 26.0, T- = -10.0, p = .313), or for the Adaptability subscale (W = 17.0, T+ = 26.5, T- = -9.5, p = .250). However, a significant difference was found between scores on the Self Esteem subscale (W = 33.0, T+ = 34.5, T- = -1.5, p = .016) in favour of the PWC.

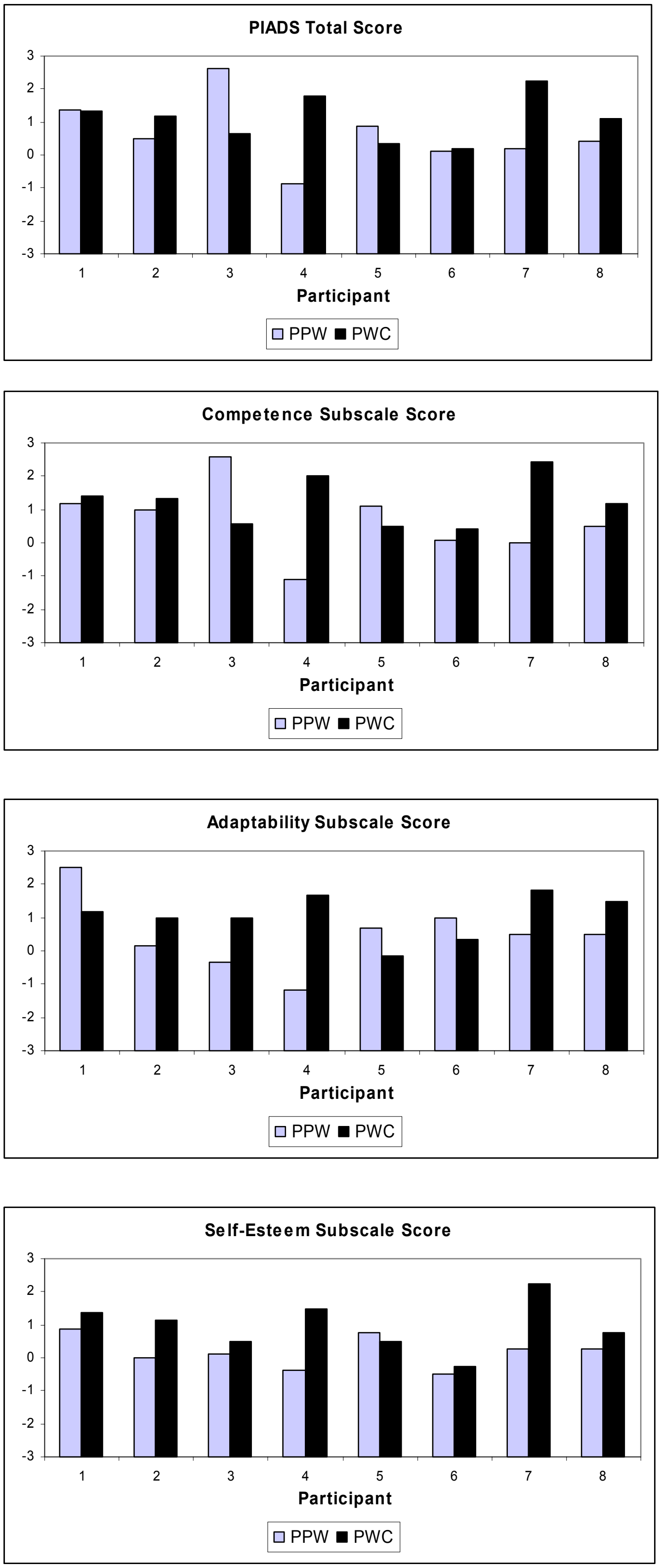
Table 12. PIADS Score Differential (PPW Score – PWC Score)

Participant	T Δ	S1 Δ	S2 Δ	S3 Δ
001	1	-3	8	-4
002	-18	-4	-5	-9
003	51	24	-8	-3
004	-69	-37	-17	-15
005	14	7	5	2
006	-2	-4	4	-2
007	-53	-29	-8	-16
008	-18	-8	-6	-4
M	-11.8	-6.8	-3.4	-6.4
SD	37.6	19.2	8.4	6.4

* T = Total score; Subscales: 1 = Competence,
2 = Adaptability, 3 = Self Esteem

In terms of clinical significance, however, a graphical representation of the data suggests a trend towards the PWC as preferable over the PPW for all components of the PIADS (see Figure 6).

Figure 6. PIADS scores (Total and subscales).



Note. The Total and Subscale scores have been standardized (i.e., sum of item scores divided by the number of test items). Number of test items: Total = 26; Competence = 12; Adaptability = 6; Self-Esteem = 8.

4.1.7 Canadian Occupational Performance Measure (COPM)

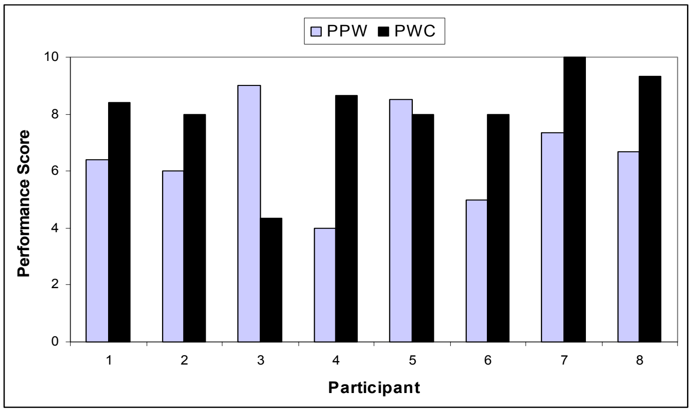
Study participants evaluated their experience performing the IOs in each of the two wheelchair options (PPW & PWC). Performance and Satisfaction were both measured using a 10-point Likert scale (see table 13).

Table 13. COPM Data for Performance (P) and Satisfaction (S) Scores

Participant	P (PPW)	P (PWC)	Δ	S (PPW)	S (PWC)	Δ
001	6.4	8.4	-2.0	8.4	8.2	0.2
002	6.0	8.0	-2.0	8.0	8.0	0.0
003	9.0	4.3	4.7	8.3	2.3	6.0
004	4.0	8.7	-4.7	2.7	9.3	-6.7
005	8.5	8.0	0.5	7.0	6.5	0.5
006	5.0	8.0	-3.0	4.5	8.5	-4.0
007	7.3	10.0	-2.7	7.3	10.0	-2.7
008	6.7	9.3	-2.7	6.0	8.0	-2.0
M	6.6	8.1	-1.5	6.5	7.6	-1.1
SD	1.7	1.7	2.9	2.0	2.4	3.8

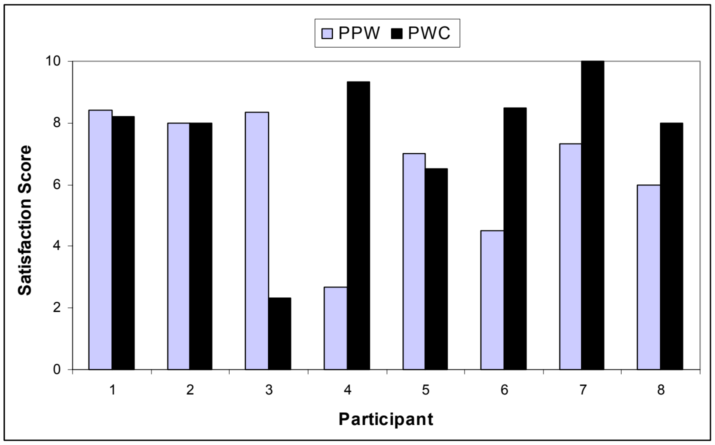
A Wilcoxon signed rank sum test was used to determine whether there was a significant difference between using the PPW and the PWC. For Performance, no statistically significant difference was indicated (W = 19, T+ = 27.5, T- = -8.5, p = .195). However, when the PPW and PWC scores are presented graphically, most participants scored the PPW much lower, suggesting a trend of poorer performance (see Figure 7).

Figure 7. COPM Performance scores for PPW and PWC.



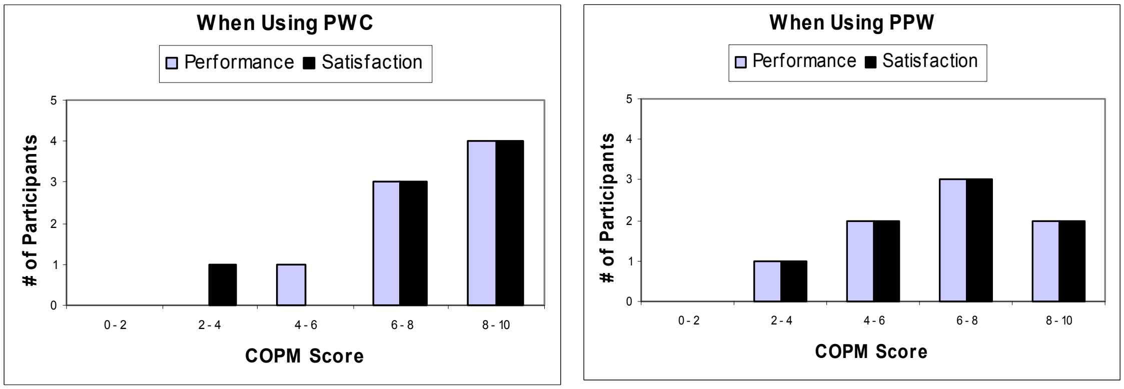
Regarding Satisfaction, there was also no statistically significant difference (W = 10, T+ = 19.0, T- = -9.0, p = .469). When the individual scores were graphed, there is a similar (although less prominent) trend towards lower Satisfaction with the PPW (see Figure 8).

Figure 8. COPM Satisfaction scores for PPW and PWC (graphed).



Mean Satisfaction and Performance scores were collapsed into five categories (i.e., 0 – 2.00; 2.01 – 4.00; 4.01 – 6.00; 6.01 – 8.00; 8.01 – 10.00). Grouping the data in this manner (see Figure 9) suggests individual participants provided very similar Performance and Satisfaction scores for a given wheelchair (i.e., scoring Performance and Satisfaction for the PPW similarly; scoring Performance and Satisfaction for the PWC similarly).

Figure 9. COPM Satisfaction and Performance scores for each wheelchair type.



4.1.8 Focus Group Data

During the analysis process, 42 categories were identified in the first focus group transcript. The second focus group transcript was reviewed, and 8 out of the 42 originally identified categories did not appear. In addition, eight additional categories were identified in this second group. The transcript of the first focus group was reviewed again, looking for content that was consistent with the newly identified categories. After further analysis, six of the eight new categories from the second focus group were retrospectively identified in the first transcript, bringing the total to 48 and indicating only two additional independent categories in the second group. The net result was a total category count of 50. Table 14 indicates the individual categories and the frequency of responses by each study participant, as well as the frequency of response by each focus group as a whole (see Appendix O for detailed description of Categories).

Table 14. Frequency of Response for Categories by Participant and by Focus Group

Theme*	R	M	S	N	E	P	G	Group 1	Group 2	Both
AC	5	4	5		1			14	1	15
AD		1	3		1	4		4	5	9
BA	3	1	3		3	3	1	7	7	14
BI		5					1	5	1	6
BR	4	4	6	2		3		14	5	19
BU	2	1	4		5	1		7	6	13
CD		3	1	3	2	5	4	4	14	18
CO	4	6	3	4	1	7	3	13	15	28
CT	1	3	2		4	1		6	5	11
DE	2	1	2	4		1	7	5	12	17
DI	2		9			2		11	2	13
DR	2	2	2	2		2		6	4	10
EE	5	2			5		2	7	7	14
EF	4		5	4		1		9	5	14
EN	2	3	4	4	2			9	6	15
EX	5	6	4	1	3			15	4	19
EZ	4	5	8		12		2	17	14	31
FA	8		4			1		12	1	13
FN	3	3	1		5	1		7	6	13
FU		1	1					2	0	2

* Focus Group 1 included Participants R, M, and S; Focus Group 2 included Participants N, E, P, and G. For detailed description of Categories see Appendix O

Table 14 (continued). Frequency of Response for Categories by Participant and by Focus Group

Theme	R	M	S	N	E	P	G	Group 1	Group 2	Both
HA	4	2	4	2		1		10	3	13
HS		4	5			2	2	9	4	13
ID	4	5	1		1	1	3	10	5	15
IE	1	2	1	4	4		6	4	14	18
IN	3	2	4	1			3	9	4	13
LC	8	7	6	5	8	5	2	21	20	41
ND		1						1	0	1
NE	7	7	7	2	2			21	4	25
OH	2					1	1	2	2	4
OP		8	2					10	0	10
PB	5	1	1					7	0	7
PH			1	4	6		2	1	12	13
PI		1						1	0	1
PO	1	1	2	1	2	2	2	4	7	11
PR	1		2	1			3	3	4	7
RA	1	1		4	1	1		2	6	8
RT	3	6	6	1	1	1	1	15	4	19
SI			1					1	0	1
SM		3	2	2	1	2		5	5	10
SP	1	1	1		9	3		3	12	15
ST		5	6			2		11	2	13
TB	2	11	3	2	1	1	1	16	5	21
TL		2						2	0	2
TR	2	4		7		3		6	10	16
TW					2	5	1	0	8	8
UE	1	7	2	9	1	1		10	11	21
UN	2	6	4	2	2	2	3	12	9	21
WI				2	5		1	0	8	8
WP		4	3					7	0	7
WT		1		3		1		1	4	5

* Focus Group 1 included Participants R, M, and S; Focus Group 2 included Participants N, E, P, and G. For detailed description of Categories see Appendix O

4.2 Qualitative Data

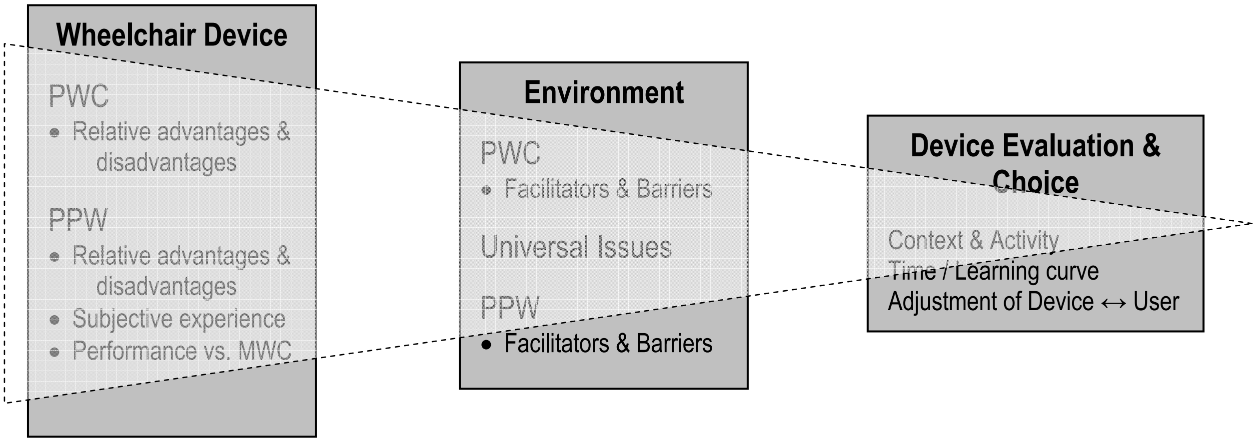
4.2.1 Data gathering process

Two focus groups were held subsequent to all participants completing phase one of the current research study. Two participants were unable to attend their scheduled focus group due to unforeseen circumstances. One participant was originally scheduled for the first focus group, and attended the second focus group instead. The other participant was scheduled for the second group but could not attend. The investigator met individually with this participant and reviewed the data summary (which had been circulated to all focus group attendees for member-checking purposes). During this meeting, the participant confirmed that the themes and experiences described in the summary were consistent with his own study experience and opinions.

4.2.2 Themes

The participants' responses can be summarized in a number of general themes. Participants talked about the relative advantages and disadvantages of the two devices used in this study: the power wheelchair/scooter (PWC) and the pushrim-activated power-assisted wheelchair (PPW). The participants identified factors in the environment that influenced the effectiveness of each device (PWC & PPW), as well as experiences of poor accessibility that affected wheelchair use generally. Finally, participants indicated a process for evaluating each device within the context of their environment. This process includes a temporal component incorporating the aforementioned device attributes, environmental and activity contexts, and reciprocal adjustment between user and device. Participants consider of all of these variables when choosing a device, as illustrated by the triangle in Figure 10.

Figure 10. Conceptual framework for focus group themes.



4.2.2.1 Wheelchair Device

The Power Wheelchair/Scooter (PWC)

There was general consensus among the participants that the PWC provided some very clear advantages in terms of providing easy mobility with very little physical demand or effort. The PWC was identified as being physically easy to operate, and did not require significant strength or coordination. This ease of operation allowed the user to travel considerable distances without concern over fatigue and tiring. One participant noted:

> *S: … if I have to go any more than, I don't know – a hundred meters, I'll take the scooter because I know that by the end of it I'm not gonna get, be exhausted, and when I get exhausted I lose a lot of cognitive ability … the scooter is a thousand times – distance wise – better, ah, cause it's no manual effort involved – it's just, I mean, when you have power, I mean it's like driving a car or walking you know.*

Not only did the PWC accommodate for the physical demands (e.g., strength and endurance), it also allowed the user to travel quickly and arrive at their destination in a relatively short period of time. The result is a method of mobility that is efficient and convenient, and does not require the user to plan ahead (i.e., how long will it take me to get there, how tired will I be, how much assistance might I require):

> *R: I don't even think about it in my electric chair. I can get around there and back in two minutes, three minutes, around that block.*
>
> *S: With the scooter, they're all easy to get from here to there – I don't have to worry about inclines or whatever, my scooter goes where I want it to go.*

Several participants identified other advantages of the PWC design. A few identified that it was convenient to be able to operate the PWC with one hand (i.e., joystick), freeing their other hand for performing functional tasks. Others identified a social or 'fun' aspect of the scooter, specifically when interacting with their children or grandchildren.

The Pushrim-Activated Power-Assisted Wheelchair (PPW)

Many of the participants reported positively on the experience of using the PPW. Most indicated a sense of excitement or curiosity around exploring a new option for mobility, and what impact it might have on their participation in life activities:

> *R: I had seen them before and I was kinda wondering what they were. So when I got the opportunity, I thought maybe I'd try it.*
>
> *S: I was curious as to how they were gonna work, how much … but , ah so I was anxious to give it a try when I saw the chance to … somebody wants to try – give me – wanted to try them.*
>
> *M: Well, I'm glad I tried it out and I … the experience was good. I was curious.*

A number of participants indicated the PPW provided a more enjoyable experience than the PWC, suggesting that it was more than just a form of transportation from one point to another, and allowed them to interact with their world to a greater degree. One participant observed:

> *R: I goes basically as fast as I can go [in the PWC], where when you're pushing a manual chair, you're going along and enjoying yourself and looking around and, you know, so that's, ah you know you haven't got blinders, and in [the PWC] I have. I just don't care who's there, or what – I'm going somewhere I gotta get … [in the PPW] you can, you can look around a little bit.*

Similarly, several participants suggested the PPW provided a sense of accomplishment in performing activities – that they were contributing to the experience, even if it was not as expedient as using the PWC:

> *S: Maybe it was a feeling of, um, I'm actually doing something and actually 'doing it' – I'm doing it and 'doing it' you know, not only am I ah physically doing it, but I'm doing something new and I'm, well, look at that I'm actually doing it you know, so it gave you that maybe feeling of satisfaction and you're actually performing ...*
>
> *R: To me, it was, ah, I was doing something that I couldn't do before.*

Some participants also highlighted the benefits of physical exercise using the PPW rather than the PWC, raising a concern that long-term use of the PWC might compromise their health status. One participant suggested an improvement during the course of the current research study:

> *M: ... after using three weeks of the power assist in the house, the massage therapist kept saying "M, you're getting muscles!" and I said "That's cause I'm not sitting on my, just using my power wheelchair, eh, I'm actually getting some [exercise]."*

Another area of relative consensus was the advantage of the PPW over a standard manual wheelchair (MWC). While this comparison was not the primary focus of the current study, participants indicated the PPW was much easier to push than their MWC and they could go faster and further than when they used their MWC.

> *M: But it was great, yeah, because you didn't ... hardly had to push, and especially in the carpeted area ... I can only push this [MWC] so far, so far, so long and then I get tired, and so if I had the power assist then it would take less effort, eh?*
>
> *E: I really enjoyed that, like not using hardly any muscle or nothing.*
>
> *P: That was really handy having those wheels – picked up the pace to more of a walking pace – keep up with everybody.*

This improvement in performance enabled participants to increase their level of function and participation, as well as accessing new environments and experiences, compared with using their MWC:

> *E: The wheels were just great, you know, like, you didn't .. that's one thing off your mind is, like, so much you know, 'cause it .. for me to use all that strength – it just, you know, engulfs me and then I , you know, like, I get so tired and it's like I .. then you get frustrated and all that, so … but if you're going with ease, then, I don't know, I felt better.*

> *S: Compared to a manual chair, I mean, like, 'wow, what is this? Look at me, hey, I can actually do this now'.*

> *R: I haven't ever pushed a wheelchair on grass until that day – when you and I went out – that was the first day – I couldn't believe it, like, that I could actually push it in the grass.*

In particular, managing inclines/ramps was identified as an important achievement, as well as propelling over softer surfaces such as grass and carpet:

> *S: I used it to go up the ramp at the MS society which, at high – when you put it on high, man it didn't take very many pushes to get up that ramp – it was really good.*

> *G: It was nice going up the slope because I didn't have to do anything much.*

> *M: But it was great, yeah, because you didn't … hardly had to push, and especially in the carpeted area.*

Some participants identified the need for assistance from others when using their MWC (i.e., when needing to access an environment that did not accommodate their PWC), and suggested that the PPW might reduce or eliminate the need for assistance in these types of situations:

> *R: I don't do a whole lot of pushing [on holidays] … whoever comes with me, they, they do the pushing, where I go.*

> *M: I just take my manual wheelchair and usually, ah, people push me around in my manual wheelchair.*

Study participants also identified certain features of the PPW design that presented barriers to use. Several people identified that the PPW still required a significant degree of upper extremity strength to operate, which could contribute to fatigue as an issue:

> *S: I didn't have the strength to go any real long distances so I never tried to go any long distances in the city [with the PPW] ... I would think that anybody with any kind of arm strength ... would find it very beneficial.*

There was general consensus that propelling the PPW required a significant amount of upper extremity coordination. Coordination was required to hold the pushrim securely, and to push with equal force on each wheel. When this demand for coordination was not adequately met, the PPW would turn or move erratically. In addition, the requirements for strength and coordination intensified during braking and when negotiating a decline.

> *N: My right hand is affected more than my left, so I use – with the totally manual one – I go in little circles, ah, with the power assist, it was the same thing ... then I was trying to brake, but since my hands don't have the same amount of strength in each – it started fishtailing, and ah, then I realized that if I grabbed the actual pushrim, that I would lock one wheel more than the other, and go in concentric circles.*
>
> *R: I went outside and right off the hop, down the incline and off the back door, well, there's a ... manhole out there, and I'm going straight for it. I just ... well, my left hand I can't grab anything, but with my right one I just grabbed onto the thing, onto the ... the pushrails on the right hand side and just held on and then spun the chair around.*

In particular, the high speed (i.e., full assist) mode was identified as much more challenging to operate, and a number of participants chose not to use the PPW in this mode.

> *P: It's a little bit erratic on high speed, weaving a lot ... one side of the sidewalk to the other.*
>
> *N: I gave it a tiny push and it broke away like a mustang.*
>
> *M: I thought I was maybe going to run into the wall, cause it was really fast, so I said "OK, I won't be using that one."*

Most focus group participants expressed concern with the length of the PPW battery charge. Some participants identified apprehension about being ‘stranded’ should the batteries run down before they could be recharged, and the high physical demands of propelling the wheelchair without the power-assist turned on.

> *M: I don’t know if there is any way that they can get it so that it would hold more charge, cause all of a sudden I would hear this beep, beep, beep, beep, beep … you’re running out of charge, eh?*
>
> *P: I didn’t like it when the batteries died – that was this hulking weight to push around.*

Several participants identified difficulty managing some features of the PPW, such as inserting/removing batteries; activating the buttons; and the additional width of the chair due to the wheel/battery design.

> *R: I had trouble changing, uh, pushing the buttons because of my hands – they don’t work … You’re just basically shooting in the dark to hit the buttons.*
>
> *E: Sometimes I’d have trouble, like, putting them in [the batteries].*
>
> *P: They’re a little bit too thick [the batteries].*

4.2.2.2 The Environment

Participants identified a variety of environmental factors that affected use of the wheelchairs when performing life activities.

Environment and PWC

Most indicated that the PWC was beneficial for outdoor environments, particularly over rough terrain. Inclines, roads and sidewalks, grass, and unpaved surfaces were reported as physical aspects of the environment that were well suited to the PWC.

> *M: I could not do that in a manual wheelchair outside, you know, down the ramp and over the gravel and all that – it would never be outside … that’s why the scooter’s very beneficial for me.*

> *P: Power chair I've been using off and on for ten years and mostly shopping, outdoor activities, and places that have rougher terrain and I [can't] get to in my manual.*
>
> *G: I know the sidewalks is terrible, so I have to use [the PWC], if I can do it on using the manual chair on the sidewalks 'cause it was terrible.*

The large dimensions and weight of the PWC contributed to difficulty with small or confined environments, particularly indoors.

> *S: My scooter is not – its very big, its not giant but its … I can't get in, in and around stores very – very well.*
>
> *M: You can't get in certain places and, you – you know, different stores and into the washroom even [laughs], depends so … that's where the manual wheelchair – that's why we generally take the manual wheelchair when we go shopping, go out for supper, cause we know its smaller, um, and so you can get in to most places in a manual.*
>
> *M: The manual wheelchair is always better cause its smaller, so you can get in places where the scooter cannot and the power wheelchair cannot.*

This additional size and weight also made transportation of the PWC difficult, whether by automobile or when traveling (i.e., flying to a destination for a vacation):

> *M: In people's homes, too, like ah, definitely don't take when I go visiting to other people's places – the scooter or the power wheelchair [in our vehicle], we take the manual.*
>
> *N: While the power assist is definitely more flexible because your spouse can load it into the back of the car without needing a crane or a ramp, so if you're going somewhere, where it doesn't matter what kind of device, power or not, you have a destination, then getting away from home is simpler.*
>
> *R: When I go on holidays, I, I just take my manual chair … you fly electric chair in airplanes and they wreck them on the way there, and on the way back.*
>
> *N: One of advantages of the totally manual wheelchairs is, if you're traveling by air … I think that I would dare try to take a power-assist [wheelchair] on a trip like that, because it's light enough to – for the guy to carry it down – see I use my own wheelchair, manual wheelchair, up to the point of the door of the plane.*

Other environmental obstacles, such as curbs, steps, or narrow entrances, presented accessibility issues for the PWC. The smaller size and weight of the MWC (or potentially the PPW) provided access to confined or small environments, particularly indoors.

> *E: I just hop on to the scooter, but then I'm stuck because scooters can't go into people's homes.*
>
> *N: You need the manual wheelchair because nobody's lift a 250 lb electric one over a Hobby Shop door step through a door that's a little narrower than it should have been.*
>
> *N: Once that one step – one four inch step – causes you to go manual.*

Environment and PPW

The PPW was also identified as providing improved access to outdoor environments, when compared with the traditional MWC. In particular, inclines and curbs were now potentially manageable, whereas with the MWC they were not.

> *G: It was nice going up the slope because I didn't have to do anything much.*
>
> *R: If I'm going somewhere I get in my electric chair. But, when I had those rims, I well, I wanted to see what I could do and … I could at least get around where I wanted to go so, and you're going half-decent speed.*
>
> *S: I never tried that curb in my manual wheelchair.*

Environment and Wheelchair Use in General

There was a common response among participants that physical barriers consistently appear in their communities to prevent participation. Participants reported numerous experiences where sidewalks were inaccessible due to disrepair; buildings did not have ramped access or the ramps were insufficient; and surfaces were not conducive to wheelchair mobility in general:

> *M: You can't get in certain places and, you – you know, different stores and into the washroom even.*

> *N: They don't have any ramps to half the restaurants, because it's a young city – they can't be bothered with people in wheelchairs.*
>
> *E: Yeah, but then you're on the road, with your manual or whatever, you know, and then you get the honking and the swerving of other cars, and what are you supposed to do? So I agree with you – the sidewalks are [inaccessible] … you can't win, you know?*
>
> *N: These cobblestones and paving blocks … they're – I hate 'em because, you know, your fillings feel like they're gonna fall out and the rattle they may be very artistic but they sure are a pain in the …*

Participants identified a social environment where there was disparity in the receptiveness of non-disabled people to creating accessible environments, and the frequency of encountering pseudo-accessible environments where some physical accommodation had been made (and identified as handicap accessible) but was insufficient to actually permit access.

> *N: You have an 18 inch hole to get at the ramp, so … we got the lady manager out there – she looked at it, "tsk, tsk'ed" a couple of times and we went our way and she went hers.*
>
> *E: What about the new buildings that they're making now and the … they put a handicap thing there where a handicap can park, but there's like 4 inches where you have to go over to get .. on to .. to get into the front door, unless you go around to the other building where there's no, like the sidewalk is flat and you can get up and then wheel up to …. Why do people do that? It's a brand new building, isn't there codes that they, like there should be an opening, like flat right? How are you gonna get up there?*

Despite these issues in the social environment, participants did not identify an increased perception of disability (either self-perception or others' perception of self) when using the PWC. A number of participants appeared to be aloof to the question of whether others in the community perceive them differently in a MWC (or PPW) versus a PWC:

> *E: I don't know.*
>
> *S: I don't know.*

> *G: I don't know whether – depends on, on the ... I think all things depends on the individual, I guess their perceives of what're the wheelchair, you know – cripple or something like ... I don't know, I guess that too depends on the individual.*

One participant went further, suggesting that the personal issues of self-concept and social perception had been stronger in the past, and were now less relevant:

> *P: For a long while I thought that, you know, using a power chair made me seem more disabled, but lately through experiences, it just seems to be irrelevant – you're in a wheelchair – wheeled, it doesn't matter if it's power or manual – it's just how you project yourself when you're in there.*

Winter weather was also identified as an environmental condition that presented barriers to both the PWC and PPW. Wind was an environmental factor that one participant identified as affecting the PPW but not the PWC.

4.2.2.3 Device Evaluation and Choice

Participants indicated that, when choosing a wheeled mobility device, consideration of the advantages and disadvantages needed to occur within the context of the environment where the device would be used. Without this contextual evaluation, they were hesitant to make decisions about the effectiveness of the device. For example, one participant identified disappointment with the lack of opportunity to fully evaluate the PPW outdoors:

> *M: I wanted to use it outside, to see what it might be like but I never did get the opportunity.*

The advantages and disadvantages of the two devices, as described previously, posed a conflict for participants. The choice of which device to use was more complicated than merely comparing lists of pros and cons; sometimes a single factor weighed more significantly, or performance within the context of use proved to be more critical than evaluation of individual attributes. Participants provided several examples of this dilemma:

> *P: I thought that the performance [of the PPW] wasn't that great, it was kinda lacking, but you know, you're not tied to a really heavy power chair in there, you have a lot more mobility and freedom right there … not a big clunky machinery you're tied to is, it's still your manual chair, it can be folded up and put away, transported.*
>
> *M: The only thing that I did not like was that I didn't have that free left arm like I have with my power wheelchair, so that's why I kinda tend to go to the power wheelchair because I have a free, free arm, eh?*
>
> *E: [Price] … it's a major barrier and I think, like ah, a lot more people would, I would because my arms and the weaknesses and … I just think, I don't know, price, you after everything you know, yeah you love it all this, but you can't afford it, so … I don't know.*

With regard to the PPW, participants clearly indicated that the process of evaluating effectiveness of the device required time:

> *P: It took me a couple of days to get over the apprehension of not smashing my kneecaps and toes onto things from all the extra 'umph' it gives you … don't worry about not ramming your knees into tables.*
>
> *M: Sometimes you would go in a circle, eh, and ah, so that … but after I got used to it, after a few days, I could figure out what.*

Many participants identified the need to make adjustments to the PPW in order to best match the users' needs. The adjustability of the PPW was identified as a benefit, but also required time and trial to arrive at an optimal setting:

> *S: … fitted to the actual person, it has to be definitely adjusted and all the rest of that stuff, like the amount of power that you can put, the brakes and the batteries … I adjusted it so they were equal and it was a lot better; however, because you're, like you're both saying that your one arm is stronger than the other, were giving you more push, you needed those adjustments to be able to adjust it down on one side.*
>
> *P: What I liked about the power-assist wheels was the variability of the settings for duration of push and the percentage of power increase. I'd like to see more variety though, like a longer duration of push, um, maybe for my stronger arm, maybe less power – more variety so you can fine-tune for your different arms a little bit better so it's not as erratic.*

They also indicated the need for the user to adjust their own performance to match the operation of the device:

> *R: The batteries were already wore out – like I had no idea how to push it, ah, you know that came later, like as I used it, it become a little more, you know I could preserve the power a little bit.*
>
> *P: There was a bit of a learning curve, you had to get used to the sensitivity of the wheels, exactly how long to push, how much pressure to push.*
>
> *M: Sometimes you would go in a circle, eh, and ah, so that ... but after I got used to it, after a few days, I could figure out what.*

This process of adjusting the device, and adjusting *to the device*, often took considerable time and experimentation. The 'learning curve' to reach an optimal balance and to learn how to best operate the device was not always achieved within the time frame of this research study, as one participant identified:

> *E: I just think if I had a little bit of ... longer time, maybe, because I, I really liked them! And I really miss them!*

Based on their exposure to the PPW in this study, participants generally agreed that the PPW did not replace the PWC, and users prefer the PWC for those environments that are accessible:

> *S: I think once the, once you're at the point of needing a power [wheelchair] or ah, either a wheelchair or a scooter or whatever ... it's too late.*
>
> *G: [I use] the power wheelchair when I go out, 'cause it gives me more ... a little bit more, able to more – do things more.*
>
> *N: [The PPW] is more flexible, ah, to – the power-assist would give you the best of both worlds, but when I know that my electric wheelchair will enter the place I'm going to, there's no question I will accept ... I'm basically lazy.*

Participants did comment that the PPW provided a good alternative when access to the environment was unknown or was not conducive to the PWC. Several participants speculated that the PPW would be an excellent option for those who did not have a PWC:

> *G: I would think that anybody who doesn't have a power [wheelchair or scooter] and all they have is a [manual] wheelchair, this thing would be the cat's meow.*
>
> *M: And like I said, definitely is beneficial for those that don't have any other type of power assist device, but ah … save your energy.*

Furthermore, there were numerous suggestions that the PPW would be a preferred alternative to the MWC, and would allow participation in activities and environments that were currently not viable to participate in with a MWC:

> *E: The wheels were just great, you know, like, you didn't .. that's one thing off your mind is, like, so much you know, 'cause it .. for me to use all that strength – it just, you know, engulfs me and then I , you know, like, I get so tired and it's like I … then you get frustrated and all that, so … but if you're going with ease, then, I don't know, I felt better.*
>
> *M: I can only push this [MWC] so far, so far, so long and then I get tired, and so if I had the power-assist then it would take less effort, eh?*
>
> *E: I think I would be more involved. For one thing, I just – I hate this thing [referring to MWC].*
>
> *R: [on holidays] I don't do a whole lot of pushing … whoever comes with me, they, they do the pushing, where I go.*

5.0 DISCUSSION

5.1 Wheelchair Usage

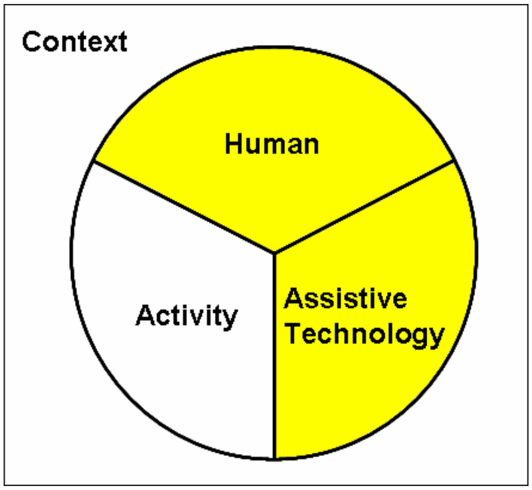
The participants in this study were asked to temporarily suspend use of their existing method of power mobility (the PWC) and use an alternative, and novel, device in its place (the PPW). Questions have been raised about how introduction of the PPW might change wheelchair usage patterns such as time spent in the wheelchair, distance traveled, and activity level (Algood et al., 2004; Fitzgerald et al., 2003; Levy et al., 2004). In the current study, the number of hours per day participants spent in the PPW was not significantly different from the number of hours per day spent in the PWC. Similarly, the total hours per day spent in any wheelchair (manual or power) were not statistically different during the PPW and the PWC streams. Furthermore, using the PPW did not significantly alter the number of hours per week participants spent performing their identified occupations compared to the PWC. These results are consistent with another study comparing MWC and PPW use, where time in the wheelchair and distance traveled did not significantly differ (Fitzgerald et al., 2003). A repeated measures cross-over design was used in this study to address a potential bias based on the order in which participants evaluated the two wheelchair options. The two study sequence cohorts (i.e., PPW first/PWC second and PWC first/PPW second) were compared using an Independent t-test, and no significant difference was found in the mean scores of the four quantitative outcome measures.

5.2 Wheelchair Device

Satisfaction with performance in the PPW has been an important issue raised in other studies (Algood et al., 2003; Levy et al., 2004). In particular, direct comparison of the PPW and PWC has been identified as a significant gap in knowledge (Levy et al., 2004; Arva et al., 2001; Cooper et al., 2001). The current study was undertaken to identify whether individuals (who use both a MWC and PWC) would find their occupational performance in a PPW satisfactory when compared with the PWC. The HAAT model identifies the need to evaluate introduction of an assistive device from the perspective of *system performance* "that is a combination of the human, the activity being performed, the environment in which it is performed, and the assistive technology … being used" (Cook & Hussey, 2002, p. 36). Several measures were used to elucidate these components, as well as a composite evaluation system performance.

The Quebec User Evaluation of Satisfaction with assistive Technology (QUEST) considers participant satisfaction with the features of each wheelchair device, or the human-assistive technology interface (see Figure 11). There was no statistically significant difference in the *composite* satisfaction scores for the PWC and PPW, representing the mean values for all eight wheelchair attributes measured. A comparison of *component* scores indicated a relatively equal distribution between the two devices, with each wheelchair option scoring higher on four attributes. Durability, Safety & security, Ease of use, and Effectiveness were identified as more satisfactory with the PWC, while the PPW

Figure 11. HAAT model - QUEST



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received higher satisfaction ratings with respect to Weight, Comfort, Adjustability, and Dimensions. This corroborates other reports in the literature that the smaller size and portability of the PPW/MWC increases accessibility for the user (Buning & Schmeler, 1999; Leonard, 1992) whereas the PWC compensates for physical limitations, and provides freedom of movement leading to increased opportunity for community participation (Buning et al., 2001; Davies et al., 2003; Evans, 2000; Field, 1999; Miles-Tapping & MacDonald, 1994). The focus group responses indicated that many participants found their PWC too large and cumbersome for transporting to other locations or when entering a less accessible environment, and preferred the PPW/MWC for such situations. Conversely, participants identified convenience and efficiency as reasons for choosing the PWC device, and suggested it was physically easy to operate, allowing them to cover longer distances in a shorter period of time.

Several authors have identified individual evaluation of the relative advantages of each device as an important variable in the decision to adopt or reject one assistive device over another (Lenker & Paquet, 2003; Roelands, Van, Depoorter, & Buysse, 2002; Rogers, 1995). From this perspective, choice is based on the user's perception of device value in meeting their expectations, based on a cost-benefit measure. These relative advantages and disadvantages of each device highlight the difficulty wheeled mobility users have in deciding between a MWC and PWC (Bates et al., 1993; Buning et al., 2001; Cooper et al., 2002a; Field, 1999; Leonard, 1992; Miles-Tapping & MacDonald, 1994; Wiart et al., 2003). The focus group data summary indicated that study participants consider these individual advantages and disadvantages as part of their device evaluation, but not in isolation from the environmental and occupational context of their situation.

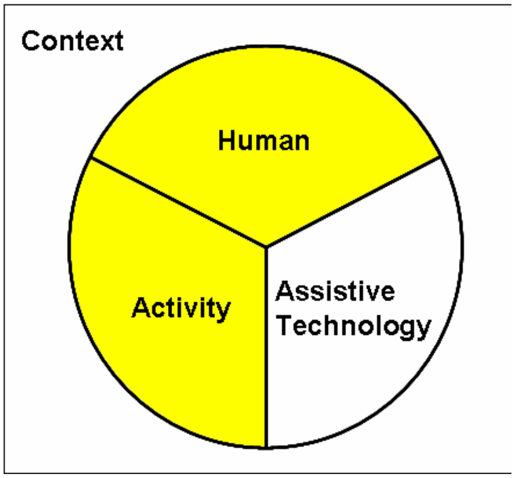
Ultimately, one attribute may outweigh all other factors (e.g., price; operation using one extremity versus two). Furthermore, personal preference in the real-life context may override any perceived benefits or limitations of the device.

5.3 Activity and Context

In addition to looking at the impact of the PPW on system performance using an assistive technology theoretical framework (i.e., HAAT model), it is also helpful to consider a more global perspective of use. The ICF model of health and function identifies the wheelchair as a contextual factor within the external environment, which accommodates for a person's impairment and enables participation. The QUEST, described previously, can serve to measure device attributes, in part, against the requirements of the user – the fit between environmental factors (i.e., the device) and body function and structure (i.e., impairment of the individual).

The Functioning Everyday with a Wheelchair (FEW) measure also evaluates features of the wheelchair device, but considers them in the context of Activity (see Figure 12). There is a focus placed on task performance, in a generic context (e.g., one question states: "The size, fit, postural support and functional features of my wheelchair/scooter allow me to operate it as independently, safely, and efficiently as possible"). This evaluation of task

Figure 12. HAAT model - FEW



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performance coincides with measurement at the Activity level of the ICF framework, and considers the congruence between Human and Activity within the HAAT model.

Section one of the FEW involved participants identifying the degree to which their wheelchair addressed personal needs or task demands. There was no statistically significant difference in participants' scoring of the two wheelchair devices. These results are consistent with the QUEST results previously mentioned. Participants found relative advantages and disadvantages of each wheelchair device specific to their individual needs and to the activity type. These advantages and disadvantages of each device had a tendency to offset one another, and generate an equivocal overall score. The sensitivity of the FEW to discriminate differences in user perception of person – activity fit at this level of detail may have been insufficient for this study.

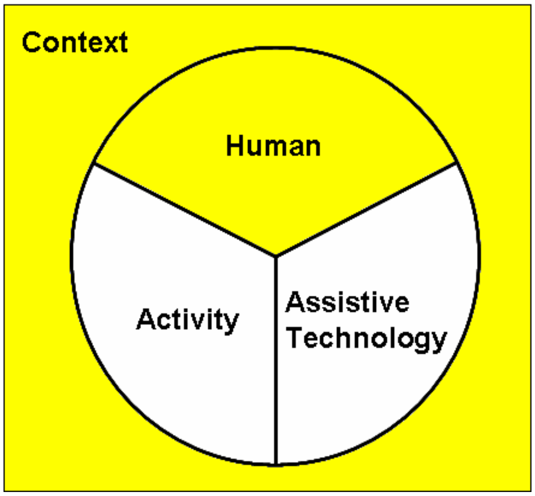
Section two of the FEW entailed a clinician (the investigator) assessing two types of activities – reaching tasks and performing transfers – in a predetermined environment (i.e., Activity level of the ICF). There was no statistically significant difference in the ability of participants to perform these tasks using the PPW and the PWC. All participants had used both a MWC and PWC for a substantial number of years, which may have contributed to this comparable performance. Cooper et al. (2001) found a similar outcome when comparing the PPW and participants' own MWC (which they were experienced in using). In addition, tasks in the current study were performed in a familiar and somewhat contrived environment (i.e., the participants' homes) – a factor that several authors identify as limiting true measurement of performance (Algood et al., 2004; Arva et al., 2001; Corfman et al., 2003; Levy et al., 2004). This would support the

ICF contention that measures of Participation need to evaluate performance within real life situations (World Health Organization, 2001).

The HAAT model identifies the need to consider social and cultural components as part of the context in which individuals perform their occupations. The relationship between device and individual is a reciprocal one, and the user's perception of self and what others think of self are important variables in measurement of system effectiveness (Bates et al., 1993; Buning et al., 2001; Fuhrer, 2001; Hocking, 1999; Scherer, 2002). The ICF also highlights the importance of considering social and cultural variables within the external context (e.g., how society views and interacts with the individual – the attitudinal environment) and internal context (e.g., unique perspective of individual evaluating the effectiveness of the wheelchair).

The Psychosocial Impact of Assistive Devices Scale (PIADS) was used to measure the degree to which the wheelchair device influenced participants' perception of self and disability (i.e., the Personal Factors component of the ICF), considering the fit between the person and the social context (see Figure 13). There was a significant difference in participants' scoring on the Self-Esteem subscale of the PIADS in favour of the PWC (p = .016). The total PIADS score and the Adaptability and Competence subscale scores were not

Figure 13. HAAT model - PIADS



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significantly different between participants' use of the PWC and the PPW. The small number of participants in the study may have contributed to this result, as a graphic interpretation did suggest a clinical difference in favour of the PWC. Buning et al. (2001) found higher PIADS scores for a PWC (compared with a MWC) in a small study with individuals transitioning between MWC and PWC use. Similarly, a small study, comparing use of a PWC versus a MWC among individuals with Multiple Sclerosis, found mean scores were lower for the MWC users on all subscales including Self-Esteem (Devitt et al., 2003). Furthermore, the Self-Esteem mean scores were lower than the other subscales – an observation consistent with the findings of the current study. It is not immediately clear why Self-Esteem was impacted more than the other subscales. The Self-Esteem subscale deals more directly with emotional response and self-perception, while the Adaptability and Competence subscales consider issues of independence, performance, enablement, and opportunity. It may be that, with the short study period, participant did not have sufficient time to feel confident in using the PPW. Items such as *Security* and *Frustration* also factor into the Self-Esteem subscale, and were specific issues raised during the focus groups as complications with PPW use.

Despite each device garnering preference for some attributes (as identified by the QUEST and FEW), participants measured these relative advantages against their performance in activities and occupations, and the resultant effect on personal and social experience. Rogers (1995), as well as proponents of Social Cognition models of AT use (Carr, 2004; Roelands et al., 2002), contend that decisions about device use are based in part on this comparison of relative advantages and perceived consequences. This would suggest that the benefits of the PWC identified in the QUEST and FEW may have had a greater bearing on overall system performance, and subsequent value in meeting participant expectations on a global Participation level.

Study participants indicated they had little concern about how the non-disabled community perceived their level of disability, and the suggestion that a PWC made them look ‘more disabled’ was of little concern. Some writers have suggested that consumers may view use of a PWC as an implication of greater disability, resulting in lower self-esteem (Bates et al., 1993; Buning et al., 2001; Buning & Schmeler, 1999; Buck et al., 2004; Karp, 1999). Somers and Wlodarczyk reported on a case study of a recently-injured man with C5/C6 tetraplegia, who felt the PPW "‘looked better’ than a power wheelchair" (2003, p. 26). These findings, however, frequently relate to new users of a PWC. The current study participants had all been long-time users of a PWC – an average of nearly seven years. It is possible that most, if not all, had sufficient time to deal with these initial responses to PWC use and were less inclined to factor perception of disability into the evaluation of their device. Evans (2000) found that MWC users in her study identified a *decrease* in self-perception of disability when transitioning from a MWC to a PWC. Interestingly, one participant in the current study did identify the PPW as beneficial in terms of ‘fitting in’ with other MWC users in the disabled community and allowed him to interact ‘at the same level’ as other MWC users (both literally and figuratively).

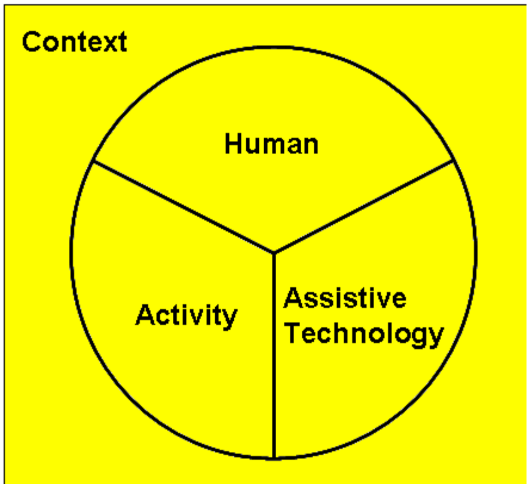
5.4 Participation

The HAAT model articulates that the ultimate measure of an assistive device is the *system performance* that results from the interaction of each component in the context of use, rather than the outcome of individual components (Cook & Hussey, 2002).

Similarly, the ICF identifies Participation as the ability to engage in activities and roles within a real world context, where the contextual factors sufficiently mediate impairments to body function and structure (World Health Organization, 2001). Evaluation of Participation should incorporate the user's perspective and focus on those activities that are relevant and meaningful to the individual. Regardless of the study participants' impressions of the PPW with respect to advantages and disadvantages, device preference seemed to relate to whether they could participate in specific activities effectively and satisfactorily.

The Canadian Occupational Performance Measure (COPM) addressed this evaluation of occupations in real life situations (see Figure 14). The COPM was used to measure participants' perception of Performance of their identified occupations (i.e., how well they did an activity), and their Satisfaction with the way they performed the activity. There was no statistically significant difference between the PPW and the PWC on either the Performance or Satisfaction scores of the COPM. However, six out of eight participants ranked the PWC higher than the PPW on Performance by at least 2 points while only one participant scored the PPW higher by at least 2 points. Differences of 2 points or greater are considered to be clinically significant (Law et al., 2005). The graphic presentation of the Performance

Figure 14. HAAT model - COPM



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scores suggests a trend toward better performance with the PWC, aside from one participant who scored the PPW much higher.

Satisfaction scores indicated a similar trend, but were not as dramatically different as the Performance scores. One participant continued to rate the PPW much higher than the PWC, while three participants rated Satisfaction as nearly equivalent. The remaining four participants scored the PWC higher than the PPW by at least 2.0 points, again suggesting a clinically significant difference. This ‘difference of degrees’ suggests that many study participants did not find performance and participation with the PPW equally comparable with the PWC, yet still found the PPW to be appealing despite these performance shortcomings. One consideration may be that over time, these Performance scores might increase as the user becomes more proficient with the PPW, and the user may potentially revise personal expectations (Fitzgerald et al., 2003). This would be consistent with the concept of relative advantage discussed earlier, and the belief that AT device adoption requires time and adaptation to reach fruition. Participants also identified the experience of using the PPW as exciting and enjoyable, particularly the feeling of accomplishment in physically propelling their wheelchair – “actually doing it.” This positive experiential component may have contributed to the smaller disparity in Satisfaction scores between the PWC and the PPW.

5.5 Application of the PPW

The focus group data identified that participants were excited about this alternative power mobility device, and appreciated some of its significant benefits compared with their PWC. The experience of contributing to their own mobility – the wheelchair being an extension of the person rather than a device ‘to ride in’ – was articulated. Participants reported the quality of their experience while performing occupations was enhanced, even if objective measures of performance were lower. Several pragmatic benefits of the PPW were highlighted as preferable to the PWC, confirming similar conclusions in the literature: physical exercise (Algood et al., 2004; Arva et al., 2001; Corfman et al., 2003; Levy & Chow, 2004); increased accessibility in the community (Algood et al., 2004); and improved transportability due to the smaller size and weight (Levy & Chow, 2004; Smith, 2004).

However, the majority of participants ultimately agreed they were not prepared to replace their PWC with the PPW. What they did indicate was the PPW provided the advantages of their MWC (i.e., mediating Environmental Factors), without many of the drawbacks that might discourage use of the MWC in favour of the PWC (e.g., less physically demanding to propel; easier to manage inclines and difficult surfaces; faster and more efficient). The result was improved performance at the Activity and Participation levels (i.e., improved occupational performance) and compensation for limitations and impairments of Body Functions and Structures. The MWC was still a necessity for study participants, as they had to deal with inaccessible and pseudo-accessible environments, yet the physical challenges of using the MWC were barriers to performance (Chaves et al., 2004). The exchange of their MWC for PPW was identified as a potential opportunity to address these barriers.

Many of the specific PPW advantages over the MWC identified by participants in this study are supported in the literature. The PPW is easier to push than a MWC (Arva et al., 2001; Cooper et al., 2001; Cooper et al., 2002a; Levy et al., 2004; Somers & Wlodarczyk, 2003), particularly on inclines and over difficult surfaces such as grass or carpet (Algood et al., 2004; Best et al., 2003; Chow et al., 2002; Levy et al., 2004), and users perceive it to be faster (Arva et al., 2001; Cooper et al., 2002a). Interestingly, Levy (2004) found that the actual time required to complete activities (albeit contrived ones in an artificial setting) was not different between the PPW and the MWC. It still remains unclear whether the PPW increases the speed of operation and consequently activity performance, or whether this is a perception of the user that reflects *easier* performance rather than *faster* performance. The particular activity chosen, by virtue of the task demands, may influence speed of performance. For example, some activities may not be dependent upon wheelchair propulsion speed (e.g., performing personal hygiene; cooking) while others inherently are (e.g., walking the dog; wheeling to the grocery store). Many of the study participants identify a willingness to explore new environments and opportunities with the PPW that they would not approach in their MWC. This perspective has also been reported in other studies where the PPW was introduced to MWC users for the first time (Levy et al., 2004; Somers & Wlodarczyk, 2003).

A number of concerns about the PPW were also raised by the current study group. Safe and effective braking was identified as an issue by many of the participants, particularly when descending a ramp. Cooper et al. (2001) found braking was not an issue, except when propelling the PPW backwards. It should be noted that a different model of PPW device was used in the latter study, incorporating an alternative method of electronic synchronization. Differences in PPW devices might contribute to different relative advantages and disadvantages, and ultimately individual user performance for specific occupations. Levy (2004) states some general cautions about operating a PPW on a decline, although no reference to research data is made. Participants in this study indicated the PPW required upper extremity coordination and a balanced push force to maintain a smooth and straight trajectory. Several studies also report these physical requirements (Best et al., 2003; Levy et al., 2004; Somers & Wlodarczyk, 2003). Participants in this study identified that the PPW still required a significant degree of strength to operate. Other studies have not reported this finding; however, such research typically involved individuals who are still exclusively MWC users or were non-disabled. It may be that participants' expectations of physical demands in other studies were greater, based on their personal experience (i.e., having normal strength; propelling a MWC on a daily basis; not having used a PWC for comparison). Participants in the current study already had a point of reference by which to compare MWC operation (i.e., a PWC that requires very little strength). As a result, they may have been more critical of *any* physical requirements for propulsion, or simply may not have possessed the strength to operate the PPW for every activity.

Greater difficulty in operating the PPW in the high-assist (high speed) mode was reported, similar to the findings of Best et al. (2003). Participants related this to issues of control and maintaining a coordinated, bilateral propelling technique. It was noted that the high-assist mode was difficult to manage indoors, where exaggerated adjustments or over-correction occurred too easily when trying to negotiate tight spaces, such as narrow corridors and doorways. Participants agreed that the low-assist mode was used with greater success in these situations. The limited range of the PPW compared with the PWC (due to shorter battery life) was identified, corroborating the findings of Cooper et al. (2001). The fact that the PPW increases the width and weight of the MWC presents some practical limitations to use – another issue identified in other PPW studies (Arva et al., 2000; Cooper et al., 2001; Corfman et al., 2003; Fitzgerald et al., 2003; Somers & Wlodarczyk, 2003). Finally, the cost of the PPW was raised as a barrier by study participants in congruence with reports by Levy and Chow (2004) as well as Somers and Wlodarczyk (2003).

Several participants suggested the PPW might be an excellent solution for those without a PWC; however, it should be noted these views were expressed from the perspective of long-term PWC users and represented speculation rather than personal experience. The transition from manual to power mobility has been explored in some detail in the literature, identifying the difficulty in making such a decision. The complexity identified in deciding between the manual and power options suggests that the PPW may be of use during this transition process, as an interim solution before individual switch to use of a PWC. One study participant did feel the PPW would provide a viable and, in fact, preferable alternative to her current power mobility device (a scooter).

5.6 Decision-Making Process

At the outset of this study, two hypotheses were proposed: “There will be no difference in satisfaction with occupational performance of user-identified tasks for individuals using PPW or PWC as measured using the QUEST, PIADS, COPM and FEW,” and “There will be no difference in measurable occupational performance for individuals using PPW or PWC as measured using COPM and FEW.” The use of a concurrent mixed-methods approach was beneficial in evaluating the results of these outcome measures. Given the exploratory nature of this study and the small *N*, it is not surprising that only one measure (the Self-Esteem subscale of the PIADS) reached statistical significance in identifying differences between the two devices. However, the PIADS and COPM measures suggested a clinically significant difference in favour of the PWC. The qualitative data from the focus groups was helpful in delineating these outcomes. Study participants identified attributes of both devices they found favourable and unfavourable, which reflected in equivocal results for the QUEST and FEW measures. It was only in consideration of these attributes within their own specified occupations, and through opportunity to trial each device in these contexts over time that participants were able to evaluate whether the PPW was comparable.

The study participants identified that, while each power mobility device offered some distinct advantages, there needed to be some adjustment made to the PPW to accommodate for the individual. The PPW was identified as being much easier to push than a MWC, but the trade-off for that advantage was sensitivity in power control, and the need to provide a uniform and coordinated push. For several participants, this meant fine-tuning the sensitivity of the PPW. The adjustability of the electronics in the PPW was seen as a benefit, but meant increased time and experimentation to find an optimal setting. Some participants needed minor modifications to the pushrims to provide greater friction (i.e., wrapping them with rubber tubing), while others had the on/off and speed control buttons augmented to improve access.

Not only did the PPW need to be modified for the user, but the user was also required to adjust to the demands of operating the device. Many participants identified a ‘learning curve’ in adjusting their operation of the PPW. This reciprocity, between adjustment of the device to the individual and adjustment by the individual to the device, is consistent with the HAAT model. Because the device-user interface requires such adjustment, there is a significant time commitment involved in obtaining a reasonable evaluation of performance. All participants had their device adjusted by the investigator and received instruction in use of the PPW prior to commencing phase one of the study. For some, this was completed in a single one-hour visit. Other participants required multiple visits and adjustments before they felt comfortable moving forwards into phase one. All study participants identified that it took at least a few days to feel competent in using the PPW, even after this initial visit, and some reported that three weeks was too short a time period to master use of the device or to participate in all of their identified occupations. Fitzgerald et al. (2003) suggested the two-week period used in their study (comparing MWC and PPW usage in the community) may not have been sufficient to uncover significant changes or allow participants to alter habits of use. Each stream in the current study was designed to last three weeks. Most PPW research studies occurred in a single testing session with a 5 – 15 minute period to acclimatize to the device (Algood et al., 2004; Arva et al., 2001; Best et al., 2003; Cooper et al., 2001; Cooper et al., 2002a; Corfman et al., 2003; Levy et al., 2004). One study had participants use the device for two weeks (Fitzgerald et al., 2003), while one case study followed an individual for a five week period in hospital (Somers & Wlodarczyk, 2003). A longer period of use in the current study would have added in the variable of winter climate (i.e., the last study participant finished at the first lasting snowfall). It would appear, from the participants' responses, that future studies should consider a longer period of use, or at least a longer period of adjustment before commencing evaluation.

This learning curve, adjustment process, and time-dependency are consistent with the developmental and acquisitional tenets of the HAAT model. Users of assistive technology must develop skills and aptitudes with the device, and this occurs through a process of experience and learning. Closely tied to this are the expectations of the user, both at the time of initial exposure and as they develop experiential knowledge of the device. This can be seen at a micro-level in another research study, where participant rating of PPW performance increased, and time for task completion decreased, between the first and third trials of the PPW device (Cooper et al., 2001).

For the participants in the current study, the process of evaluating their powered mobility devices (the PPW and the PWC) required evaluation of the device attributes, adjustment/readjustment of the device and the user, and evaluation/re-evaluation within the context and occupations of real life situations. This process requires a significant degree of time to employ and demands some expertise on the part of the device prescriber/provider. Evaluating or selecting a wheeled mobility device appears to be a much more complex process than one might expect.

The analogy of a miner panning for gold could be used to illustrate this endeavour. The miner’s pan represents the evaluative process. The aggregate the miner collects from the river bed is the specific wheelchair device. The device is composed of more desirable and less desirable features (i.e., gold nuggets and sludge). Viewed in isolation (i.e., without the benefit of evaluation in the context and occupations of interest), it is very difficult for the miner to pick out anything valuable regardless of how much the aggregate is swirled in the pan. When the pan is introduced into the river water (i.e., the activities and environment of use) and the contents are churned, the less desirable components can be modified and flushed out, while retaining the enabling features. This is not a singular process, where the aggregate is simply sifted through a filter or screen. Rather, with each adjustment, the system is reintroduced into the environment in an iterative process, until ultimately the miner reaches a conclusion. The miner may find their nugget of gold (i.e., a device that provides a satisfactory fit) or an empty pan, in which case they seek out a new mound of aggregate (i.e., another potential device).

5.7 Limitations

Several limitations of this research study should be identified. The small sample size increased the possibility of a type II error, that differences between the PWC and PPW scores that truly exist were not uncovered. The use of nonparametric data analysis, required because of the small sample size and ordinal type data, also contributed to this possibility. This study was designed as exploratory, and consequently the results should not be broadly generalized. The heterogeneity of the participant group may have made it more difficult to find common results and experiences related to functional ability. More than half of participants ($N = 5$) owned a wheelchair that did not have quick-release axles, and therefore could not accommodate the PPW wheels. Consequently, they used a wheelchair provided by the investigator. While the wheelchair provided was of a superior quality, this may have affected their experience, and therefore their performance and satisfaction ratings.

The time period for use of the PPW was three weeks; this may not have been a sufficient period of time to acclimatize to the PPW and achieve effective operation. A longer trial period may have resulted in a better reference point for evaluation of performance. The three week period did not offer an opportunity for all participants to participate in all of the occupations they identified with both the PPW and the PWC (i.e., only 22 out of 30 occupations identified were included in the data analysis). A longer trial period may have increased the amount of data collected and could have impacted on the quantitative results.

5.8 Recommendations and Future Study

The results of the current research study may provide some valuable insight for clinicians prescribing PPW, as well as the developers of PPW technology. There are indications that some individuals may be better suited to using the PPW than others. Over time, people seem to develop a comfort and familiarity with their PWC device, and express a hesitance to concede the convenience and ease of using their PWC. In addition, the more they use their PWC (compared to their MWC), the more this reluctance seems to emerge. The PPW might be best introduced early on, before an individual becomes accustomed to using a PWC exclusively. The current study does lend credence to the concept of using PPW during a ‘transition’ period, where a MWC user experiences difficulty with propulsion and occupational performance, but does not want to convert to the use of a PWC. Among individuals who are dual users, the PPW may be more appropriate for those who avail their MWC more predominantly. Consideration should also be given to individuals who identify the PWC as having a negative impact on perceptions of disability.

Some aspects of the individual’s health condition may also influence successful use of the PPW. The ability to engage the pushrims effectively and provide a push that is smooth and coordinated (both unilaterally and bilaterally) seems to be critical. To a lesser extent, a degree of strength and endurance is also required. When practicing with the PPW, clinicians should pay particular attention to managing declines and braking the wheelchair, as these are particularly challenging maneuvers. Consideration should be made to the activities in which an individual chooses to participate. Individuals who anticipate transporting their wheelchair (particularly by car) may be more satisfied with the PPW, as well as those who travel by plane and want to bring their wheelchair along.

Therapists should consider several factors during the PPW evaluation process. The PPW does provide a degree of adjustability, and clinicians should exploit the features that can be modified. The user's initial experience may not be a reflection of optimal PPW performance, and sufficient experimentation with different adjustments is imperative. This process does require the clinician (or vendor) to have sufficient familiarity and expertise with the PPW technology. Therapists should also be aware that more than one PPW device is available, and that not all users may be best suited for one product. An integral part of the PPW evaluation is provision of adequate information and appropriate expectations. Clinicians should inform potential PPW users that effective performance requires adjustment of both the device and user, and that there is a 'learning period' that requires both time and patience. In addition, the activities and environments in which the individual plans to participate are difficult to simulate, and the evaluation process should optimally occur in the actual context.

Several suggestions for advancement of the PPW technology should be highlighted. With the advancement of electronics and composite materials, a reduction in the weight and width of the PPW wheels should be anticipated. Participants expressed a desire for greater battery capacity, to allow a longer period of use between charging. Some participants suggested better access to the on/off and power setting buttons (a remote control feature was introduced by the PPW distributor during the course of the study and was not available to the participants). Participants also applauded the existing adjustability features, and indicated expansion of these options. Specifically, more alternatives to the starting, degree of assist, and after-running parameters are desirable, as well as greater flexibility in combining these three parameter adjustments. The ability to electronically synchronize asymmetrical force applications on the pushrims would address some of the control issues expressed by participants. Further advancement in the electronic components might allow the PPW device to incorporate some ‘learning effect’ based on the performance of the specific user, to accommodate for individual differences and limitations. Alternately, providing some function-specific modes of operation (e.g., driving in a straight line; ascending or descending a ramp; negotiating confined spaces) with the appropriate electronic adjustment might provide better performance for users. Finally, braking (particularly in emergent situations and while descending a ramp) has been perceived as inadequate by some study participants, noting the force required to stop the PPW was greater than the user was able to produce comfortably. Some adaptation to provide efficient braking, particularly when the PPW is subject to additional acceleration (i.e., gravity), would be welcomed.

The results of this study raise a variety of questions that warrant further investigation. The study participants identified a number of relative advantages and disadvantages of the PWC and PPW devices; however, the ultimate decision of choice placed greater weight on some attributes over others. Exploration of the relative importance consumers place on these attributes would be of value.

Some specific attributes of PPW use are of particular interest. Transportability of the PPW was identified as an appealing feature compared with the PWC. The issue of dismantling and loading the PPW into a vehicle would feature highly in a consumer's choice to purchase, either as an incentive (e.g., for the PWC user who cannot easily transport their device) or a disincentive (e.g., for the MWC user who may have more difficulty disassembling and lifting the PPW components). An objective measure of this procedure, and whether it can be performed independently or with assistance from a caregiver, is worthy of investigation. Participants in this study, as well as other studies, perceived the PPW to be faster than a MWC, and that individuals are able to perform occupations more quickly in the PPW. It is not clear, however, whether this perception is based on tasks being completed with greater ease (i.e., efficiently) or more quickly (i.e., expediently). Evaluation of effort and time in activity performance, as well as activity type and level of impairment, might shed light on this experience.

Participants identified their experience using the PPW as exciting and enjoyable, even though they may not have identified their performance of occupations as better than the PWC. They highlighted the sense of accomplishment that came from physically contributing to propulsion of the wheelchair, and the more interactive nature of their experience in performing occupations versus the PWC. Further exploration of this subjective experience might shed light on how much this contributes to rating of satisfaction, and whether this decreases with time as the novelty of the device diminishes.

Participants identified time as a crucial factor in fully evaluating the PPW device. A number of time-related variables should be explored further. It would be useful to inquire how much time is required for individuals to feel comfortable with the PPW, and to achieve some mastery of operation. In addition, it would be interesting to identify whether performance and satisfaction scores change over time, and if so, whether these changes relate to improved skill or modification of user expectations. With a longer trial period, it would be easier to capture the types and number of new activities and environments that users might attempt with the PPW.

Participants in the current study indicated that the adjustability of the PPW was beneficial in meeting individual user needs. Further exploration of how specific electronic and performance adjustments of the PPW address different physical limitations would benefit both prescribers and consumers. The comments and experiences of study participants suggested there may be differences between the performance attributes of the PPW used in the current study and PPWs used in other research studies. Comparison of performance characteristics and features between different PPW types and models (e.g., synchronization of wheels) would also help in guiding prescription of the most appropriate device for individual consumers.

At the outset of the study, it was suggested that climate plays a critical role in community participation for wheelchair users. By intention, the study precluded use of the PPW during winter months to optimize performance. Further study should be made of how climate, specifically snow and cold weather, impact on the satisfaction and performance evaluation of the different wheelchair configurations compared with use in warm weather months. In particular, evaluation of PPW performance in snow and slush would be a great value.

Participants indicated the PPW provided a variety of advantages over the traditional MWC and even suggested they might be willing to attempt new and different activities with the PPW that they currently do not perform in their MWC. Future study should be undertaken to compare measures of performance and community participation between PPW and MWC use, particularly among individuals who identify difficulty with MWC propulsion. Further study is required to delineate which individuals are better candidates for PPW use. There appears to be some indication that individuals who spend a greater percentage of time using the MWC versus the PWC rate their performance and satisfaction higher with the PPW. Future study should explore whether the PPW is more appropriate for individuals who use their MWC predominantly versus their PWC. As well, the timing for introduction of the PPW is also worthy of further study. Some participants identified regret that they did not have sufficient opportunity to master MWC prior to the introduction of their PWC and others suggested it was “too late” to look at alternatives to their PWC as they had become too accustomed to its use. Earlier introduction to the PPW option may, in fact, delay the transition to the PWC. Finally, a closer examination of the type and degree of impairment among users, and the relationship to PPW use, merits investigation.

6.0 SUMMARY

A variety of outcome measures were used to evaluate the impact of the PPW on occupational performance and satisfaction with community participation for the study participants. During the period when participants used the PPW rather than their PWC, there was no statistically significant difference in their level of participation in identified occupations; the number of hours spent using a powered wheelchair; or the total number of hours spent in either a manual or powered wheelchair. Community participation patterns and habits did not appear to be impacted by the introduction of the PPW.

The QUEST results, measuring satisfaction with device attributes, indicated participants found the PWC more effective, durable, safe and secure, and was easier to use; while the PPW was smaller and lighter and provided greater adjustability and comfort. These relative advantages of each device were offsetting, and there was no statistically significant difference in the overall score between the two. The FEW identified similar results, with offsetting relative advantages in task performance for each device, and no statistically significant difference in total score between them. The external evaluation of participant performance in activities using each device (i.e., FEW section two) also resulted in no statistically significant difference between the PWC and the PPW.

Quality of life and the impact of wheelchair device in the social context was measured using the PIADS. Scores on the Self-Esteem subscale were significantly higher when using the PWC, and clinically superior on the total PIADS score as well as the Adaptability and Competence subscales. There was no evidence to suggest that use of the

PWC for study participants increased either their self-perception of disability or their perception of how disabled others thought them to be.

Participants were able to use the PPW to perform occupations they typically did in a PWC. The COPM was used to evaluate their performance and satisfaction with performing these activities. There was no statistically significant difference in COPM scores for either Performance or Satisfaction; however, a clinically significant difference was suggested. A large proportion of participants identified higher performance scores for the PWC, and the focus group data supported this perspective. One participant reported a preference for the PPW, but most indicated they would not want to replace their PWC with a PPW. Satisfaction scores were higher for the PWC in most cases, but less dramatically than Performance. This was also supported by participants' comments suggesting many positive attributes of the PPW, particularly in comparison with their MWC. Rather than replacing the PWC for all of their identified activities, participants indicated the PPW improved upon the MWC by retaining the advantages and compensating for its shortcomings. As a result, participants expressed a willingness to try more (and new) activities, including some that might have been previously performed with the PWC.

Participants also identified some limitations of the PPW that they felt should be addressed. This included the high demand for coordinated bilateral propulsion (particularly in the high-assist mode); challenges in controlled braking particularly on a descent; the limited time/distance traveled before recharging; an increased in width compared to the MWC configuration; and the high cost of purchase.

The process by which participants evaluate (and ultimately choose) a wheelchair is a highly complex one and reflects more than comparing attributes of one device over another. The performance of the device within the actual context of use, and the subjective experience of the user in performing those occupations, are carefully measured against expectations. The evaluative process is an iterative one, requiring both adjustment of the device to the user and user to the device. Furthermore, this process requires sufficient expertise in the prescriber and adequate time using the wheelchair device to accurately evaluate the outcome.

REFERENCES

Abraham-Murali, L., Kane, W., & Staples, C. (2001). Perceptual criteria and attributes used for evaluation of clothing by women using wheelchairs. *Perceptual and Motor Skills, 93,* 727-733.

Aissaoui, R., Arabi, H., Lacoste, M., Zalzal, V., & Dansereau, J. (2002). Biomechanics of manual wheelchair propulsion in elderly: System tilt and back recline angles. *American Journal of Physical Medicine and Rehabilitation, 81,* 94-100.

Algood, D., Cooper, R. A., Boninger, M. L., Cooper, R., Ambrosio, F., Hoover, A. et al. (2003). Stroke frequency and excursion differences between manual wheelchair propulsion and pushrim activated power assisted propulsion among persons with tetraplegia. In *RESNA 26th International Annual Conference* RESNA Press.

Algood, D., Cooper, R. A., Boninger, M. L., Cooper, R. C., Ambrosio, F., Reeves, S. A. et al. (2002). Physiological comparison of a pushrim activated power assist wheelchair and traditional manual wheelchair propulsion among persons with tetraplegia. In R. Simpson (Ed.), *RESNA 25th International Conference* (pp. 285-287). Arlington, VA: RESNA Press.

Algood, S. D., Cooper, R. A., Fitzgerald, S. G., Cooper, R., & Boninger, M. L. (2004). Impact of a pushrim-activated power-assisted wheelchair on the metabolic demands, stroke frequency, and range of motion among subjects with tetraplegia. *Archives of Physical Medicine and Rehabilitation, 85,* 1865-1871.

Arva, J., Cooper, R. A., Spaeth, D. M., Corfman, T. A., Fitzgerald, S. G., & Boninger, M. L. (2003). *User power reduction in Yamaha JWII pushrim activated power assisted wheelchair*. Retrieved May 1, 2004 from http://www.wheelchairnet.org/WCN_WCU/SlideLectures/Lectures/lectures.html.

Arva, J., Fitzgerald, S. G., Cooper, R. A., & Boninger, M. L. (2001). Mechanical efficiency and user power requirement with a pushrim activated power assisted wheelchair. *Medical Engineering and Physics, 23,* 699-705.

Arva, J., Fitzgerald, S. G., Cooper, R. A., Corfman, T. A., Spaeth, D. M., & Boninger, M. L. (2000). *Physiologic comparison of Yamaha JWII power assisted and traditional manual wheelchair propulsion*. Proceedings of the 2000 Annual RESNA Conference, RESNA Press.

Bain, B. K. & Leger, D. (1997). *Assistive technology: An interdisciplinary approach*. New York: Churchill Livingstone Inc.

Barrett, L. & Kielhofner, G. (2003). Theories derived from occupational behavior perspectives. In E.B.Crepeau, E. S. Cohn, & B. A. Boyt Schell (Eds.), *Willard &*

Spackman's occupational therapy (10 ed., pp. 209-212). Philadelphia: Lippincott Williams & Wilkens.

Bates, P. S., Spencer, J. C., Young, M. E., & Rintala, D. H. (1993). Assistive technology and the newly disabled adult: Adaptation to wheelchair use. *American Journal of Occupational Therapy, 47,* 1014-1021.

Bauer, S. M., Lane, J. P., Stone, V. I., & Unnikrishnan, N. (1998). The voice of the customer--Part 2: Benchmarking battery chargers against the Consumer's Ideal Product. *Assistive Technology, 10,* 51-60.

Best, K. L., Kirby, R. L., & Smith, C. (2003). Comparison of a pushrim-activated power-assisted wheelchair and a manual wheelchair on the Wheelchair Skills Test. In *RESNA 26th International Annual Conference* RESNA Press.

Boninger, M. L., Baldwin, M., Cooper, R. A., Koontz, A., & Chan, L. (2000). Manual wheelchair pushrim biomechanics and axle position. *Archives of Physical Medicine and Rehabilitation, 81,* 608-613.

Boninger, M. L., Cooper, R. A., Shimada, S. D., & Rudy, T. E. (1998). Shoulder and elbow motion during two speeds of wheelchair propulsion: A description using a local coordinate system. *Spinal Cord, 36,* 418-426.

Boninger, M. L., Souza, A. L., Cooper, R. A., Fitzgerald, S. G., Koontz, A. M., & Fay, B. T. (2002). Propulsion patterns and pushrim biomechanics in manual wheelchair propulsion. *Archives of Physical Medicine and Rehabilitation, 83,* 718-723.

Bosch, J. (1995). *The reliability and validity of the Canadian Occupational Performance Measure.* Unpublished Masters Thesis, McMaster University, Hamilton, Ontario, Canada.

Bottos, M., Bolcati, C., Sciuto, L., Ruggeri, C., & Feliciangeli, A. (2001). Powered wheelchairs and independence in young children with tetraplegia. *Developmental Medicine and Child Neurology, 43,* 769-777.

Brandt, A., Iwarsson, S., & Stahle, A. (2003). Satisfaction with rollators among community-living users: A follow-up study. *Disability and Rehabilitation, 25,* 343-353.

Brandt, A., Iwarsson, S., & Stahle, A. (2004). Older people's use of powered wheelchairs for activity and participation. *Journal of Rehabilitation Medicine, 36,* 70-77.

Bromley, B. E. (2001). Assistive technology assessment: A comparative analysis of five models. In *Technology And Persons With Disabilities Conference 2001* California State University Northridge.

Buning, M. E., Angelo, J. A., & Schmeler, M. R. (2001). Occupational performance and the transition to powered mobility: A pilot study. *American Journal of Occupational Therapy, 55,* 339-344.

Buning, M. E. & Schmeler, M. R. (1999). Effects of the transition to powered mobility on occupational performance. In *The proceedings of the RESNA Annual Conference* Retrieved May 1, 2004 from http://www.wheelchairnet.org/WCN_WCU/ SlideLectures/MEB/EffectsofTransition.pdf.

Burke, J. P. (2003). Philosophical basis of human occupation. In P.Kramer, J. Hinojosa, & C. Brasic Royeen (Eds.), *Perspectives in human occupation: Participation in life* (pp. 32-44). Philadelphia: Lippincott Williams & Wilkens.

Carey, M. A. (1994). The group effect in focus groups: Planning, implementing, and interpreting focus group research. In J.M.Morse (Ed.), *Critical issues in qualitative research methods* (pp. 225-241). Thousand Oaks, CA: Sage Publishing, Inc.

Carlson, D. & Myklebust, J. (2002). Wheelchair use and social integration. *Topics in Spinal Cord Injury Rehabilitation, 7,* 28-46.

Carr, V. H. (2004). *Technology adoption and diffusion*. U.S. National Library of Medicine. Retrieved November 24, 2004 from http://collab.nlm.nih.gov/ tutorialspublicationsandmaterials/sourcebook/adoptiondiffusion.html.

Carswell, A., McColl, M. A., Baptiste, S., Law, M., Polatajko, H., & Pollock, N. (2004). The Canadian Occupational Performance Measure: A research and clinical literature review. *Canadian Journal of Occupational Therapy, 71,* 210-222.

Chaves, E. S., Boninger, M. L., Cooper, R., Fitzgerald, S. G., Gray, D. B., & Cooper, R. A. (2004). Assessing the influence of wheelchair technology on perception of participation in spinal cord injury. *Archives of Physical Medicine and Rehabilitation, 85,* 1854-1858.

Chow, J. W., Tillman, M. D., Levy, C. E., Mann, W. C., Hanson, C. S., & Donohue, T. J. (2002). Electromyographic comparison of wheelchair propulsion using manual and power-assisted chairs. *Medicine & Science in Sports & Exercise, 34,* S90.

Christiansen, C. & Baum, C. (1997). Person-environment occupational performance: A conceptual model for practice. In C.Christiansen & C. Baum (Eds.), *Occupational therapy: Enabling function and well-being* (2nd ed., pp. 47-70). Thorofare, NJ: SLACK Incorporated.

Clifford, M. (2002). *Step 1: Designing focus group questions*. North Central Regional Educational Laboratory. Retrieved January 3, 2005 from http://www.ncrel.org/ info/notes/fall02/step1.htm.

Cook, A. M. & Hussey, S. M. (2002). *Assistive technologies: Principles and practice*. (2nd ed.) St. Louis: Mosby, Inc.

Cooper, R. A. & Cooper, R. (2003). *Trends and issues in wheeled mobility technologies*. Retrieved October 10, 2003 from http://www.ap.buffalo.edu/idea/space% 20workshop/Papers/WEB%20-%20Trends_Iss_WC%20(Cooper).htm.

Cooper, R. A., Corfman, T. A., Fitzgerald, S. G., Boninger, M. L., Spaeth, D. M., Ammer, W. et al. (2002a). Performance assessment of a pushrim-activated power-assisted wheelchair control system. *IEEE Transactions on Control Systems Technology, 10,* 121-126.

Cooper, R. A., Fitzgerald, S. G., Boninger, M. L., Prins, K., Rentschler, A. J., Arva, J. et al. (2001). Evaluation of a pushrim-activated, power-assisted wheelchair. *Archives of Physical Medicine and Rehabilitation, 82,* 702-708.

Cooper, R. A., Thorman, T., Cooper, R., Dvorznak, M. J., Fitzgerald, S. G., Ammer, W. et al. (2002b). Driving characteristics of electric-powered wheelchair users: How far, fast, and often do people drive? *Archives of Physical Medicine and Rehabilitation, 83,* 250-255.

Corfman, T. A., Cooper, R. A., Boninger, M. L., Koontz, A. M., & Fitzgerald, S. G. (2003). Range of motion and stroke frequency differences between manual wheelchair propulsion and pushrim-activated power-assisted wheelchair propulsion. *Journal of Spinal Cord Medicine, 26,* 135-140.

Crepeau, E. B. & Boyt Schell, B. A. (2003). Theory and practice in occupational therapy. In E.B.Crepeau, E. S. Cohn, & B. A. Boyt Schell (Eds.), *Willard & Spackman's occupational therapy* (10th ed., pp. 203-208). Philadelphia: Lippincott Williams & Wilkens.

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage Publications, Inc.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches*. (2nd ed.) Thousand Oaks, CA: Sage Publications, Inc.

Cup, E. H., Scholte op Reimer, W. J., Thijssen, M. C., & van Kuyk-Minis, M. A. (2003). Reliability and validity of the Canadian Occupational Performance Measure in stroke patients. *Clinical Rehabilitation, 17,* 402-409.

Davies, A., De Souza, L. H., & Frank, A. O. (2003). Changes in the quality of life in severely disabled people following provision of powered indoor/outdoor chairs. *Disability & Rehabilitation, 25,* 286-290.

Day, H. & Jutai, J. (1996a). Measuring the Psychosocial Impact of Assistive Devices: The PIADS. *Canadian Journal of Rehabilitation, 9,* 159-168.

Day, H. & Jutai, J. (1996b). *PIADS: The Psychosocial Impact of Assistive Devices Scale (Version 4.2.1)*. London, Ontario: University of Western Ontario.

Day, H., Jutai, J., & Campbell, K. A. (2002). Development of a scale to measure the psychosocial impact of assistive devices: Lessons learned and the road ahead. *Disability & Rehabilitation, 24,* 31-37.

Day, H. Y., Jutai, J., Woolrich, W., & Strong, G. (2001). The stability of impact of assistive devices. *Disability & Rehabilitation, 23,* 400-404.

Demers, L., Weiss-Lambrou, R., & Ska, B. (2002). The Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST 2.0); An overview and recent progress. *Technology and Disability, 14,* 101-105.

Demers, L., Wessels, R., Weiss-Lambrou, R., Ska, B., & De Witte, L. P. (1999). An international content validation of the Quebec User Evaluation of Satisfaction with assistive Technology (QUEST). *Occupational Therapy International, 6,* 159-175.

Demers, L., Monette, M., Lapierre, Y., Arnold, D. L., & Wolfson, C. (2002). Reliability, validity, and applicability of the Quebec User Evaluation of Satisfaction with assistive Technology (QUEST 2.0) for adults with multiple sclerosis. *Disability & Rehabilitation, 24,* 21-30.

Demers, L., Weiss-Lambrou, R., & Ska, B. (1996). Development of the Quebec User Evaluation of Satisfaction with assistive Technology (QUEST). *Assistive Technology, 8,* 3-13.

Demers, L., Weiss-Lambrou, R., & Ska, B. (2000a). Item analysis of the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST). *Assistive Technology, 12,* 96-105.

Demers, L., Weiss-Lambrou, R., & Ska, B. (2000b). *Quebec User Evaluation of Satisfaction with assistive Technology (QUEST Version 2.0) - An outcome measure for assistive technology devices*. Webster: Institute for Matching Person & Technology.

Depoy, E. & Gitlow, L. (2001). A model of evidence-based practice for occupational therapy. In L.W.Pedretti & M. B. Early (Eds.), *Occupational therapy: Practice skills for physical dysfunction* (5 ed., pp. 58-68). St. Louis: Mosby, Inc.

Devitt, R., Chau, B., & Jutai, J. W. (2003). The effect of wheelchair use on the quality of life of persons with multiple sclerosis. *Occupational Therapy in Health Care, 17,* 63-79.

Edyburn, D. L. (2001). Models, theories, and frameworks: Contributions to understanding special education technology. *Special Education Technology Practice, 4,* 16-24.

Engel, P. & Hildebrandt, G. (1974). Wheelchair design - technological and physiological aspects. *Proceedings of the Royal Society of Medicine, 67,* 409-413.

Evans, R. (2000). The effect of electrically powered indoor/outdoor wheelchairs on occupation: A study of users' views. *British Journal of Occupational Therapy, 63,* 547-553.

Fay, B. T. & Boninger, M. L. (2002). The science behind mobility devices for individuals with multiple sclerosis. *Medical Engineering and Physics, 24,* 375-383.

Field, D. (1999). Powered mobility: A literature review illustrating the importance of a multifaceted approach. *Assistive Technology, 11,* 20-33.

Fitzgerald, S. G., Arva, J., Cooper, R. A., Dvorznak, M. J., Spaeth, D. M., & Boninger, M. L. (2003). A pilot study on community usage of a pushrim-activated, power-assisted wheelchair. *Assistive Technology, 15,* 113-119.

Frank, A. O., Ward, J., Orwell, N. J., McCullagh, C., & Belcher, M. (2000). Introduction of a new NHS electric-powered indoor/outdoor chair (EPIOC) service: Benefits, risks and implications for prescribers. *Clinical Rehabilitation, 14,* 665-673.

Fuhrer, M. J. (2001). Assistive technology outcomes research: Challenges met and yet unmet. *American Journal of Physical Medicine and Rehabilitation, 80,* 528-535.

Fuhrer, M. J., Jutai, J. W., Scherer, M. J., & DeRuyter, F. (2003). A framework for the conceptual modelling of assistive technology device outcomes. *Disability & Rehabilitation, 25,* 1243-1251.

Glaser, R. M., Sawka, M. N., Brune, M. F., & Wilde, S. W. (1980). Physiological responses to maximal effort wheelchair and arm crank ergometry. *Journal of Applied Physiology, 48,* 1060-1064.

Glass, T. A., de Leon, C. M., Marottoli, R. A., & Berkman, L. F. (1999). Population based study of social and productive activities as predictors of survival among elderly Americans. *British Medical Journal, 319,* 478-483.

Hassard, T. H. (1991). *Understanding biostatistics*. St. Louis: Mosby - Year Book, Inc.

Hocking, C. (1999). Function or feelings: Factors in abandonment of assistive devices. *Technology and Disability, 11,* 3-11.

Hoenig, H., Landerman, L. R., Shipp, K. M., & George, L. (2003). Activity restriction among wheelchair users. *Journal of the American Geriatrics Society, 51,* 1244-1251.

Holm, M. B. (2004). Measuring the impact of the environment on function: Outcome measures using Activity/Participation performance qualifiers. In *10th North*

American Collaborating Center Conference on ICF January 6, 2004, Halifax, Nova Scotia.

Holm, M. B. (2005). Wheelchair outcome tool briefs: Functioning Everyday with a Wheelchair - Capacity (FEW-C) and Performance (FEW-P). *International Journal of MS Care, 7,* 111-114.

Jedeloo, S., De Witte, L. P., Linssen, B. A., & Schrijvers, A. J. (2002). Client satisfaction with service delivery of assistive technology for outdoor mobility. *Disability and Rehabilitation, 24,* 550-557.

Jutai, J. (1999). Quality of life impact of assistive technology. *Rehabilitation Engineering, 14,* 2-7.

Jutai, J. & Day, H. (2002). Psychosocial Impact of Assistive Devices Scale (PIADS). *Technology and Disability, 14,* 107-111.

Kreutz, D. & Johnson-Taylor, S. (2002). Wheelchair mobility. In D.A.Olson & F. DeRuyter (Eds.), *Clinician's guide to assistive technology* (pp. 311-329). St. Louis: Mosby, Inc.

Krueger, R. A. & Casey, M. A. (2000). *Focus groups: A practical guide for applied research*. (3rd ed.) Thousand Oaks, CA: Sage Publications, Inc.

Law, M., Baptiste, S., Carswell, A., McColl, M., Polatajko, H., & Pollock, N. (1998). *Canadian Occupational Performance Measure (3rd ed.)*. Ottawa, Ontario: CAOT.

Law, M., Baptiste, S., Carswell, A., McColl, M., Polatajko, H., & Pollock, N. (2005). *Canadian Occupational Performance Measure (4th ed.)*. Ottawa: CAOT Publications ACE.

Law, M., Cooper, B., Strong, S., Stewart, D., Rigby, P., & Letts, L. (1996). The Person-Environment-Occupation Model: A transactive approach to occupational therapy. *Canadian Journal of Occupational Therapy, 63,* 9-23.

Law, M. & Stewart, D. (1996). *Test retest reliability of the COPM with children*. Masters thesis, McMaster University School of Rehabilitation Science.

Lenker, J. A. & Jutai, J. (2002). Assistive technology outcomes research and clinical practice: What role for ICF? In *The 8th North American Collaborating Center Conference on ICF* June 2-4, 2002, Toronto, Canada.

Lenker, J. A. & Paquet, V. L. (2003). A review of conceptual models for assistive technology outcomes research and practice. *Assistive Technology, 15,* 1-15.

Leonard, R. B. (1992). A Question of Power. *TeamRehab Report,* 22-23.

Levins, S. M., Redenbach, D. M., & Dyck, I. (2004). Individual and societal influences on participation in physical activity following spinal cord injury: A qualitative study. *Physical Therapy, 84,* 496-509.

Levy, C. E. & Chow, J. W. (2004). Pushrim-activated power-assist wheelchairs: Elegance in motion. *American Journal of Physical Medicine and Rehabilitation, 83,* 166-167.

Levy, C. E., Chow, J. W., Tillman, M. D., Hanson, C., Donohue, T., & Mann, W. C. (2004). Variable-ratio pushrim-activated power-assist wheelchair eases wheeling over a variety of terrains for elders. *Archives of Physical Medicine and Rehabilitation, 85,* 104-112.

Madriz, E. (2000). Focus groups in feminist research. In N.K.Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed., pp. 835-850). Thousand Oaks, CA: Sage Publications, Inc.

Manns, P. J. & Chad, K. E. (2001). Components of quality of life for persons with a quadriplegic and paraplegic spinal cord injury. *Qualitative Health Research, 11,* 795-811.

Martel, G., Noreau, L., & Jobin, J. (1991). Physiological responses to maximal exercise on arm cranking and wheelchair ergometer with paraplegics. *Paraplegia, 29,* 447-456.

McClain, L., Medrano, D., Marcum, M., & Schukar, J. (2000). A qualitative assessment of wheelchair users' experience with ADA compliance, physical barriers, and secondary health conditions. *Topics in Spinal Cord Injury Rehabilitation, 6,* 99-118.

McColl, M. A., Paterson, M., Davies, D., Doubt, L., & Law, M. (2000). Validity and community utility of the Canadian Occupational Performance Measure. *Canadian Journal of Occupational Therapy, 67,* 22-30.

McConnell, T. J., Horvat, M. A., Beutel-Horvat, T. A., & Golding, L. A. (1989). Arm crank versus wheelchair treadmill ergometry to evaluate the performance of paraplegics. *Paraplegia, 27,* 307-313.

McNamara, C. (1999). *Basics of conducting focus groups*. Retrieved March 1, 2005 from http://www.mapnp.org/library/evaluatn/focusgrp.htm.

Medvescek, C. (2003). Power assist: Add more 'oomph' to your push. *Quest, 10*.

Meyers, A. R., Anderson, J. J., Miller, D. R., Shipp, K., & Hoenig, H. (2002). Barriers, facilitators, and access for wheelchair users: substantive and methodologic lessons from a pilot study of environmental effects. *Social Science and Medicine, 55,* 1435-1446.

Miles-Tapping, C. (1996). Power wheelchairs and independent life styles. *Canadian Journal of Rehabilitation, 10,* 137-145.

Miles-Tapping, C. & MacDonald, L. J. (1994). Lifestyle implications of power mobility... electric wheelchair and scooter users. *Physical and Occupational Therapy in Geriatrics, 12,* 31-49.

Mills, T., Holm, M. B., Schmeler, M., Trefler, E., Fitzgerald, S., Boninger, M. et al. (2002a). The Functional Evaluation in a Wheelchair (FEW) instrument: Test-retest reliability and cross-validation with consumer goals. In *Technology & disability: Research, design, practice, and policy* (pp. 245-247). Arlington, VA: RESNA Press.

Mills, T., Holm, M. B., Trefler, E., Schmeler, M., Fitzgerald, S., & Boninger, M. (2002b). Development and consumer validation of the Functional Evaluation in a Wheelchair (FEW) instrument. *Disability and Rehabilitation, 24,* 38-46.

Morgan, D. L. (1998). *The focus group guidebook.* Thousand Oaks, CA: SAGE Publications.

National Organization on Disability (2001a). *Barriers to community participation.* Washington, D.C.: Author.

National Organization on Disability (2001b). *People with disabilities and specific community activities.* Washington, D.C.: Author.

NHS Executive and Department of Health (2000). *York Health Economics Consortium. Evaluation of the powered wheelchair and voucher scheme initiatives. Final report.* London: Stationery Office.

Noreau, L., Fougeyrollas, P., & Boschen, K. A. (2002). Perceived influence of the environment on social participation among individuals with spinal cord injury. *Topics in Spinal Cord Injury Rehabilitation, 7,* 56-72.

Noreau, L., Fougeyrollas, P., & Vincent, C. (2002). The LIFE-H: Assessment of the quality of social participation. *Technology and Disability, 14,* 113-118.

Oertel, J., Brundig, B., & Henze, W. (1999). Spiroergometric field-study of wheelchair propulsion with different hand-drive systems. In L.H.van der Woude, M. T. E. Hopman, & C. H. van Kemenade (Eds.), *Bio-medical aspects of manual wheelchair propulsion: State of the art II* (pp. 187-190). Amsterdam: IOS Press.

Pan, A. W., Chung, L., & Hsin-Hwei, G. (2003). Reliability and validity of the Canadian Occupational Performance Measure for clients with psychiatric disorders in Taiwan. *Occupational Therapy International, 10,* 269-277.

Pierce, L. L. (1998). Barriers to access: frustrations of people who use a wheelchair for full-time mobility. *Rehabilitation Nursing, 23,* 120-125.

Portney, L. G. & Watkins, M. P. (2000). *Foundations of clinical research*. (2nd ed.) Upper Saddle River, NJ: Prentice-Hall, Inc.

Ragnarsson, K. T. (1990). Prescription considerations and a comparison of conventional and lightweight wheelchairs. *Journal of Rehabilitation Research and Development Clinical Supplement,* 8-16.

Reid, D., Laliberte-Rudman, D., & Hebert, D. (2002). Impact of wheeled seated mobility devices on adult users' and their caregivers' occupational performance: A critical literature review. *Canadian Journal of Occupational Therapy, 69,* 261-280.

Reid, D., Rigby, P., & Ryan, S. (1999). Functional impact of a rigid pelvic stabilizer on children with cerebral palsy who use wheelchairs: Users' and caregivers' perceptions. *Pediatric Rehabilitation, 3,* 101-118.

Richards, J. S., Bombardier, C. H., Tate, D., Dijkers, M., Gordon, W., Shewchuk, R. et al. (1999). Access to the environment and life satisfaction after spinal cord injury. *Archives of Physical Medicine and Rehabilitation, 80,* 1501-1506.

Riemer-Reiss, M. L. (1999). Applying Rogers' Diffusion of Innovations theory to assistive technology discontinuance. *Journal of Applied Rehabilitation Counseling, 30,* 16-21.

Riemer-Reiss, M. L. & Wacker, R. R. (2000). Factors associated with assistive technology discontinuance among individuals with disabilities. *Journal of Rehabilitation, 66,* 44-50.

Ripat, J. & Booth, A. (2005). Characteristics of assistive technology service delivery models: stakeholder perspectives and preferences. *Disability and Rehabilitation, 27,* 1461-1470.

Ripat, J. & Strock, A. (2004). Users' perceptions of the impact of electronic aids to daily living throughout the acquisition process. *Assistive Technology, 16,* 63-72.

Roelands, M., Van, O. P., Depoorter, A., & Buysse, A. (2002). A social-cognitive model to predict the use of assistive devices for mobility and self-care in elderly people. *Gerontologist, 42,* 39-50.

Rogers, E. M. (1995). *Diffusion of innovations*. (4th ed.) New York: The Free Press.

Routhier, F., Desrosiers, J., Vincent, C., & Nadeau, S. (2005). Reliability and construct validity studies of an obstacle course assessment of wheelchair user performance. *International Journal of Rehabilitation Research, 28,* 49-56.

Routhier, F., Vincent, C., Morissette, M. J., & Desaulniers, L. (2001). Clinical results of an investigation of paediatric upper limb myoelectric prosthesis fitting at the Quebec Rehabilitation Institute. *Prosthetics and Orthotics International, 25,* 119-131.

Sanford, J., Law, M., Swanson, L., & Guyatt, G. (1994). *Assessing clinically important change in an outcome of rehabilitation in older adults*. Paper presented at the Conference of the American Society of Aging; San Francisco, CA.

Scherer, M. J. (2002). The change in emphasis from people to person: Introduction to the special issue on assistive technology. *Disability and Rehabilitation, 24,* 1-4.

Scherer, M. J. & Craddock, G. (2002). Matching Person & Technology (MPT) assessment process. *Technology and Disability, 14,* 125-131.

Scherer, M. J. & Galvin, J. C. (1996). An outcomes perspective of quality pathways to the most appropriate technology. In M.J.Scherer & J. C. Galvin (Eds.), *Evaluating, selecting, and using appropriate assistive technology* (pp. 1-26). Gaithersburg, MD: Aspen Publishers, Inc.

Sedlock, D. A., Knowlton, R. G., & Fitzgerald, P. I. (1990). Circulatory and metabolic responses of women to arm crank and wheelchair ergometry. *Archives of Physical Medicine and Rehabilitation, 71,* 97-100.

Seidel, A. C. (2003). Theories derived from rehabilitation perspectives. In E.B.Crepeau, E. S. Cohn, & B. A. Boyt Schell (Eds.), *Willard & Spackman's occupational therapy* (10 ed., pp. 235-237). Philadelphia: Lippincott Williams & Wilkins.

Shechtman, O., Locklear, C., MacKinnon, L., & Hanson, C. (2003). The relationship between strength, pain, and community integration in wheelchair users: A pilot study. *Occupational Therapy in Health Care, 17,* 5-21.

Shone, S. M., Ryan, S., Rigby, P. J., & Jutai, J. W. (2002). Toward a comprehensive evaluation of the impact of electronic aids to daily living: Evaluation of consumer satisfaction. *Disability and Rehabilitation, 24,* 115-125.

Smith, M. E. (2004). *A helping hand: Power-assist manual wheelchair technology*. Retrieved June 26, 2003 from http://www.wheelchairjunkie.com/powerassist.html.

Somers, M. F. & Wlodarczyk, S. (2003). Use of a pushrim-activated, power-assisted wheelchair enhanced mobility for an individual with cervical 5/6 tetraplegia. *Neurology Report, 27,* 22-28.

Speziale, H. J. & Rinaldi Carpenter, D. (2003). *Qualitative research in nursing: Advancing the humanistic imperative*. (3rd ed.) Philadelphia: Lippincott Williams & Wilkins.

Stickel, M. S., Ryan, S., Rigby, P. J., & Jutai, J. W. (2002). Toward a comprehensive evaluation of the impact of electronic aids to daily living: Evaluation of consumer satisfaction. *Disability and Rehabilitation, 24,* 115-125.

Tam, C., Reid, D., Naumann, S., & O'Keefe, B. (2002). Perceived benefits of word prediction intervention on written productivity in children with spina bifida and hydrocephalus. *Occupational Therapy International, 9,* 237-255.

Townsend, E. (2004). *Enabling occupation: An occupational therapy perspective.* Ottawa: CAOT Publications ACE.

Trefler, E., Fitzgerald, S. G., Hobson, D. A., Bursick, T., & Joseph, R. (2004). Outcomes of wheelchair systems intervention with residents of long-term care facilities. *Assistive Technology, 16,* 18-27.

van der Woude, L. H., Dallmeijer, A. J., Janssen, T. W., & Veeger, D. (2001a). Alternative modes of manual wheelchair ambulation: An overview. *American Journal of Physical Medicine and Rehabilitation, 80,* 765-777.

van der Woude, L. H., de Groot, G., Hollander, A. P., van Ingen Schenau, G. J., & Rozendal, R. H. (1986). Wheelchair ergonomics and physiological testing of prototypes. *Ergonomics, 29,* 1561-1573.

van der Woude, L. H., van Kranen, E., Ariens, G., Rozendal, R. H., & Veeger, H. E. (1995). Physical strain and mechanical efficiency in hubcrank and handrim wheelchair propulsion. *Journal of Medical Engineering and Technology, 19,* 123-131.

van der Woude, L. H., Veeger, H. E., Dallmeijer, A. J., Janssen, T. W., & Rozendaal, L. A. (2001b). Biomechanics and physiology in active manual wheelchair propulsion. *Medical Engineering and Physics, 23,* 713-733.

van der Woude, L. H., Veeger, H. E., de, B. Y., & Rozendal, R. H. (1993). Physiological evaluation of a newly designed lever mechanism for wheelchairs. *Journal of Medical Engineering and Technology, 17,* 232-240.

van der Woude, L. H. V. & Botden, E. (1997). Mechanical advantage in wheelchair lever propulsion: Effect on physical strain and efficiency. *Journal of Rehabilitation Research & Development, 34,* 286-294.

van der Woude, L. H. V., Mass, K., & Rozendal, R. H. (1995). Physiological responses during hub crank and hand rim wheelchair propulsion. *Journal of Rehabilitation Science, 8,* 13-19.

Vincent, C., Drouin, G., & Routhier, F. (2002). Examination of new environmental control applications. *Assistive Technology, 14,* 98-111.

Warren, C. G. (1990). Powered mobility and its implications. *Journal of Rehabilitation Research and Development Clinical Supplement,* 74-85.

Watts, E. H., O'Brian, M., & Wojcik, B. W. (2004). Four models of assistive technology consideration: How do they compare to recommended educational assessment practices? *Journal of Special Education Technology E Journal, 19*.

Whiteneck, G., Meade, M. A., Dijkers, M., Tate, D. G., Bushnik, T., & Forchheimer, M. B. (2004). Environmental factors and their role in participation and life satisfaction after spinal cord injury. *Archives of Physical Medicine and Rehabilitation, 85,* 1793-1803.

Wiart, L., Darrah, J., Cook, A., Hollis, V., & May, L. (2003). Evaluation of powered mobility use in home and community environments. *Physical and Occupational Therapy in Pediatrics, 23,* 59-75.

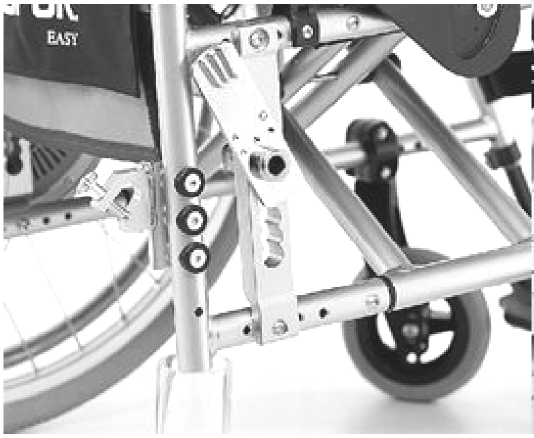
World Health Organization (2001). *International classification of functioning, disability, and health: ICF*. Geneva: World Health Organization.

World Health Organization (2002). *Towards a common language for functioning, disability and health: ICF.* Geneva: World Health Organization.

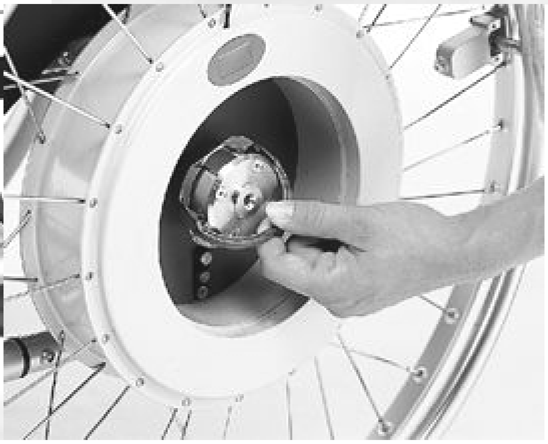
Wressle, E. & Samuelsson, K. (2004). User satisfaction with mobility assistive devices. *Scandinavian Journal of Occupational Therapy, 11,* 143-150.

Appendix A

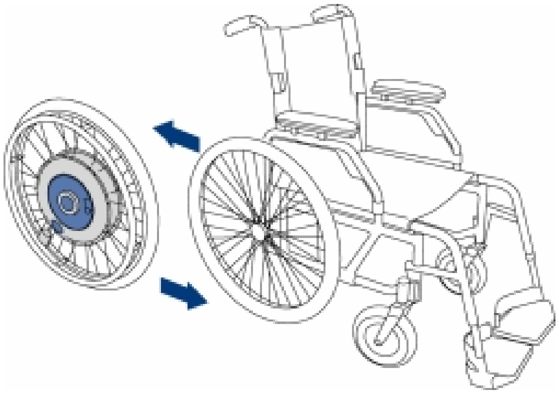
The e-motion® power assist product



Mounting bracket – PAPAW or manual wheels can be inserted here

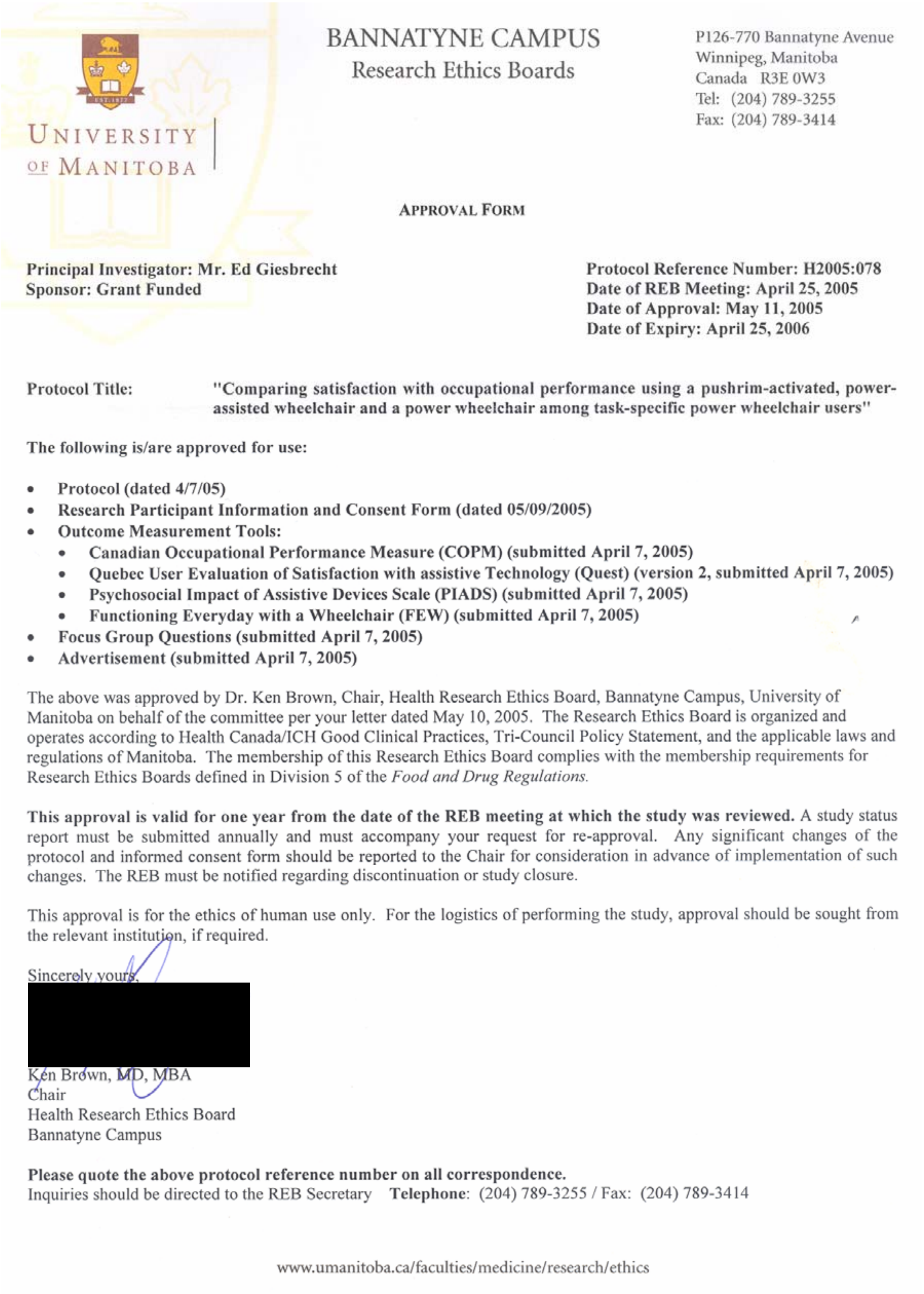


Quick-release mechanism to remove PAPAW wheel and replace with manual



Note: Images courtesy of http://www.ulrich-alber.de/html_e/html_prod_emotion_e/ab_set_e.html and http://www.alber.de/produkte/e-motion.php. Copied with permission from Ulrich Alber GmbH.

Appendix B



UNIVERSITY OF MANITOBA

BANNATYNE CAMPUS
Research Ethics Boards

P126-770 Bannatyne Avenue
Winnipeg, Manitoba
Canada R3E 0W3
Tel: (204) 789-3255
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APPROVAL FORM

Principal Investigator: Mr. Ed Giesbrecht
Sponsor: Grant Funded

Protocol Reference Number: H2005:078
Date of REB Meeting: April 25, 2005
Date of Approval: May 11, 2005
Date of Expiry: April 25, 2006

Protocol Title: **"Comparing satisfaction with occupational performance using a pushrim-activated, power-assisted wheelchair and a power wheelchair among task-specific power wheelchair users"**

The following is/are approved for use:

- **Protocol (dated 4/7/05)**
- **Research Participant Information and Consent Form (dated 05/09/2005)**
- **Outcome Measurement Tools:**
  - **Canadian Occupational Performance Measure (COPM) (submitted April 7, 2005)**
  - **Quebec User Evaluation of Satisfaction with assistive Technology (Quest) (version 2, submitted April 7, 2005)**
  - **Psychosocial Impact of Assistive Devices Scale (PIADS) (submitted April 7, 2005)**
  - **Functioning Everyday with a Wheelchair (FEW) (submitted April 7, 2005)**
- **Focus Group Questions (submitted April 7, 2005)**
- **Advertisement (submitted April 7, 2005)**

The above was approved by Dr. Ken Brown, Chair, Health Research Ethics Board, Bannatyne Campus, University of Manitoba on behalf of the committee per your letter dated May 10, 2005. The Research Ethics Board is organized and operates according to Health Canada/ICH Good Clinical Practices, Tri-Council Policy Statement, and the applicable laws and regulations of Manitoba. The membership of this Research Ethics Board complies with the membership requirements for Research Ethics Boards defined in Division 5 of the *Food and Drug Regulations.*

This approval is valid for one year from the date of the REB meeting at which the study was reviewed. A study status report must be submitted annually and must accompany your request for re-approval. Any significant changes of the protocol and informed consent form should be reported to the Chair for consideration in advance of implementation of such changes. The REB must be notified regarding discontinuation or study closure.

This approval is for the ethics of human use only. For the logistics of performing the study, approval should be sought from the relevant institution, if required.

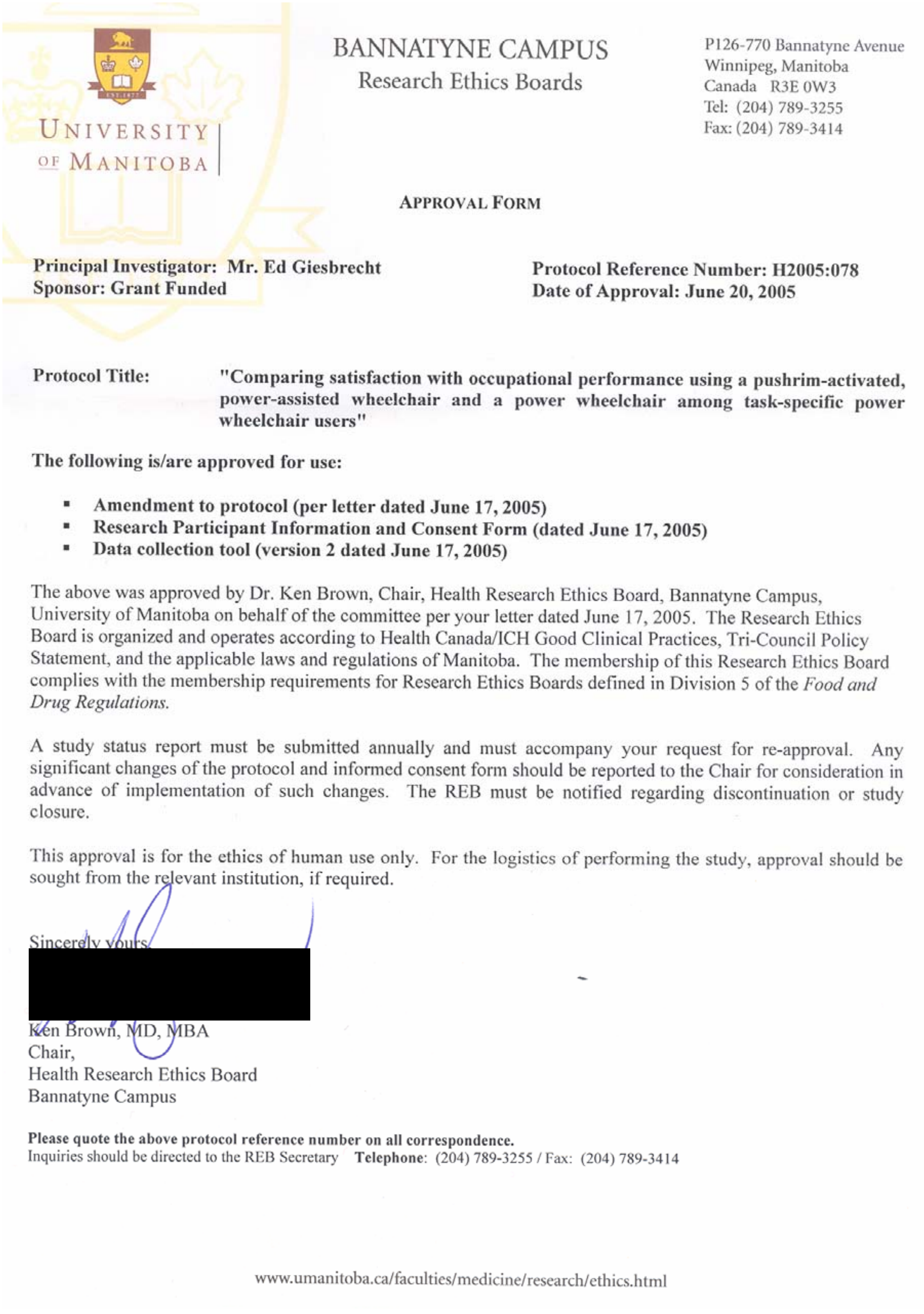
Sincerely yours,

[redacted]

Ken Brown, MD, MBA
Chair
Health Research Ethics Board
Bannatyne Campus

Please quote the above protocol reference number on all correspondence.
Inquiries should be directed to the REB Secretary **Telephone**: (204) 789-3255 / Fax: (204) 789-3414

www.umanitoba.ca/faculties/medicine/research/ethics



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APPROVAL FORM

Principal Investigator: Mr. Ed Giesbrecht
Sponsor: Grant Funded

Protocol Reference Number: H2005:078
Date of Approval: June 20, 2005

Protocol Title: **"Comparing satisfaction with occupational performance using a pushrim-activated, power-assisted wheelchair and a power wheelchair among task-specific power wheelchair users"**

The following is/are approved for use:

- **Amendment to protocol (per letter dated June 17, 2005)**
- **Research Participant Information and Consent Form (dated June 17, 2005)**
- **Data collection tool (version 2 dated June 17, 2005)**

The above was approved by Dr. Ken Brown, Chair, Health Research Ethics Board, Bannatyne Campus, University of Manitoba on behalf of the committee per your letter dated June 17, 2005. The Research Ethics Board is organized and operates according to Health Canada/ICH Good Clinical Practices, Tri-Council Policy Statement, and the applicable laws and regulations of Manitoba. The membership of this Research Ethics Board complies with the membership requirements for Research Ethics Boards defined in Division 5 of the *Food and Drug Regulations.*

A study status report must be submitted annually and must accompany your request for re-approval. Any significant changes of the protocol and informed consent form should be reported to the Chair for consideration in advance of implementation of such changes. The REB must be notified regarding discontinuation or study closure.

This approval is for the ethics of human use only. For the logistics of performing the study, approval should be sought from the relevant institution, if required.

Sincerely yours,

[redacted]

Ken Brown, MD, MBA
Chair,
Health Research Ethics Board
Bannatyne Campus

Please quote the above protocol reference number on all correspondence.
Inquiries should be directed to the REB Secretary **Telephone**: (204) 789-3255 / Fax: (204) 789-3414

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Appendix C

RESEARCH PARTICIPANT INFORMATION AND CONSENT FORM

Title of Study: "Comparing satisfaction with occupational performance using a pushrim-activated, power-assisted wheelchair and a power wheelchair among task-specific power wheelchair users"

Principal Investigator:
Ed Giesbrecht, Instructor II, Rm. R028 – 771 McDermot Ave., Occupational Therapy, University of Manitoba. 204-[redacted]

Co-Investigators:
Art Quanbury, Assistant Professor, Occupational Therapy, University of Manitoba. 204-[redacted]
Jacquie Ripat, Assistant Professor, Occupational Therapy, University of Manitoba. 204-[redacted]

Sponsor:
Lorraine Mischuk and Leanne Leclair, Co-chairs, Manitoba Society of Occupational Therapists Research Fund, 1114-425 Elgin Ave, Winnipeg, 204-[redacted].

You are being asked to participate in a research study. Please take your time to review this consent form and discuss any questions you may have with the study staff. You may take your time to make your decision about participating in this study and you may discuss it with your friends, family or (if applicable) your doctor before you make your decision. This consent form may contain words that you do not understand. Please ask the study staff to explain any words or information that you do not clearly understand.

Purpose of Study

This research study is being conducted to study whether a pushrim-activated power assist wheelchair (PAPAW) is a satisfactory alternative to a power wheelchair (PW) for individuals who use **both** a manual and a power wheelchair, depending upon which activity or location they are participating in. A total of 8 participants will participate in this study.

Study procedures

Participation in the study will be for six (6) weeks. During that time, you will be asked to use your manual and power wheelchair as you normally do for a period of three (3) weeks. You will also be asked to use the power-assisted wheels on your manual wheelchair - *instead of using your power wheelchair* – for a period of three (3) weeks, for those activities that you would normally use your power wheelchair. During this 3 weeks, you may use the power-assisted wheels all of the time, if you wish, or you may switch between the power-assisted wheels and your regular wheels.

One half of the study participants will use their power chair for the first 3 weeks of the study and then switch to the power-assisted wheels. The other half of the study participants will use the power-assisted wheels for the first 3 weeks, and then go back to using their power wheelchair. The study investigator will tell you which order will be used in your case.

If you agree to participate in this study, you will meet with the study investigator (an occupational therapist who is a graduate student) at your home (or other location if you desire) for approximately 30 minutes. The investigator will ask you for some basic information about yourself (e.g. name, age, gender, medical condition or history) and ask you to identify which activities and locations you typically use your power wheelchair for, and which ones you use your manual wheelchair for.

The investigator will attach special brackets to your wheelchair. This will allow you to put either your own wheels or the power-assist wheels on your current manual wheelchair. No other modifications to your wheelchair should be required, and the brackets should not alter the appearance, function or comfort of your wheelchair. At the end of the study, the investigator will remove the brackets and return your wheelchair to its original condition. You will have a contact phone number and email address for the investigator. If you have any concerns or problems with the power-assisted wheels during the study, you can contact the investigator immediately, and every effort will be made to solve the problem as quickly as possible. The investigator will come out to your home, if necessary, to make any adjustments. The investigator will teach you how to insert and remove the power-assist wheels so you can switch between the power-assist wheels and your manual wheels whenever you want. The investigator will also instruct you in how to use the power-assist wheels, and ensure you can operate the wheelchair safely with the power-assist wheels before beginning the study.

If you take part in this study, you will have the following procedures. After the **first** 3-week period described above, the study investigator will come and visit you for 30-60 minutes, and will ask you to complete three (3) assessment forms evaluating either your power wheelchair or the power-assist wheels, depending upon which one you were using.

You may complete these forms on your own, or the study investigator can assist you. One assessment form will ask you to rate the activities you performed with the wheelchair, including how satisfied you were with doing the activity and how well you thought you performed the activity. The second assessment will ask you a series of questions about how satisfied you were with the wheelchair. The third assessment will ask you how the wheelchair affected the quality of your life. The study investigator will also ask you to perform a short series of physical tasks in your wheelchair, such as picking up an object from the floor or from a table. After the **second** 3-week period, the investigator will visit you again and repeat the four procedures just described, evaluating either your power wheelchair or the power-assist wheels, depending upon which one you were using.

At the end of each week of the six-week study, the investigator will contact you (either by telephone or in person) and ask you to estimate the number of hours you typically spent each day using your manual chair and using your power wheelchair or power-assist wheels. The investigator will also ask you to estimate how many hours you have spent during that week performing each of the activities you identified at the beginning of the study.

After all the participants have finished using the power-assist wheels, you will be invited to meet with the other study participants in a ‘focus group’, and share your experiences and opinions about using the power-assist wheels. This will occur at an accessible and central location (e.g. the Health Sciences Centre). You will be reimbursed for the cost of transportation and parking to attend this meeting. The study investigator will be leading the focus group. At the meeting, the investigator will ask the group questions about their experience using the power-assist wheels, and participants will have an opportunity to share and compare ideas. The meeting will be audio taped so that all the responses can be accurately written down at a later time. After the audiotape has been transcribed, the participants’ answers will be summarized in a report. You will receive a copy of this report, and will have an opportunity to review and comment on whether it is accurate and reflects what you think was said at the meeting. You will not be identified by name in the report. If you decide you do not want to have your opinions or information recorded or included in the report, you may speak to the investigator to request that your opinions be removed from the report. The audiotape, as well as the written transcription and summary, will be kept in a locked filing cabinet.

The researcher may decide to take you out of this study if you develop problems in your health that make propelling a wheelchair difficult or dangerous; if you begin to develop problems with your health or your ability to participate in normal daily activities because you are using the power-assist wheels; or if weather conditions (i.e. cold temperatures or snow) make it difficult to use the power-assist wheels or cause you to change your normal activity participation.

You can stop participating at any time. However, if you decide to stop participating in the study, we encourage you to talk to the study staff first.

If you are interested in seeing the results of this study, the investigator will provide you with information on where you can view the finished thesis or any published article that may come as a result of this study.

Risks and Discomforts

You are being asked to use a power-assist wheelchair to perform activities or tasks that you would normally use a power wheelchair for. Propelling the power-assisted wheelchair is expected to be much easier than propelling your manual wheelchair. However, it is possible that you will experience discomfort or become tired performing these activities and tasks. You may choose to stop using the power-assist wheels and/or withdraw from the study at any time.

The power-assist wheels are sensitive to the amount of force with which you push. Initially, you may find a period of adjustment to using these wheels. You will be asked to use anti-tippers on your wheelchair to prevent it from accidentally tipping backwards. If you do not have anti-tippers on your wheelchair, the investigator will provide them for the duration of the study. The investigator will spend time practicing with you initially, so you will feel more confident using the power-assist wheels.

Like a power wheelchair, the power-assist wheels have batteries. If the batteries should run down while you are using the wheelchair, you will still be able to propel it like a manual chair, but it will be more difficult because the wheels are heavier than those you use on your manual wheelchair. You will need to recharge the batteries in your power-assist wheels, probably every night, similar to your current power wheelchair. You will be provided with a special battery charger during this portion of the study.

The power-assist wheels weight about 12 kg each. You may have difficulty changing or lifting the wheels yourself, and may require the assistance of another person for these kinds of activities (e.g. disassembling the wheelchair and lifting it into a car).

Depending upon your particular manual wheelchair, using the power-assist wheels may increase the width of your wheelchair by 1-2”. This may create some difficulty for you when managing narrow spaces. The width of your wheelchair should not change significantly if you use your regular wheels.

Benefits

There may or may not be direct benefit to you from participating in this study. We hope the information learned from this study will help benefit other people who use both a manual and a power wheelchair in the future by demonstrating whether power-assist wheels are an alternative to using a power wheelchair. Participating in this study will give you a chance to try the power-assist wheels for yourself, and see whether they might be beneficial for you.

Costs

All the procedures, which will be performed as part of this study, are provided at no cost to you.

Payment for participation

For participating in this study, you will be paid an honourarium equivalent to $20.00 (twenty dollars) each time you complete the assessment forms (i.e. after 3 weeks and again after 6 weeks), and $10.00 (ten dollars) for participating in the focus group. The total value of the honourarium will therefore be equivalent to $50.00 (fifty dollars), recognizing the time and interest required. In addition, any costs related to attending the focus group (e.g. transportation, parking) will be reimbursed.

Confidentiality

Information gathered in this research study may be published or presented in public forums; however, your name and other identifying information will not be used or revealed. Confidentiality is assured within the limits of the law.

All study related documents will bear only your assigned study number. Data gathered on the assessment forms, as well as transcribed statements from the focus group, will be entered into a computer for electronic storage and analysis. This information may be transmitted to the Biostatistical Consulting Unit at the University of Manitoba, for the purposes of data analysis only. In this case, individual information will only be identified using your assigned study number to ensure confidentiality.

It is possible that other individuals will learn of your involvement in this study through other means. If this is a concern to you, you may wish to withdraw your participation.

Everything you say during the focus group is also held confidential. It is important for you not to repeat this information outside of the focus group.

The University of Manitoba Health Research Ethics Board may review records related to the study for quality assurance purposes. All records will be kept in a locked secure area and only those persons identified in this consent form will have access to these records. No information revealing any personal information such as your name, address or telephone number will leave the University of Manitoba.

Voluntary Participation/Withdrawal from the Study

Your decision to take part in this study is voluntary. You may refuse to participate or you may withdraw from the study at any time. Your decision not to participate or to withdraw from the study will not affect your access to equipment or services normally provided by agencies in Manitoba (e.g. Society for Manitobans with Disabilities (Wheelchair Services); Canadian Paraplegic Association (Manitoba)).

Medical Care for Injury Related to the Study

You are not waiving any of your legal rights by signing this consent form nor are you releasing the investigator(s) from their legal and professional responsibilities.

Questions

You are free to ask any questions that you may have about your treatment and your rights as a research participant. If any questions come up during or after the study or if you have a research-related injury, contact the investigator: Ed Giesbrecht at (204) [redacted].

For questions about your rights as a research participant, you may contact The University of Manitoba, Bannatyne Campus Research Ethics Board Office at (204) [redacted]

Do not sign this consent form unless you have had a chance to ask questions and have received satisfactory answers to all of your questions.

Statement of Consent

I have read this consent form. I have had the opportunity to discuss this research study with Ed Giesbrecht and/or the study staff. I have had my questions answered by them in language I understand. The risks and benefits have been explained to me. I believe that I have not been unduly influenced by any study team member to participate in the research study by any statements or implied statements. Any relationship (such as employer, supervisor or family member) I may have with the study team has not affected my decision to participate. I understand that I will be given a copy of this consent form after signing it. I understand that my participation in this study is voluntary and that I may choose to withdraw at any time. I freely agree to participate in this research study.

I understand that information regarding my personal identity will be kept confidential, but that confidentiality is assured only within the limits of the law. I authorize the inspection of any of my records that relate to this study by The University of Manitoba Research Ethics Board for quality assurance purposes.

By signing this consent form, I have not waived any of the legal rights that I have as a participant in a research study.

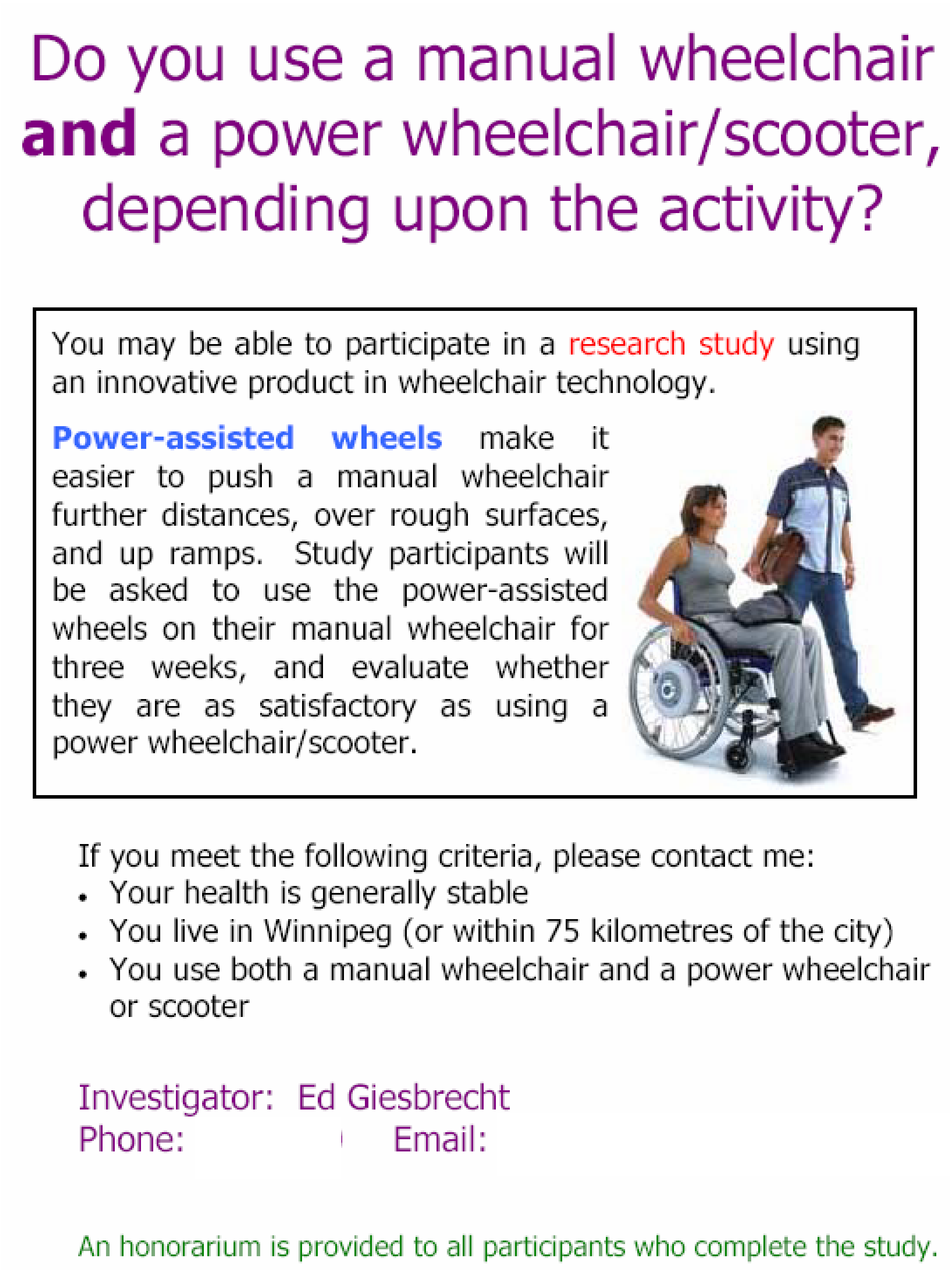
Participant signature: __________________ **Date:** __________________

Participant printed name: ____________________________

Primary Investigator signature: _______________________

Appendix D

Recruitment Poster



Do you use a manual wheelchair **and** a power wheelchair/scooter, depending upon the activity?

You may be able to participate in a research study using an innovative product in wheelchair technology.

Power-assisted wheels make it easier to push a manual wheelchair further distances, over rough surfaces, and up ramps. Study participants will be asked to use the power-assisted wheels on their manual wheelchair for three weeks, and evaluate whether they are as satisfactory as using a power wheelchair/scooter.

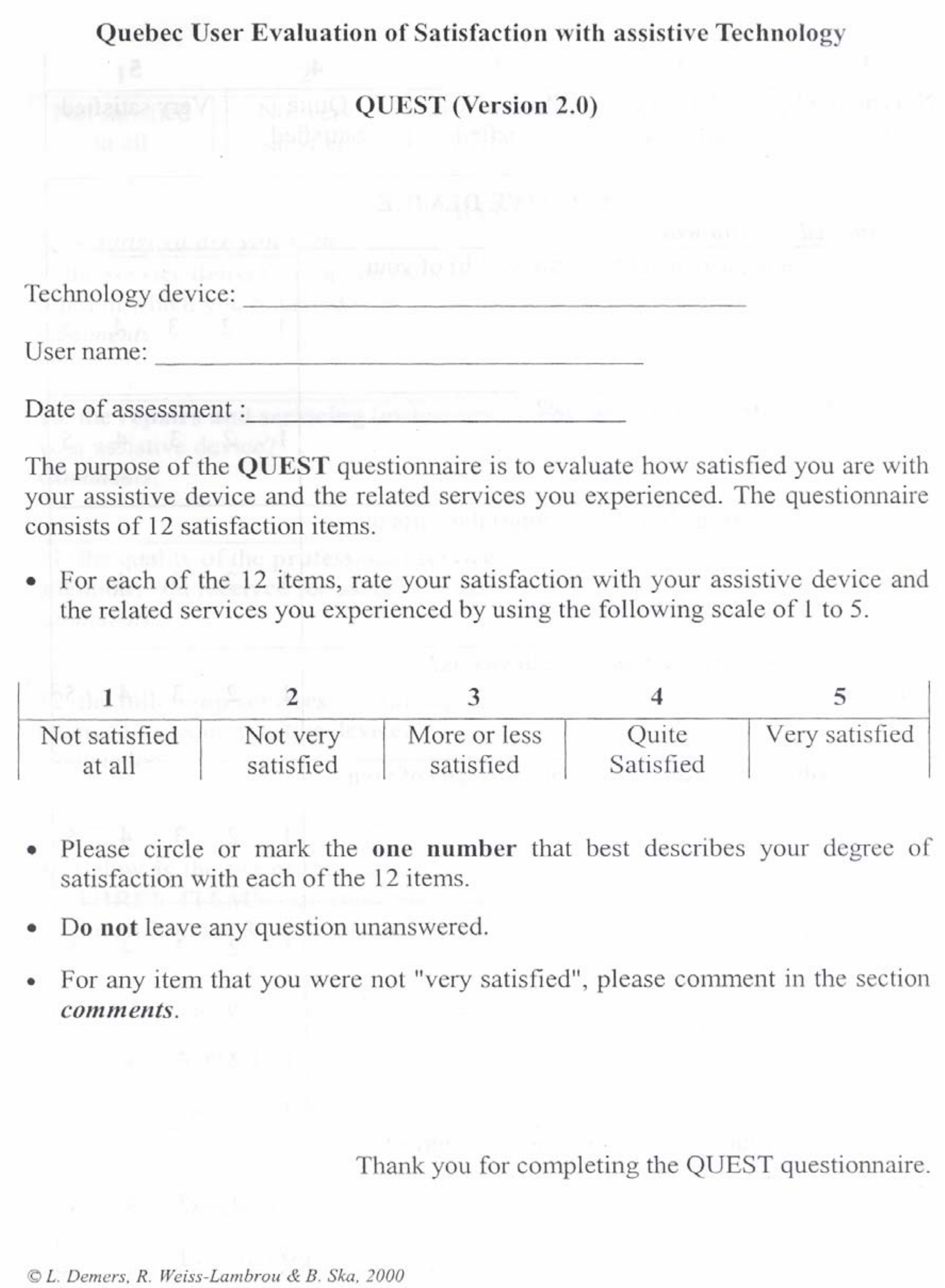
If you meet the following criteria, please contact me:

- Your health is generally stable
- You live in Winnipeg (or within 75 kilometres of the city)
- You use both a manual wheelchair and a power wheelchair or scooter

Investigator: Ed Giesbrecht
Phone: Email:

An honorarium is provided to all participants who complete the study.

Appendix E



Quebec User Evaluation of Satisfaction with assistive Technology

QUEST (Version 2.0)

Technology device: ____________________________________

User name: ____________________________________

Date of assessment :____________________________________

The purpose of the **QUEST** questionnaire is to evaluate how satisfied you are with your assistive device and the related services you experienced. The questionnaire consists of 12 satisfaction items.

- For each of the 12 items, rate your satisfaction with your assistive device and the related services you experienced by using the following scale of 1 to 5.

1	**2**	**3**	**4**	**5**
Not satisfied at all	Not very satisfied	More or less satisfied	Quite Satisfied	Very satisfied

- Please circle or mark the **one number** that best describes your degree of satisfaction with each of the 12 items.
- D**o not** leave any question unanswered.
- For any item that you were not "very satisfied", please comment in the section ***comments***.

Thank you for completing the QUEST questionnaire.

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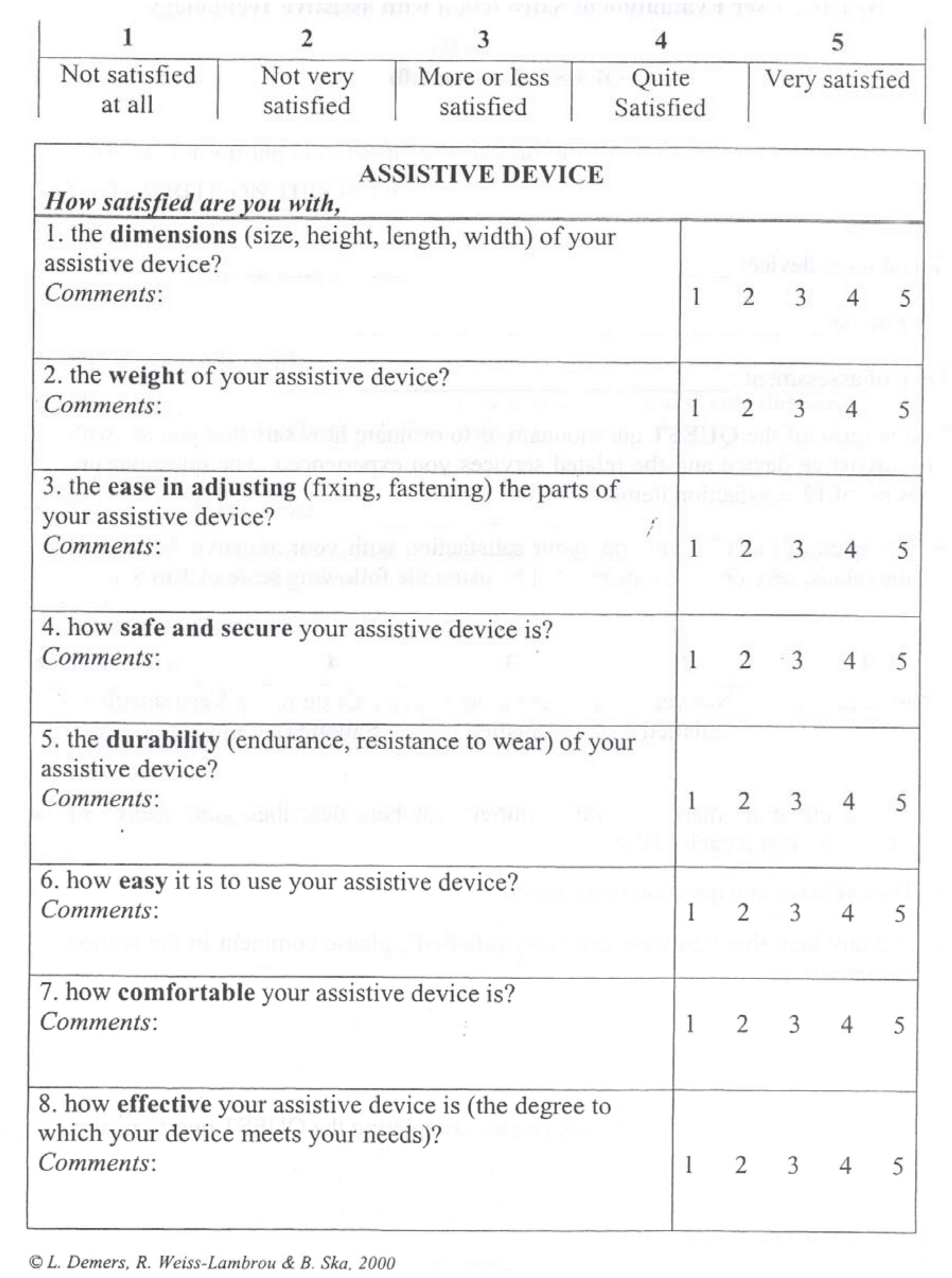

1	2	3	4	5
Not satisfied at all	Not very satisfied	More or less satisfied	Quite Satisfied	Very satisfied

ASSISTIVE DEVICE ***How satisfied are you with,***	
1. the **dimensions** (size, height, length, width) of your assistive device? *Comments*:	1 2 3 4 5
2. the **weight** of your assistive device? *Comments*:	1 2 3 4 5
3. the **ease in adjusting** (fixing, fastening) the parts of your assistive device? *Comments*:	1 2 3 4 5
4. how **safe and secure** your assistive device is? *Comments*:	1 2 3 4 5
5. the **durability** (endurance, resistance to wear) of your assistive device? *Comments*:	1 2 3 4 5
6. how **easy** it is to use your assistive device? *Comments*:	1 2 3 4 5
7. how **comfortable** your assistive device is? *Comments*:	1 2 3 4 5
8. how **effective** your assistive device is (the degree to which your device meets your needs)? *Comments*:	1 2 3 4 5

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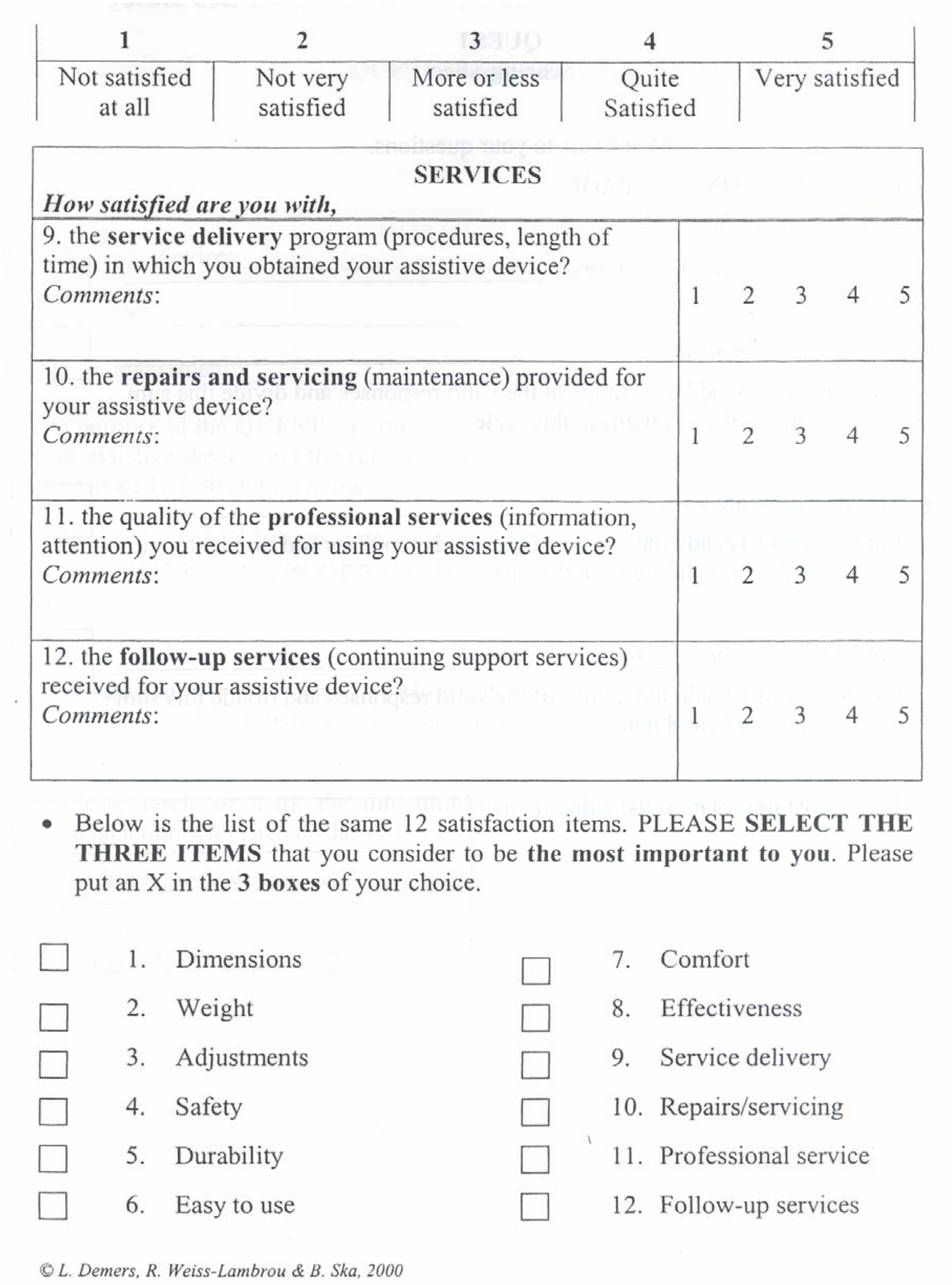

1	2	3	4	5
Not satisfied at all	Not very satisfied	More or less satisfied	Quite Satisfied	Very satisfied

SERVICES ***How satisfied are you with,***	
9. the **service delivery** program (procedures, length of time) in which you obtained your assistive device? *Comments*:	1 2 3 4 5
10. the **repairs and servicing** (maintenance) provided for your assistive device? *Comments*:	1 2 3 4 5
11. the quality of the **professional services** (information, attention) you received for using your assistive device? *Comments*:	1 2 3 4 5
12. the **follow-up services** (continuing support services) received for your assistive device? *Comments*:	1 2 3 4 5

- Below is the list of the same 12 satisfaction items. PLEASE **SELECT THE THREE ITEMS** that you consider to be **the most important to you**. Please put an X in the **3 boxes** of your choice.

☐ 1. Dimensions
☐ 2. Weight
☐ 3. Adjustments
☐ 4. Safety
☐ 5. Durability
☐ 6. Easy to use
☐ 7. Comfort
☐ 8. Effectiveness
☐ 9. Service delivery
☐ 10. Repairs/servicing
☐ 11. Professional service
☐ 12. Follow-up services

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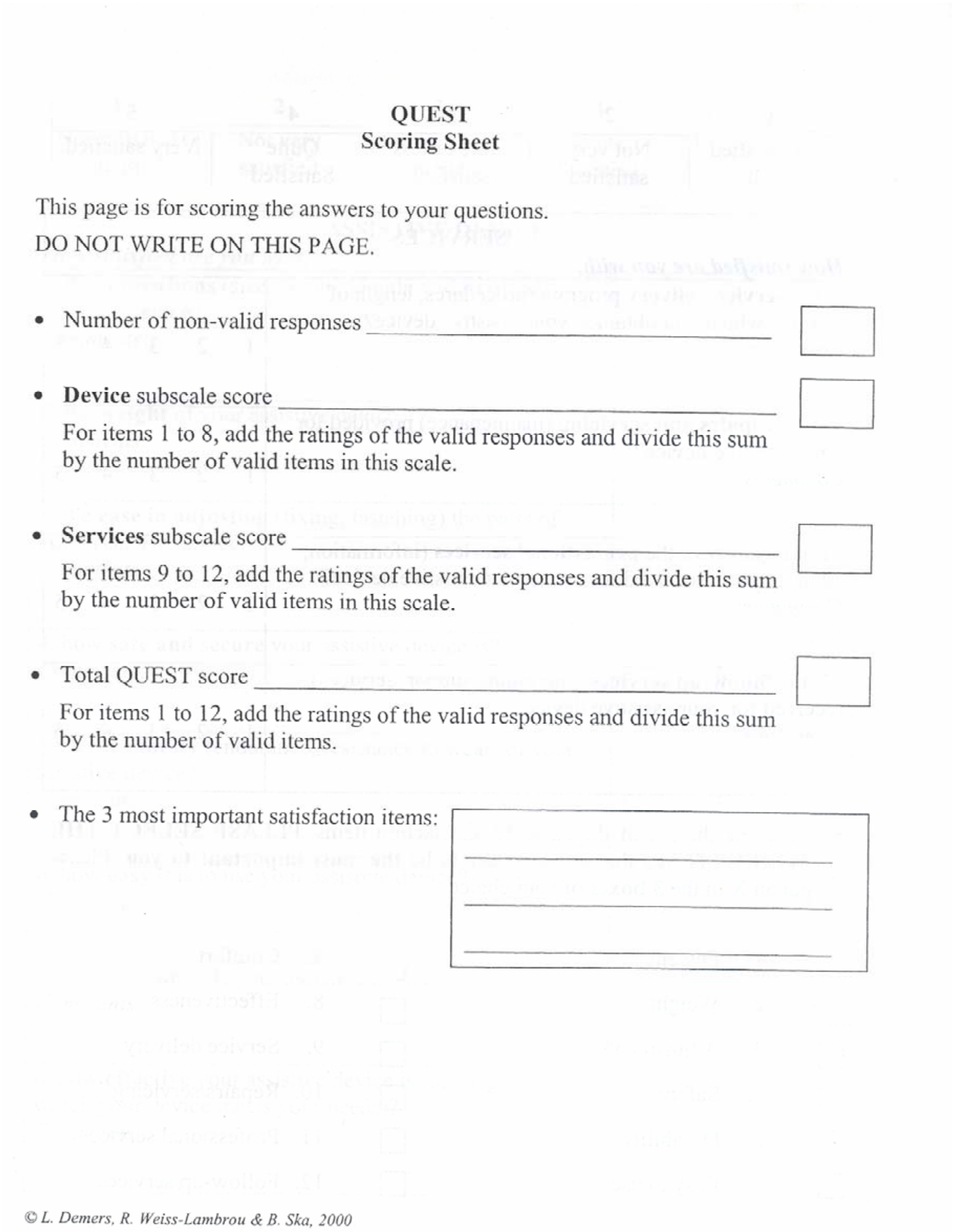

QUEST
Scoring Sheet

This page is for scoring the answers to your questions.
DO NOT WRITE ON THIS PAGE.

- Number of non-valid responses ______________ ☐
- **Device** subscale score ______________ ☐
  For items 1 to 8, add the ratings of the valid responses and divide this sum by the number of valid items in this scale.
- **Services** subscale score ______________ ☐
  For items 9 to 12, add the ratings of the valid responses and divide this sum by the number of valid items in this scale.
- Total QUEST score ______________ ☐
  For items 1 to 12, add the ratings of the valid responses and divide this sum by the number of valid items.
- The 3 most important satisfaction items:
  ____
  ____
  ____

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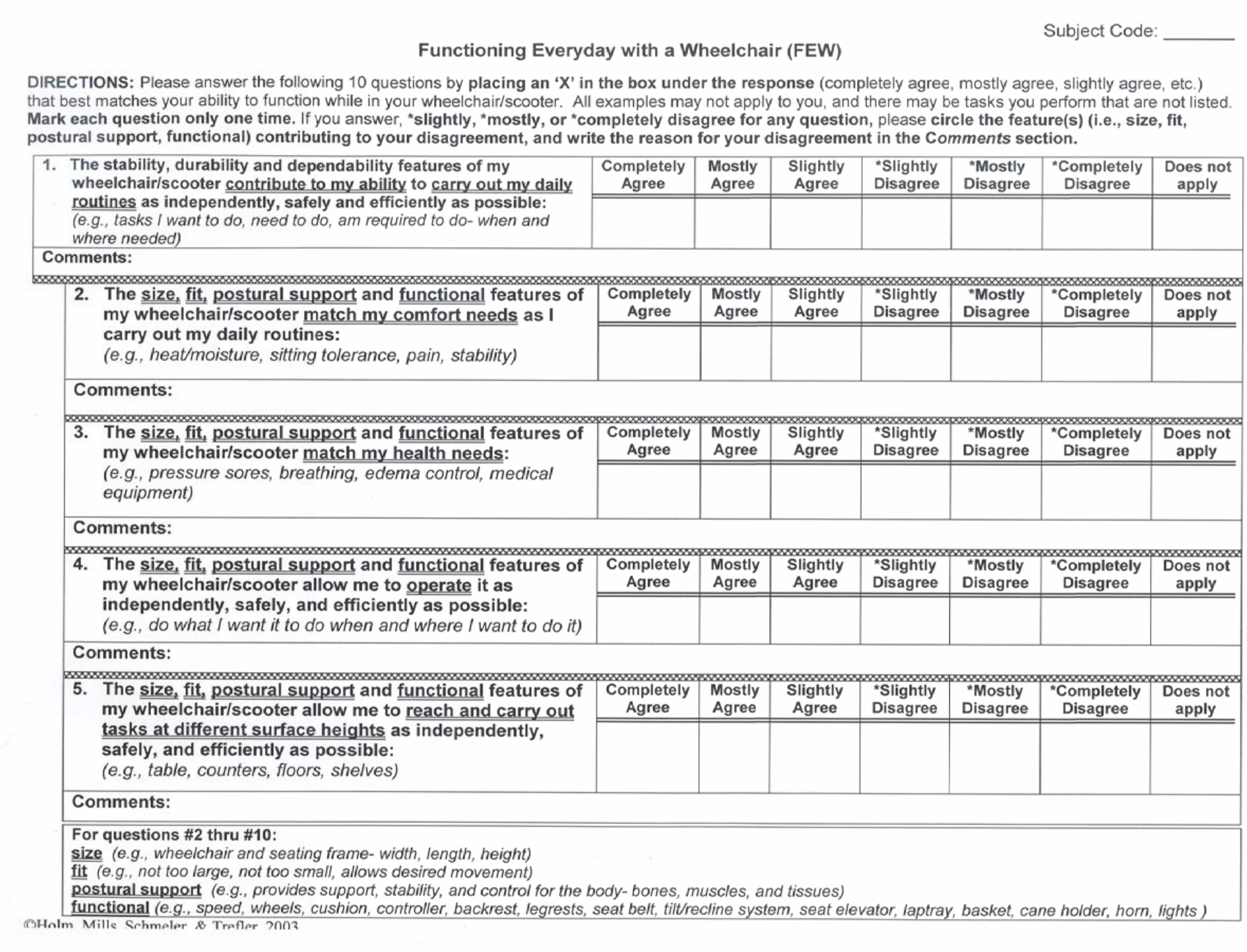
Appendix F



Subject Code: _______

Functioning Everyday with a Wheelchair (FEW)

DIRECTIONS: Please answer the following 10 questions by **placing an 'X' in the box under the response** (completely agree, mostly agree, slightly agree, etc.) that best matches your ability to function while in your wheelchair/scooter. All examples may not apply to you, and there may be tasks you perform that are not listed. **Mark each question only one time.** If you answer, ***slightly, *mostly, or *completely disagree for any question,** please **circle the feature(s) (i.e., size, fit, postural support, functional) contributing to your disagreement, and write the reason for your disagreement in the C*omments* section.**

1. The stability, durability and dependability features of my wheelchair/scooter contribute to my ability to carry out my daily routines as independently, safely and efficiently as possible: *(e.g., tasks I want to do, need to do, am required to do- when and where needed)*	Completely Agree	Mostly Agree	Slightly Agree	*Slightly Disagree	*Mostly Disagree	*Completely Disagree	Does not apply
Comments:							
2. The size, fit, postural support and functional features of my wheelchair/scooter match my comfort needs as I carry out my daily routines: *(e.g., heat/moisture, sitting tolerance, pain, stability)*	Completely Agree	Mostly Agree	Slightly Agree	*Slightly Disagree	*Mostly Disagree	*Completely Disagree	Does not apply
Comments:							
3. The size, fit, postural support and functional features of my wheelchair/scooter match my health needs: *(e.g., pressure sores, breathing, edema control, medical equipment)*	Completely Agree	Mostly Agree	Slightly Agree	*Slightly Disagree	*Mostly Disagree	*Completely Disagree	Does not apply
Comments:							
4. The size, fit, postural support and functional features of my wheelchair/scooter allow me to operate it as independently, safely, and efficiently as possible: *(e.g., do what I want it to do when and where I want to do it)*	Completely Agree	Mostly Agree	Slightly Agree	*Slightly Disagree	*Mostly Disagree	*Completely Disagree	Does not apply
Comments:							
5. The size, fit, postural support and functional features of my wheelchair/scooter allow me to reach and carry out tasks at different surface heights as independently, safely, and efficiently as possible: *(e.g., table, counters, floors, shelves)*	Completely Agree	Mostly Agree	Slightly Agree	*Slightly Disagree	*Mostly Disagree	*Completely Disagree	Does not apply
Comments:							

For questions #2 thru #10:
size *(e.g., wheelchair and seating frame- width, length, height)*
fit *(e.g., not too large, not too small, allows desired movement)*
postural support *(e.g., provides support, stability, and control for the body- bones, muscles, and tissues)*
functional *(e.g., speed, wheels, cushion, controller, backrest, legrests, seat belt, tilt/recline system, seat elevator, laptray, basket, cane holder, horn, lights)*

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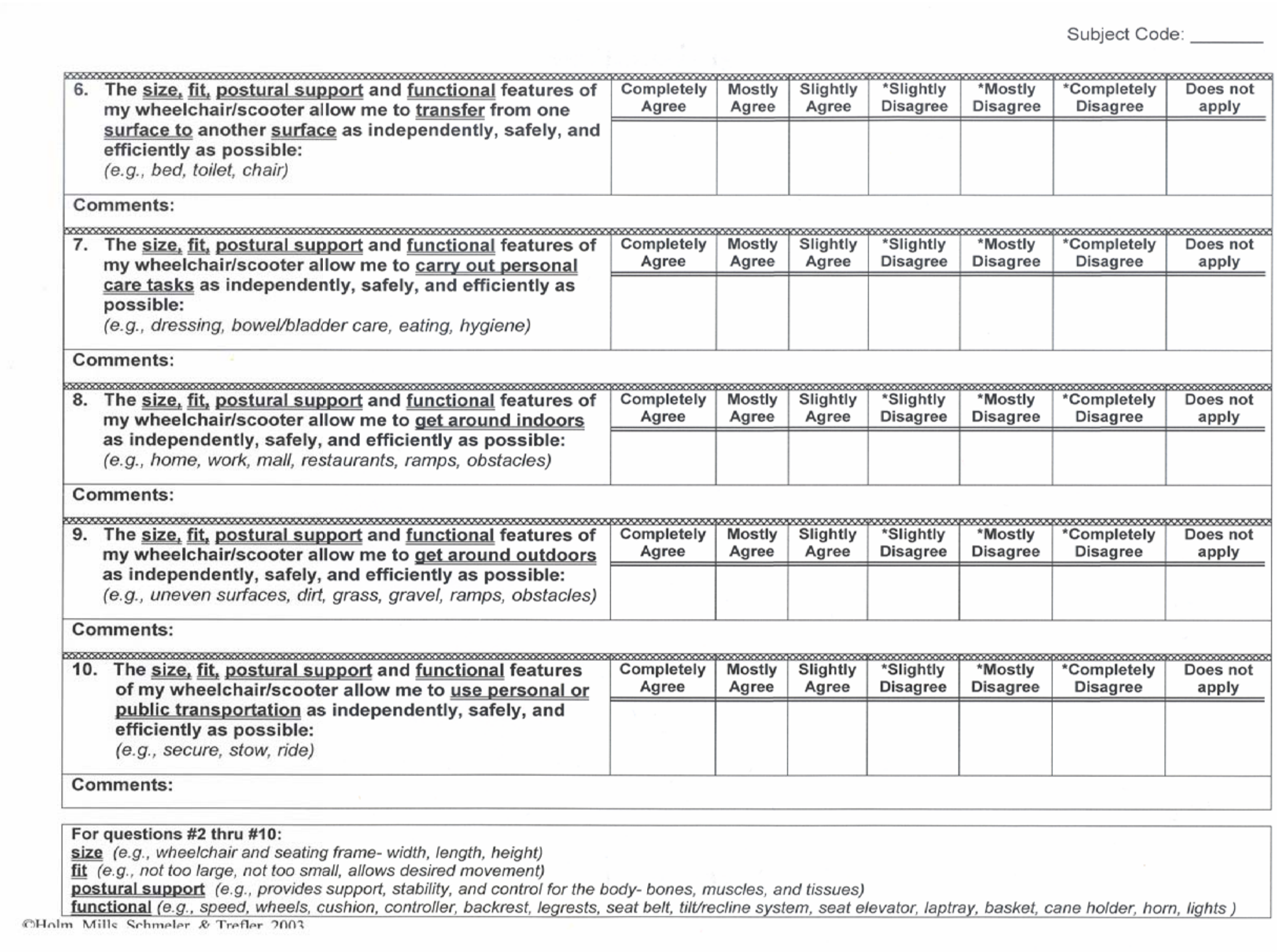

Subject Code: ________

6. **The size, fit, postural support and functional features of my wheelchair/scooter allow me to transfer from one surface to another surface as independently, safely, and efficiently as possible:** *(e.g., bed, toilet, chair)*	**Completely Agree**	**Mostly Agree**	**Slightly Agree**	***Slightly Disagree**	***Mostly Disagree**	***Completely Disagree**	**Does not apply**
Comments:							
7. **The size, fit, postural support and functional features of my wheelchair/scooter allow me to carry out personal care tasks as independently, safely, and efficiently as possible:** *(e.g., dressing, bowel/bladder care, eating, hygiene)*	**Completely Agree**	**Mostly Agree**	**Slightly Agree**	***Slightly Disagree**	***Mostly Disagree**	***Completely Disagree**	**Does not apply**
Comments:							
8. **The size, fit, postural support and functional features of my wheelchair/scooter allow me to get around indoors as independently, safely, and efficiently as possible:** *(e.g., home, work, mall, restaurants, ramps, obstacles)*	**Completely Agree**	**Mostly Agree**	**Slightly Agree**	***Slightly Disagree**	***Mostly Disagree**	***Completely Disagree**	**Does not apply**
Comments:							
9. **The size, fit, postural support and functional features of my wheelchair/scooter allow me to get around outdoors as independently, safely, and efficiently as possible:** *(e.g., uneven surfaces, dirt, grass, gravel, ramps, obstacles)*	**Completely Agree**	**Mostly Agree**	**Slightly Agree**	***Slightly Disagree**	***Mostly Disagree**	***Completely Disagree**	**Does not apply**
Comments:							
10. **The size, fit, postural support and functional features of my wheelchair/scooter allow me to use personal or public transportation as independently, safely, and efficiently as possible:** *(e.g., secure, stow, ride)*	**Completely Agree**	**Mostly Agree**	**Slightly Agree**	***Slightly Disagree**	***Mostly Disagree**	***Completely Disagree**	**Does not apply**
Comments:							

For questions #2 thru #10:
size *(e.g., wheelchair and seating frame- width, length, height)*
fit *(e.g., not too large, not too small, allows desired movement)*
postural support *(e.g., provides support, stability, and control for the body- bones, muscles, and tissues)*
functional *(e.g., speed, wheels, cushion, controller, backrest, legrests, seat belt, tilt/recline system, seat elevator, laptray, basket, cane holder, horn, lights)*

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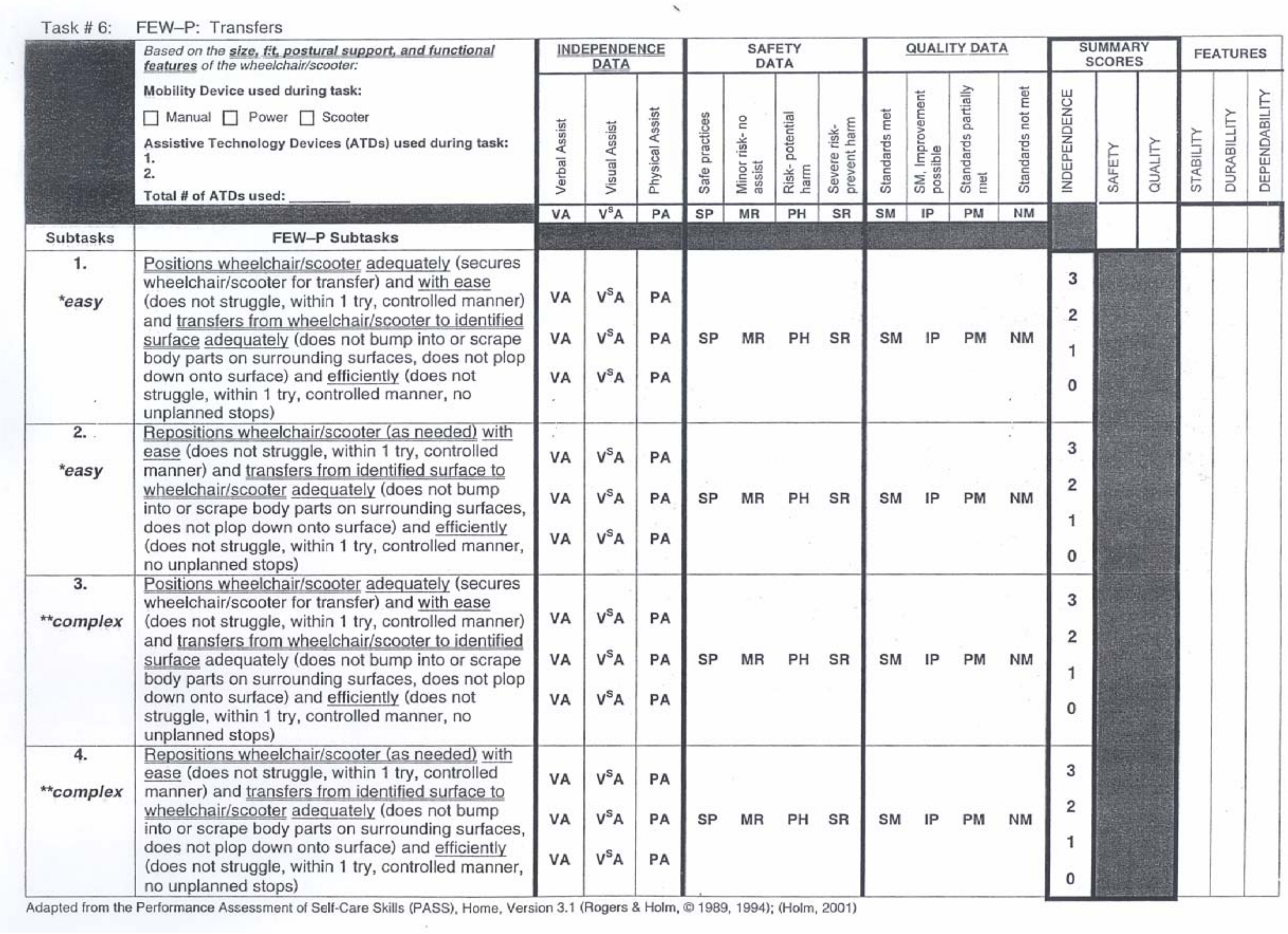

Task # 6: FEW–P: Transfers

*Based on the **size, fit, postural support, and functional features** of the wheelchair/scooter:*

Mobility Device used during task:

☐ Manual ☐ Power ☐ Scooter

Assistive Technology Devices (ATDs) used during task:

1.
2.

Total # of ATDs used: ________

		INDEPENDENCE DATA			SAFETY DATA				QUALITY DATA				SUMMARY SCORES			FEATURES		
		Verbal Assist	Visual Assist	Physical Assist	Safe practices	Minor risk- no assist	Risk- potential harm	Severe risk- prevent harm	Standards met	SM, Improvement possible	Standards partially met	Standards not met	INDEPENDENCE	SAFETY	QUALITY	STABILITY	DURABILLITY	DEPENDABILITY
		VA	$V^{S}A$	PA	SP	MR	PH	SR	SM	IP	PM	NM						
Subtasks	FEW–P Subtasks																	
1. *easy	Positions wheelchair/scooter adequately (secures wheelchair/scooter for transfer) and with ease (does not struggle, within 1 try, controlled manner) and transfers from wheelchair/scooter to identified surface adequately (does not bump into or scrape body parts on surrounding surfaces, does not plop down onto surface) and efficiently (does not struggle, within 1 try, controlled manner, no unplanned stops)	VA VA VA	$V^{S}A$ $V^{S}A$ $V^{S}A$	PA PA PA	SP	MR	PH	SR	SM	IP	PM	NM	3 2 1 0					
2. *easy	Repositions wheelchair/scooter (as needed) with ease (does not struggle, within 1 try, controlled manner) and transfers from identified surface to wheelchair/scooter adequately (does not bump into or scrape body parts on surrounding surfaces, does not plop down onto surface) and efficiently (does not struggle, within 1 try, controlled manner, no unplanned stops)	VA VA VA	$V^{S}A$ $V^{S}A$ $V^{S}A$	PA PA PA	SP	MR	PH	SR	SM	IP	PM	NM	3 2 1 0					
3. **complex	Positions wheelchair/scooter adequately (secures wheelchair/scooter for transfer) and with ease (does not struggle, within 1 try, controlled manner) and transfers from wheelchair/scooter to identified surface adequately (does not bump into or scrape body parts on surrounding surfaces, does not plop down onto surface) and efficiently (does not struggle, within 1 try, controlled manner, no unplanned stops)	VA VA VA	$V^{S}A$ $V^{S}A$ $V^{S}A$	PA PA PA	SP	MR	PH	SR	SM	IP	PM	NM	3 2 1 0					
4. **complex	Repositions wheelchair/scooter (as needed) with ease (does not struggle, within 1 try, controlled manner) and transfers from identified surface to wheelchair/scooter adequately (does not bump into or scrape body parts on surrounding surfaces, does not plop down onto surface) and efficiently (does not struggle, within 1 try, controlled manner, no unplanned stops)	VA VA VA	$V^{S}A$ $V^{S}A$ $V^{S}A$	PA PA PA	SP	MR	PH	SR	SM	IP	PM	NM	3 2 1 0					

Adapted from the Performance Assessment of Self-Care Skills (PASS), Home, Version 3.1 (Rogers & Holm, © 1989, 1994); (Holm, 2001)

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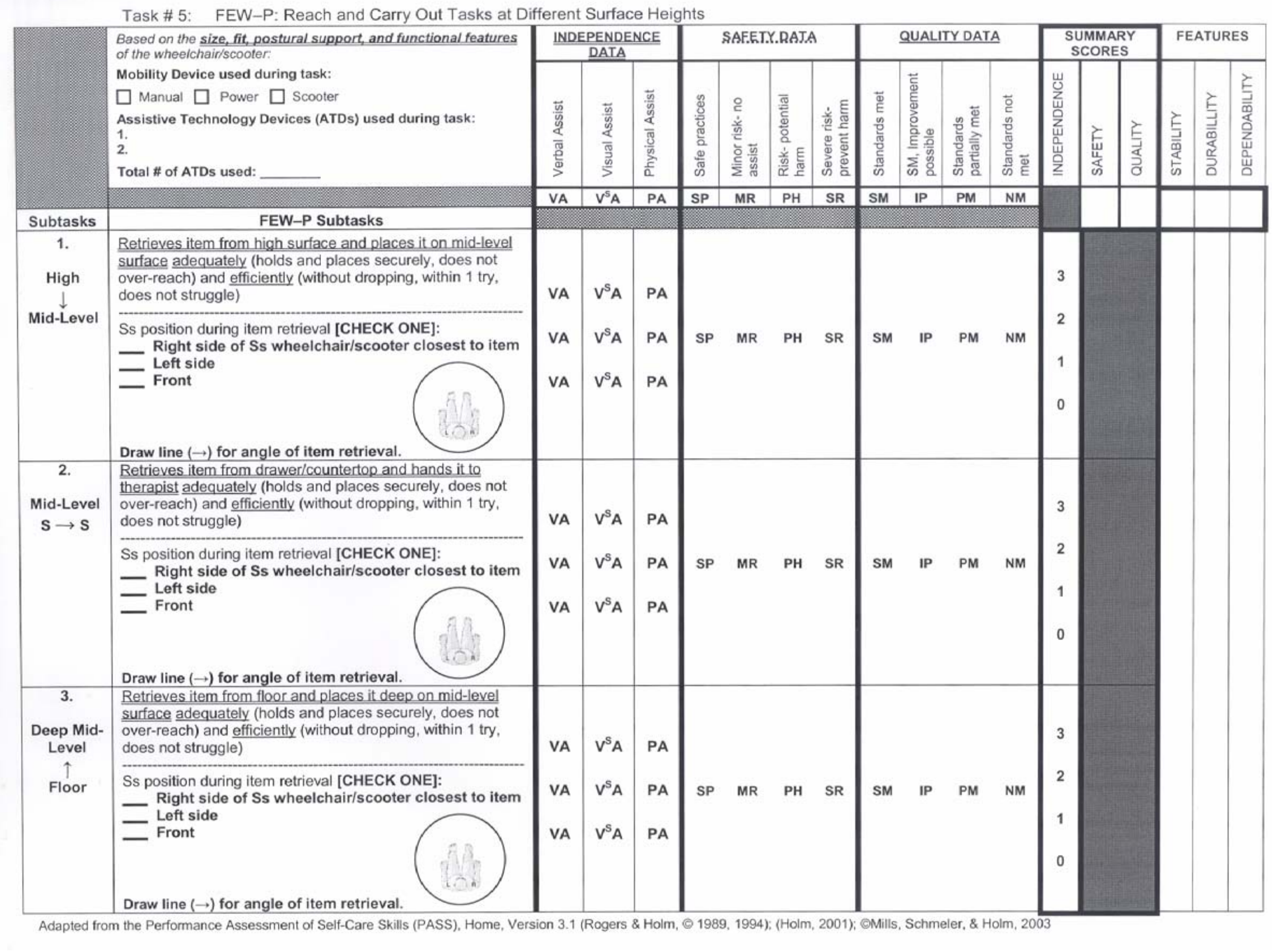

Task # 5: FEW–P: Reach and Carry Out Tasks at Different Surface Heights

Based on the ***size, fit, postural support, and functional features*** *of the wheelchair/scooter:*

Mobility Device used during task:

☐ Manual ☐ Power ☐ Scooter

Assistive Technology Devices (ATDs) used during task:

1.

2.

Total # of ATDs used: ________

		INDEPENDENCE DATA			SAFETY DATA				QUALITY DATA				SUMMARY SCORES			FEATURES		
		Verbal Assist	Visual Assist	Physical Assist	Safe practices	Minor risk- no assist	Risk- potential harm	Severe risk- prevent harm	Standards met	SM, Improvement possible	Standards partially met	Standards not met	INDEPENDENCE	SAFETY	QUALITY	STABILITY	DURABILLITY	DEPENDABILITY
		VA	$V^{S}A$	PA	SP	MR	PH	SR	SM	IP	PM	NM						
Subtasks	**FEW–P Subtasks**																	
1. **High** ↓ **Mid-Level**	Retrieves item from high surface and places it on mid-level surface adequately (holds and places securely, does not over-reach) and efficiently (without dropping, within 1 try, does not struggle) Ss position during item retrieval **[CHECK ONE]:** ___ **Right side of Ss wheelchair/scooter closest to item** ___ **Left side** ___ **Front** **Draw line (→) for angle of item retrieval.**	VA VA VA	$V^{S}A$ $V^{S}A$ $V^{S}A$	PA PA PA	SP	MR	PH	SR	SM	IP	PM	NM	3 2 1 0					
2. **Mid-Level** **S → S**	Retrieves item from drawer/countertop and hands it to therapist adequately (holds and places securely, does not over-reach) and efficiently (without dropping, within 1 try, does not struggle) Ss position during item retrieval **[CHECK ONE]:** ___ **Right side of Ss wheelchair/scooter closest to item** ___ **Left side** ___ **Front** **Draw line (→) for angle of item retrieval.**	VA VA VA	$V^{S}A$ $V^{S}A$ $V^{S}A$	PA PA PA	SP	MR	PH	SR	SM	IP	PM	NM	3 2 1 0					
3. **Deep Mid-Level** ↑ **Floor**	Retrieves item from floor and places it deep on mid-level surface adequately (holds and places securely, does not over-reach) and efficiently (without dropping, within 1 try, does not struggle) Ss position during item retrieval **[CHECK ONE]:** ___ **Right side of Ss wheelchair/scooter closest to item** ___ **Left side** ___ **Front** **Draw line (→) for angle of item retrieval.**	VA VA VA	$V^{S}A$ $V^{S}A$ $V^{S}A$	PA PA PA	SP	MR	PH	SR	SM	IP	PM	NM	3 2 1 0					

Adapted from the Performance Assessment of Self-Care Skills (PASS), Home, Version 3.1 (Rogers & Holm, © 1989, 1994); (Holm, 2001); ©Mills, Schmeler, & Holm, 2003

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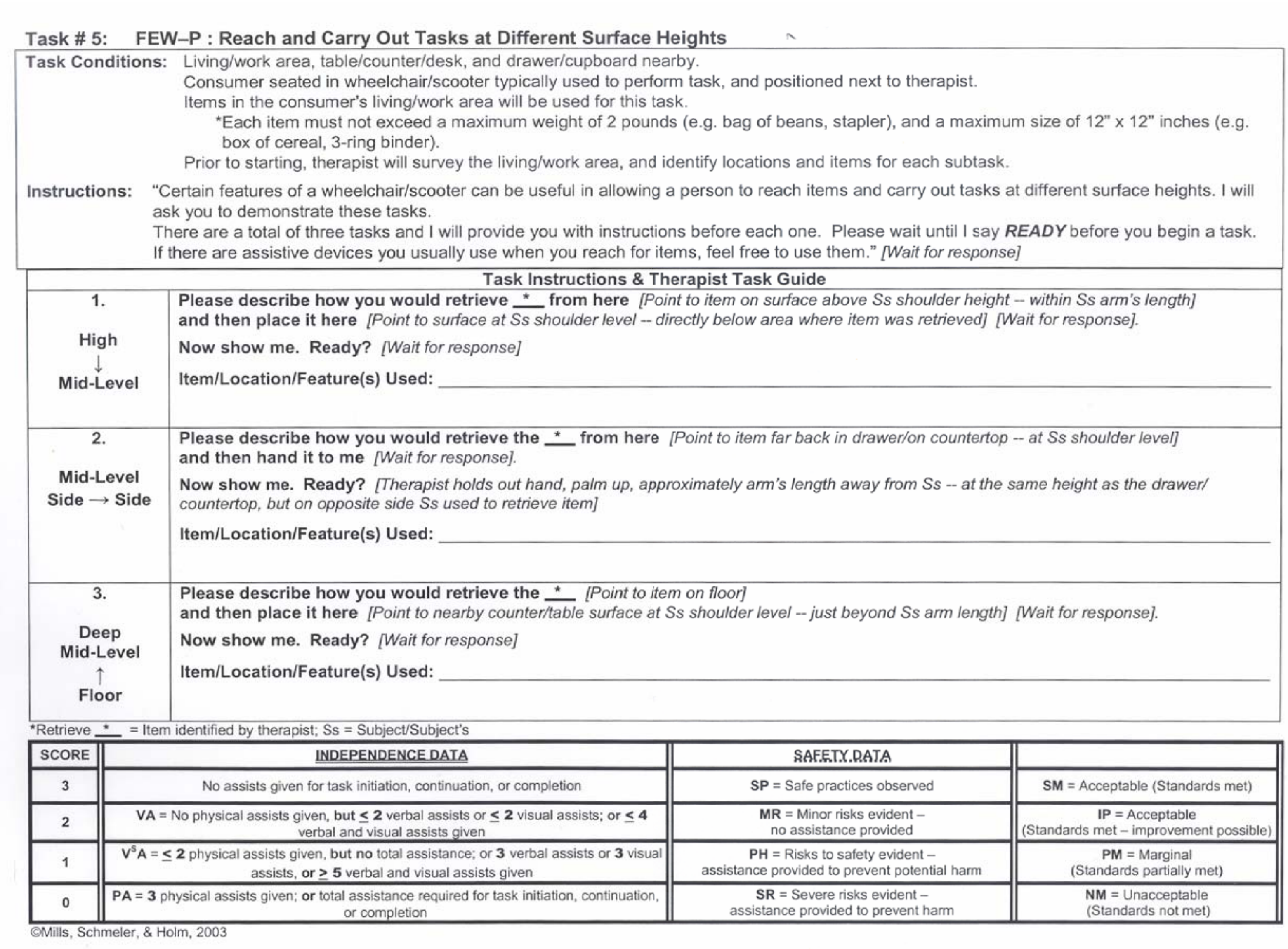

Task # 5: FEW–P : Reach and Carry Out Tasks at Different Surface Heights

Task Conditions: Living/work area, table/counter/desk, and drawer/cupboard nearby.
Consumer seated in wheelchair/scooter typically used to perform task, and positioned next to therapist.
Items in the consumer's living/work area will be used for this task.
*Each item must not exceed a maximum weight of 2 pounds (e.g. bag of beans, stapler), and a maximum size of 12" x 12" inches (e.g. box of cereal, 3-ring binder).
Prior to starting, therapist will survey the living/work area, and identify locations and items for each subtask.

Instructions: "Certain features of a wheelchair/scooter can be useful in allowing a person to reach items and carry out tasks at different surface heights. I will ask you to demonstrate these tasks.
There are a total of three tasks and I will provide you with instructions before each one. Please wait until I say ***READY*** before you begin a task.
If there are assistive devices you usually use when you reach for items, feel free to use them." *[Wait for response]*

Task Instructions & Therapist Task Guide

1. **High** **↓** **Mid-Level**	**Please describe how you would retrieve _*_ from here** *[Point to item on surface above Ss shoulder height -- within Ss arm's length]* **and then place it here** *[Point to surface at Ss shoulder level -- directly below area where item was retrieved] [Wait for response].* **Now show me. Ready?** *[Wait for response]* **Item/Location/Feature(s) Used:** __________
2. **Mid-Level** **Side → Side**	**Please describe how you would retrieve the _*_ from here** *[Point to item far back in drawer/on countertop -- at Ss shoulder level]* **and then hand it to me** *[Wait for response].* **Now show me. Ready?** *[Therapist holds out hand, palm up, approximately arm's length away from Ss -- at the same height as the drawer/ countertop, but on opposite side Ss used to retrieve item]* **Item/Location/Feature(s) Used:** __________
3. **Deep** **Mid-Level** **↑** **Floor**	**Please describe how you would retrieve the _*_** *[Point to item on floor]* **and then place it here** *[Point to nearby counter/table surface at Ss shoulder level -- just beyond Ss arm length] [Wait for response].* **Now show me. Ready?** *[Wait for response]* **Item/Location/Feature(s) Used:** __________

*Retrieve _*_ = Item identified by therapist; Ss = Subject/Subject's

SCORE	INDEPENDENCE DATA	SAFETY DATA	
3	No assists given for task initiation, continuation, or completion	**SP** = Safe practices observed	**SM** = Acceptable (Standards met)
2	**VA** = No physical assists given, **but ≤ 2** verbal assists or **≤ 2** visual assists; **or ≤ 4** verbal and visual assists given	**MR** = Minor risks evident – no assistance provided	**IP** = Acceptable (Standards met – improvement possible)
1	**V^SA** = **≤ 2** physical assists given, **but no** total assistance; or **3** verbal assists or **3** visual assists, **or ≥ 5** verbal and visual assists given	**PH** = Risks to safety evident – assistance provided to prevent potential harm	**PM** = Marginal (Standards partially met)
0	**PA** = **3** physical assists given; **or** total assistance required for task initiation, continuation, or completion	**SR** = Severe risks evident – assistance provided to prevent harm	**NM** = Unacceptable (Standards not met)

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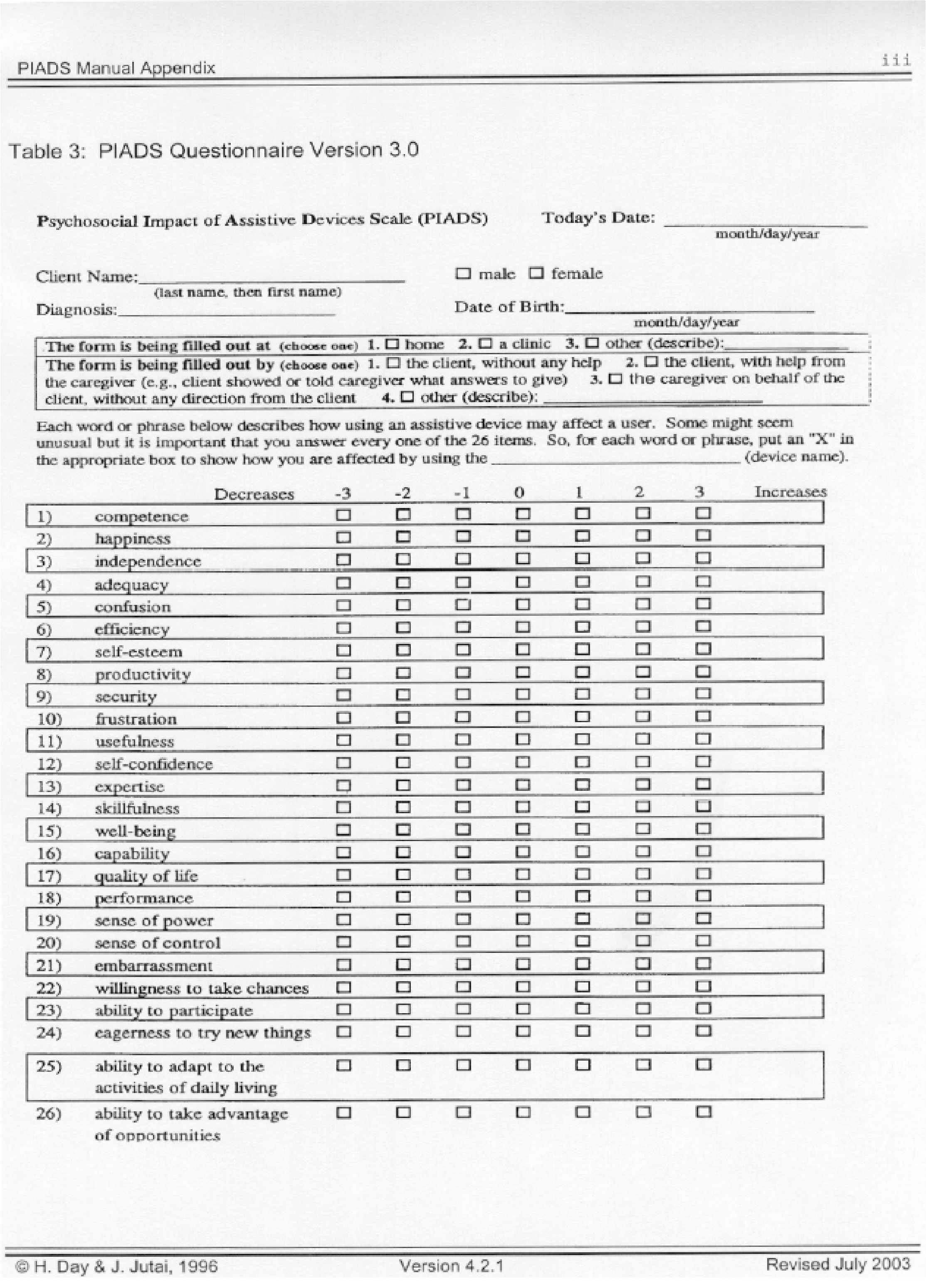
Appendix G



PIADS Manual Appendix iii

Table 3: PIADS Questionnaire Version 3.0

Psychosocial Impact of Assistive Devices Scale (PIADS) **Today's Date:** ____________________ month/day/year

Client Name:______________________ (last name, then first name) ☐ male ☐ female

Diagnosis:______________________ Date of Birth:______________________ month/day/year

The form is being filled out at (choose one) **1.** ☐ home **2.** ☐ a clinic **3.** ☐ other (describe):____________

The form is being filled out by (choose one) **1.** ☐ the client, without any help **2.** ☐ the client, with help from the caregiver (e.g., client showed or told caregiver what answers to give) **3.** ☐ the caregiver on behalf of the client, without any direction from the client **4.** ☐ other (describe): ____________________

Each word or phrase below describes how using an assistive device may affect a user. Some might seem unusual but it is important that you answer every one of the 26 items. So, for each word or phrase, put an "X" in the appropriate box to show how you are affected by using the ____________________ (device name).

	Decreases	-3	-2	-1	0	1	2	3	Increases
1)	competence	☐	☐	☐	☐	☐	☐	☐	
2)	happiness	☐	☐	☐	☐	☐	☐	☐	
3)	independence	☐	☐	☐	☐	☐	☐	☐	
4)	adequacy	☐	☐	☐	☐	☐	☐	☐	
5)	confusion	☐	☐	☐	☐	☐	☐	☐	
6)	efficiency	☐	☐	☐	☐	☐	☐	☐	
7)	self-esteem	☐	☐	☐	☐	☐	☐	☐	
8)	productivity	☐	☐	☐	☐	☐	☐	☐	
9)	security	☐	☐	☐	☐	☐	☐	☐	
10)	frustration	☐	☐	☐	☐	☐	☐	☐	
11)	usefulness	☐	☐	☐	☐	☐	☐	☐	
12)	self-confidence	☐	☐	☐	☐	☐	☐	☐	
13)	expertise	☐	☐	☐	☐	☐	☐	☐	
14)	skillfulness	☐	☐	☐	☐	☐	☐	☐	
15)	well-being	☐	☐	☐	☐	☐	☐	☐	
16)	capability	☐	☐	☐	☐	☐	☐	☐	
17)	quality of life	☐	☐	☐	☐	☐	☐	☐	
18)	performance	☐	☐	☐	☐	☐	☐	☐	
19)	sense of power	☐	☐	☐	☐	☐	☐	☐	
20)	sense of control	☐	☐	☐	☐	☐	☐	☐	
21)	embarrassment	☐	☐	☐	☐	☐	☐	☐	
22)	willingness to take chances	☐	☐	☐	☐	☐	☐	☐	
23)	ability to participate	☐	☐	☐	☐	☐	☐	☐	
24)	eagerness to try new things	☐	☐	☐	☐	☐	☐	☐	
25)	ability to adapt to the activities of daily living	☐	☐	☐	☐	☐	☐	☐	
26)	ability to take advantage of opportunities	☐	☐	☐	☐	☐	☐	☐	

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Appendix H

Focus Group Questions

1. Tell us a little bit about yourself, and about using a power wheelchair.
    a. Have you always used a manual *and* power wheelchair?
    - *Tell us about your experience using power mobility: how long have you used it, what kind of device do you use (w/c or scooter) and why you use it instead of manual wheelchair.*
2. What was your experience using the PAPAW (power assist wheelchair)?
    a. How did your experience compare with using your power wheelchair?
    b. What activities do you use your power wheelchair to complete?
    - *Did it feel different using the PAPAW?*
    - *What did you like and not like about the PAPAW?*
    - *From the questionnaires, many of you reported high satisfaction using the PAPAW device, even though your performance of activities was lower. What was it about the PAPAW that made it attractive, even if the performance wasn't superior?*
    - *You seemed to like the device itself. Was your opinion or satisfaction with the PAPAW* ***in general (overall)*** *different than for* ***specific tasks or activities****?*
3. Do you think other people in the community see you differently when you use a manual/PAPAW wheelchair, compared to using a power wheelchair?
    - *One focus of this study was your ability to* ***participate*** *in your community and be an active member in society. The questionnaire results suggest that* ***quality of life, self-esteem, and the ability to participate*** *in society was not enhanced using the PAPAW, as much as with a power wheelchair/scooter. Can you comment on your experience?*
4. Would you see PAPAW as an alternative to (or replacement for) using a power wheelchair?
    a. For yourself, or for other people with a mobility impairment?
    b. What are barriers in the community to using a power wheelchair/PAPAW?
5. What advice would you suggest to the designers of the PAPAW?
    a. What would you like to see changed/different with the PAPAW?
    b. Is there anything you wanted to say that you did not get a chance to?

Appendix I

Detailed Experimental Protocol

1. Greet the participant and provide them with a general overview of the purpose and intent of the research study. Briefly explain the procedure as outlined in the Protocol.
2. Provide the participant with a copy of the Information and Consent Form to read and answer any questions they may have. Have the participant sign the Information and Consent Form. The study cannot proceed without the participant signing this form. Print the participants name on the appropriate line, as well as the date and sign on the Investigator line.
3. Complete relevant sections of the Research Study Participant Cover Sheet and ensure there is a Participant Number assigned. Place in the Participants' folder, with two (2) copies of each outcome measurement tool (i.e. COPM, QUEST, PIADS, FEW). Each pair of outcome measurement tools should have the Participant Number and either PW or PAPAW written clearly on the front page.
4. Indicate to the participant whether they will begin the study using PW or PAPAW, and document this on the Participant Cover Sheet.
5. Complete steps 1 and 2 of the COPM. This involves identifying activities, occupations and roles that the participant currently uses their power wheelchair to perform, rather than their manual wheelchair. This is completed using a semi-structured interview process. Explain to the participant that you are trying to identify activities they choose to perform using their power wheelchair instead of their manual wheelchair. These activities are generally performed outside of the home – in the community – and can be related to self care, productivity or leisure. Examples of each of these categories can be provided to guide the participant, as well as use of general interviewing strategies and skills. Indicate that these should be activities they would normally expect to participate in at least once in a typical three week period. Activities should not be used if the participant does not expect they will perform them during **each** of the three-week study blocks. If the participant identifies *less* than five activities, document those activities on the COPM in the section labeled Occupational Performance Problems. If the participant identifies *more* than five activities, the Importance rating scale is used. Show the participant the rating card and indicate "1" represents "not important at all" and "10" represents "extremely important". Ask the participant to rate each of their identified activities, using a whole number between 1 and 10 on the scale. Select the five activities with the highest ratings. If there are still more than five activities because of tied scores, ask the participant to rank the activities that are tied in score from higher to lower and select the highest rated activities until a total of five activities are obtained. Document these five activities on the COPM in the section labeled Occupational Performance Problems.
6. If the participant is beginning the study using PW, go to step 13 and return to step 6 when the participant commences PAPAW. If the participant is using PAPAW, make the necessary adaptations to their manual wheelchair. Replace the existing axle plate with the appropriate PAPAW bracket. Retain any hardware removed

from the participant's wheelchair and place in a secure container with the participant's name and number clearly labeled. This hardware will be retained by the investigator and returned to the participant's chair at the conclusion of the PAPAW portion of the study. Ensure that the PAPAW and the participant's own wheels fit securely on the wheelchair, and can be inserted and removed appropriately. The gap between the wheelchair frame and the PAPAW should be minimized, without impeding performance or use of the wheelchair. Ensure that there are appropriate anti-tippers on the participant's wheelchair, and that they prevent the wheelchair from tipping over backward under normal circumstances. Ensure that the batteries in the PAPAW are fully charged. The investigator will briefly trial the wheelchair in PAPAW configuration to ensure safe and proper performance.

7. Train the participant in maintenance of the PAPAW. All instruction should include both verbal explanation and physical demonstration, and cover the following areas:
    a. Removing and replacing the PAPAW and manual wheels. The participant may not be able to perform this independently, but should know the process and be able to instruct someone else in this action.
    b. The battery charging procedure. This should include the battery level display and a reminder to recharge the batteries every night.
    c. Turning the PAPAW on and off, and changing the power setting.
    d. The warning sounds and what they indicate.
8. Train the participant in operation of the PAPAW. Ask the participant to transfer into the PAPAW and then turn it on. Ask the participant to change the power setting from high to low and low to high. Provide verbal instruction on propelling the PAPAW, indicating that less force is required than with a manual wheelchair and that the participant should anticipate the wheelchair may lurch forwards during this period of training as they adapt to it. Begin training on the low power setting. Ask the participant to try propelling the PAPAW in an open area, where possible, and stand immediately next to the participant during this training to ensure safety. Have the participant practice propelling in a straight line, stopping, turning and (where available) up and down a grade. When the participant is able to perform these functions independently, repeat the process at the high power setting. Training is complete when the participant can perform these functions independently at low and high power settings, and indicates they feel confident enough to continue practicing without the investigator.
9. Explain to the participant that the PAPAW can still be propelled manually, should the batteries lose their charge, or if the participant turns the power off. Explain that they should turn the PAPAW off when not in use to prolong the battery charge, and that both wheels need to be turned off. Explain that the PAPAW will also turn itself off after a period of disuse.

10. Adjust the performance settings on the PAPAW to the participant's preferences. This includes the sensitivity of the pushrim activation force and the overall power assist setting.
11. Provide the participant with a copy of the PAPAW owner's manual, and a quick reference sheet.
12. Tell the participant that they should contact the investigator if they have any questions about the PAPAW, any technical problems related to the PAPAW, or they have any concern about the study. Indicate that the investigator will make all reasonable efforts to address any of these issues as quickly as possible, but cannot guarantee an immediate response. Instruct the participant about attempting to perform activities using the PAPAW:

    > **"I want you to try to use the PAPAW for all of the activities you normally use your power wheelchair for, including those we listed earlier - but also any others. If you feel unsafe performing any of your daily activities in the PAPAW instead of your power wheelchair, you can choose to use the power wheelchair. In this case, try to use the PAPAW for whatever activities you do feel safe performing. If this situation occurs, please contact me immediately and we can talk about how to proceed."**

13. Provide the participant with the investigator contact information, including telephone number and email address. Tell the participant that you will be returning in three weeks to complete a series of questionnaires and assessments.
14. At the three week follow-up appointment, greet the participant and briefly review the intent of the study again. Complete the COPM, QUEST, PIADS and FEW according to the detailed instructions following the protocol.
15. Update the Participant Cover Sheet as appropriate. Give the participant their $20 gift certificate.
16. If the participant is progressing to the PW section of the study, remove all PAPAW equipment from the manual wheelchair and replace the participant's original parts from the secured container. Ensure that the wheelchair performs appropriate, as it did prior to the PAPAW modification. Ensure the participant is satisfied with the adjustment. If the participant is progressing to the PAPAW section of the study, complete steps 6 through 15 before proceeding to step 17.
17. After the participant has completed both the PAPAW and PW sections of the study, and all data has been collected, thank them for their participation. Tell the participant that you will be contacting them again to participate in a focus group, and will try to arrange a time and location that is convenient for all of the study participants. Tell the participant that they will be reimbursed for expenses to attend the focus group, including parking and/or transportation, and will receive the remaining $10 gift certificate at that time.
18. Contact all participants and ask them what dates, times, and locations would be convenient to attend a focus group. After all participants have been contacted, determine the date, time and location that allows the greatest number of

participants to attend. Contact all participants and tell them the date, time and location of the focus group, and encourage them to attend. Indicate that they can contact the investigator to assist with any arrangements or special needs for participation. Send a letter with the date, time and location to each participant in advance of the focus group.

19. Complete the focus group as outlined in the detailed instructions following the protocol.
20. Give each participant their $10 gift certificate and thank them for their time and participation.

Protocol for Administering the QUEST

1. The investigator will complete the cover sheet indicating "Power Wheelchair" or "PAPAW" beside device; participant identification number beside user name and date of assessment.
2. The investigator will review the instructions with the participant:

   "The purpose of the QUEST questionnaire is to evaluate how satisfied you are with your power wheelchair/PAPAW. The questionnaire consists of eight satisfaction items. For each of the eight items, rate your satisfaction with your power wheelchair/PAPAW by using the following scale of 1 to 5 [show participant the scoring scale]. Please circle or mark the one number that best describes your degree of satisfaction with each of the eight items. Do not leave any question unanswered. For any item that you were not 'very satisfied', please comment in the section *comments*. Do you have any questions?"

3. Provide any clarification as needed.
4. Tell the participant that one portion of the QUEST (relating to services) has been removed since it is not being investigated in the study, and they should ignore any references to "Services".
5. Ask the participant if they would like to fill it out themselves, or would like the investigator to mark the answers and write their comments.
6. When the participant is done, ensure that all of the questions are competed and have the participant finish any questions unanswered.
7. Instruct the participant to complete the last section of the QUEST. Ensure that the Service items have been occluded and the participant is only selecting from the Device items in the list.

   "This is a list of the same eight satisfaction items. Please select the three items that you consider to be the most important to you. Please put an X in the 3 boxes of your choice."

8. Ensure that the participant has identified 3 boxes. If they have selected less, prompt them until they select three. If they have selected more, ask them to remove the less important items until only three remain.
9. Tell the participant:

   "Thank you. That completes this assessment tool."

Protocol for Administering the FEW

1. Complete the cover sheet, indicating the device ("Power wheelchair" or "PAPAW"), date of assessment and the participant identification number.
2. Explain to the participant the purpose of the tool:

   > **"The FEW is an assessment tool designed to measure your ability to function while using a wheelchair. It involves two parts. The first part asks you about your ability to function while in your wheelchair. In the second part, you will perform some simple activities, and I will watch you and measure how independently you can do them. Do you have any questions?"**

3. Provide any clarification as needed.
4. Part 1. Read the instructions with the participant:

   > **"Please answer the following 10 questions by placing an 'X' in the box under the response that best matches your ability to function while in your wheelchair/scooter/PAPAW. All examples may not apply to you, and there may be tasks you perform that are not listed. Mark each question only one time. If you answer "slightly, mostly or completely disagree for any question, please circle the feature(s) contributing to your disagreement, and write the reason for your disagreement in the Comments section. Here is a form that may help you with deciding which response applies to you [show participant the rating scale]. Do you have any questions?"**

5. Ask the participant if they would like to complete the form independently, or with the assistance of the investigator.
6. Compete or have the participant complete the FEW Part 1. Ensure that all of the questions are completed.
7. Part 2. Explain this portion of the assessment:

   > **"In this part of the assessment, I will ask you to perform some simple tasks. I want you to try to do them on your own, without any help. If you need help, let me know. I will provide assistance if I think it is required."**

8. Subtask 1. Place a common object on a surface at least at shoulder height, but not beyond the comfortable range of motion of the participant. Identify a surface at approximately waist level, also within the comfortable range of motion of the participant. Instruct the participant:

   > "**I want you to grasp this object from here [point to object on high surface] and place it carefully on this surface [point to level surface]. Try to do this without moving your wheelchair, but you may move your wheelchair if you need to. You can go ahead now."**

9. Observe participant, and score the FEW under the INDEPENDENCE DATA column. If the participant performs the activity efficiently (within 1 try, without dropping) and adequately (holds and places securely, does not over-reach or reposition wheelchair), score “3”. If they require verbal assistance, circle VA next to the item and score “2”. If they require visual assist, circle V^SA next to the item and score “1”. If they require physical assistance, circle PA next to the item and score “0”.
10. Subtask 2. Place a common object on a surface at waist level, but within the comfortable range of motion of the participant. Instruct the participant:

    > **“I want you to grasp this object from here [point to object on the level surface] and hand it to me. Try to do this without moving your wheelchair, but you may move your wheelchair if you need to. You can go ahead now.”**

11. Observe participant, and score under the INDEPENDENCE DATA column. If the participant performs the activity efficiently (within 1 try, without dropping) and adequately (holds and places securely, does not over-reach or reposition wheelchair), score “3”. If they require verbal assistance, circle VA next to the item and score “2”. If they require visual assist, circle V^SA next to the item and score “1”. If they require physical assistance, circle PA next to the item and score “0”.
12. Subtask 3. Place a common object on the floor, but not beyond the comfortable range of motion of the participant. Identify a surface at approximately waist level, also within the comfortable range of motion of the participant. Instruct the participant:

    > **“I want you to grasp this object from here [point to object on floor] and place it carefully on this surface [point to level surface]. Try to do this without moving your wheelchair, but you may move your wheelchair if you need to. You can go ahead now.”**

13. Observe participant, and score under the INDEPENDENCE DATA column. If the participant performs the activity efficiently (within 1 try, without dropping) and adequately (holds and places securely, does not over-reach or reposition wheelchair), score “3”. If they require verbal assistance, circle VA next to the item and score “2”. If they require visual assist, circle V^SA next to the item and score “1”. If they require physical assistance, circle PA next to the item and score “0”.
14. Explain to the participant that you will now have them perform two transfers. Ask the participant to identify a transfer in the current environment that is easy for them to perform (e.g. wheelchair to chair), and a transfer that is more complex (e.g. wheelchair to car).
15. Subtask 1. Ask the participant to perform the easier transfer from their wheelchair:

    > **“I want you to transfer from your power wheelchair/PAPAW to [location of easier transfer]. You can go ahead now.”**

16. Observe participant, and score under the INDEPENDENCE DATA column. If the participant performs the activity efficiently, adequately and with ease (according to scoring sheet guidelines) score “3”. If they require verbal assistance, circle VA next to the item and score “2”. If they require visual assist, circle $V^{S}A$ next to the item and score “1”. If they require physical assistance, circle PA next to the item and score “0”.
17. Subtask 2. Ask the participant to perform the easier transfer back to their wheelchair:

    > **“I want you to transfer from [location of easier transfer] to your power wheelchair/PAPAW. You can go ahead now.”**

18. Score as per step 16.
19. Subtask 3. Ask the participant to perform the complex transfer from their wheelchair:

    > **“I want you to transfer from your power wheelchair/PAPAW to [location of complex transfer]. You can go ahead now.”**

20. Score as per step 16.
21. Subtask 4. Ask the participant to perform the complex transfer back to their wheelchair:

    > **“I want you to transfer from [location of complex transfer] to your power wheelchair/PAPAW. You can go ahead now.”**

22. Tell the participant that the assessment is complete.

Protocol for Administering the PIADS

1. Complete the cover sheet indicating "Power Wheelchair" or "PAPAW" beside device; participant identification number beside user name and date of assessment.
2. Explain to the participant the purpose of the tool:

   > **"The PIADS is a self-rating scale designed to measure the impact of assistive devices, like a power wheelchair or a PAPAW, on the quality of life of the users of these products. The PIADS measures quality of life in terms of *adaptability*, or attitudes towards social participation; *competence*, or ability to perform activities independently; and *self-esteem*, or self-confidence and emotional well-being."**

3. Review the instructions with the participant, as written on the cover sheet:

   > **"Each word or phrase below describes how using an assistive device may affect a user. Some might seem unusual but it is important that you answer every one of the 26 items. So, for each word or phrase, put an 'x' in the appropriate box to show how you are affected by using the power wheelchair/PAPAW. The boxes on the left mean your device decreases the affect and the boxes on the right mean your device increases the affect. The box in the middle marked '0' means the device neither increases nor decreases how you are affected."**

4. Ask the participant if they have any questions, and provide clarification as needed.
5. Ask the participant if they would like to complete the form independently, or with the assistance of the investigator.
6. Ensure that all of the questions are competed. If the participant has questions out, ask them to complete them, making their best judgment.
7. Tell the participant:

   "Thank you. That completes this assessment tool."

Protocol for Administering the COPM

1. Complete the cover sheet indicating "Power Wheelchair" or "PAPAW" beside device, participant identification number beside user name, and date of assessment. Ensure the Occupational Performance Problems (OPP) are written in the assessment form.
2. Show the participant the COPM scoring sheet, with the five (or less) Occupational Performance Problems they identified at the outset of the study. Remind them of the purpose of the tool:

   "The COPM is a tool designed to identify which activities are most important to you, and measure how well you feel you can perform these activities and how satisfied you are with your performance. At the beginning of the study we identified [number] activities that you use your power wheelchair to perform. Now you are going to rate your performance and satisfaction with these activities, using your power wheelchair/PAPAW."

3. Explain to the participant rating of performance:

   "First, we will consider performance. I want you to rate each of these activities using this scale [show participant the Performance rating scale]. "1" means you are not able to do it at all and "10" means you are able to do it extremely well. How would you rate the way you do this activity now, using your power wheelchair/PAPAW?"

4. Document the participants rating score in the box next to the activity, in the PERFORMANCE 1 column. Repeat steps 3 and 4 for the remaining activities listed under OPP.
5. Explain to the participant rating of satisfaction:

   "Now, we will consider satisfaction. I want you to rate each of these activities using this scale [show participant the Satisfaction rating scale]. "1" means you are not satisfied at all and "10" means you are extremely satisfied. How satisfied are you with the way you do this activity now, using your power wheelchair/PAPAW?"

6. Document the participants rating score in the box next to the activity, in the SATISFACTION 1 column. Repeat steps 3 and 4 for the remaining activities listed under OPP.
7. Total the scores in the PERFORMANCE and SATISFACTION columns, and document below each column in the SCORING section. Divide each total by the number of OPPs, and document in the dotted box in the SCORING section.
8. Tell the participant:

   "Thank you. That completes this assessment tool."

Protocol for Focus Group

1. At the focus group, arrange participants in a circle or similar arrangement such that they can all see each other and the facilitator. Greet the participants, and explain the purpose of the focus group and general expectations for behaviour.

   "Thank you all for coming to the focus group today. I appreciate the time and effort you have all put into this research study. The purpose of this focus group is to share your experiences using the PAPAW during this research study. Your experiences may be very similar or very different. All of your experiences are important, so don't be afraid to share what you think. I will be asking a series of questions over the next one to one and a half hours. These questions are for everyone. You can talk to me, or you can talk to each other. There are refreshments on the table. Please feel free to get something now, during the group, or afterwards. If you need any assistance, I will be happy to help you."

2. Tell the participants that the focus group will be audiotaped:

   "I will be using this tape recorder to record the focus group. I am doing this so that I can focus on listening to what you are saying, rather than trying to write it down. You might find this a little distracting at first, but most people forget about it once we get talking. After the focus group is over, I will transcribe everything into written text. The things that you say will be identified by your participant number, not your name, so no one other than me will know who said what. I will summarize everything said here today, and will send each of you a copy. If you think something is inaccurate or doesn't reflect what is said here today, you can contact me and we will make any changes required. Do you have any questions before we begin?"

3. Turn on the tape recorder(s).
4. Ask questions as per question outline. Use introductory questions, and if required, pursue with follow-up questions.
5. When all questions have had sufficient discussion, and time is up, briefly summarize the session, and thank individuals for their participation. Invite participants to stay for remaining refreshments and interaction, if desired.
6. Turn off tape recorder(s).
7. Give each participant their $10 gift certificate.

Appendix J

Research Study Participant Cover Sheet

Participant Number: ______________
Name: __________________________
Sex: ☐ Male ☐ Female
Age: _____________
Primary Diagnosis: ____
Secondary Diagnosis: ____
Years using a manual wheelchair: _____ power wheelchair: _____
Device Sequence:
☐ 1. PAPAW 2. Power Wheelchair
☐ 1. Power Wheelchair 2. PAPAW
Enrolment Source:
☐ CPA
☐ SMD
☐ Other: ____________________
☐ Consent obtained. Date: ___________________
☐ OPIs identified via COPM. Date: ___________________

PAPAW
☐ PAPAW brackets installed and operation confirmed.
☐ Anti-tippers in place.
☐ PAPAW training completed.
☐ Contact information provided.
☐ PAPAW section commenced. Date: ___________________
☐ PAPAW section completed. Date: ___________________
☐ Data collection completed Date: ___________________
☐ Gift certificate provided Date: ___________________
☐ PAPAW equipment removed and original operation confirmed.
Signature: ________________

PW
☐ PW section commenced. Date: ___________________
☐ PW section completed. Date: ___________________
☐ Data collection completed Date: ___________________
☐ Gift certificate provided Date: ___________________
Signature: ________________

Focus group
☐ Contacted re: date and location Date: ___________________
☐ Follow-up letter: date and location Date: ___________________
☐ Attended focus group Date: ___________________
☐ Reimbursement for:
  ☐ Parking Amount: _____________
  ☐ Transportation Amount: _____________
☐ Gift certificate provided Date: ___________________
Signature: ________________
☐ Summary of focus group mailed Date: ___________________

Appendix K

Handbook for Using the Pushrim-Activated Power Assist Wheels (PAPAW)

Problems

If you have any problems with the PAPAW, please contact **Ed Giesbrecht** immediately. Normally, I am in the office **Monday - Friday from 8:00 - 4:00**.
Telephone: **(204)** [redacted]
Email: [redacted]

If it is an **emergency**, and you need to get a hold of me **outside of office hours**, call me at home at **(204)** [redacted].

What if something goes wrong with the PAPAW?

If the batteries in the PAPAW run out or the PAPAW malfunctions, you can ***still push it like your regular manual wheelchair***. The PAPAW wheels are heavier than your regular wheels, so it will be **more difficult** to push. You may want to ask someone else to push you if you have a long distance to travel or you are tired. If you have your regular wheels close by (and are able to transfer out of the wheelchair temporarily) you may want to take the PAPAW wheels off and replace them with your own manual wheelchair wheels.

If you have any technical issues with the PAPAW equipment, please **call me at my office at (204)** [redacted] and I will come out and resolve them as quickly as possible.

What if I don't want to use the PAPAW anymore?

The purpose of this research study is to compare your experience using the PAPAW and using your power wheelchair. You should try, as much as possible, to use the PAPAW for the activities that we identified at the beginning of the study. **However, you can choose to stop using the PAPAW at any time during the study if you feel you need or want to.**

If you do decide you want to stop using the PAPAW, even for one activity, please **call me at my office at (204)** [redacted] so we can discuss it. I promise that I will not pressure you into changing your mind – knowing *why* you stopped is also important to this study and it may be possible to change your wheelchair set-up to resolve the issue!

Note: Images courtesy of http://www.ulrichalber.de/html_e/html_prod_emotion_e/ab_set_e.html and http://www.alber.de/produkte/e-motion.php. Copied with permission from Ulrich Alber GmbH.

General Guidelines for Using the PAPAW

If you are using a **cell phone**, turn your PAPAW off. When turned on, a cell phone emits electromagnetic signals, which could potentially interfere with or accidentally activate the PAPAW. However, the likelihood of this happening is **very low**.

Always **apply the brakes** on your wheelchair when you are turning the PAPAW off or on; when transferring in/out of your wheelchair; and when removing the batteries.

In addition to making the wheelchair easier to push, the PAPAW wheels can help to **slow the chair down** when you are going down a decline (e.g. ramp) and reduce the friction between your hand and the handrim. Holding onto the handrims gently and intermittently will help to slow the wheelchair. Alternating left and right hands is sometimes helpful.

Always have anti-tipper devices in place, with the anti-tip guards pointing down towards the ground, when using the PAPAW. It is possible to tip the wheelchair over backwards when propelling with the PAPAW, particularly when you begin pushing from a standing start.

Always **turn the PAPAW off** when you do not need assistance pushing your wheelchair. This will keep the batteries charged for a longer period of time, and reduce the chances that you will run out of electrical power when you need it. If you are stopping to do some work or look at something for awhile (e.g. 5 minutes or longer), turn the PAPAW off. You can turn it on again when you're ready to go.

Do not turn the PAPAW off if you are only pausing for a minute or two (e.g. waiting for an elevator) – you want it to be ready when you need it. If you forget to turn the PAPAW off, it will turn itself off after 30 minutes, but the battery charge will run down more quickly than if you turn it off and on yourself.

Check the battery level frequently. The indicator lights will let you know how much charge is left in the batteries and approximately how much longer you have until the batteries are discharged (see chart on page 5 – charging the batteries).

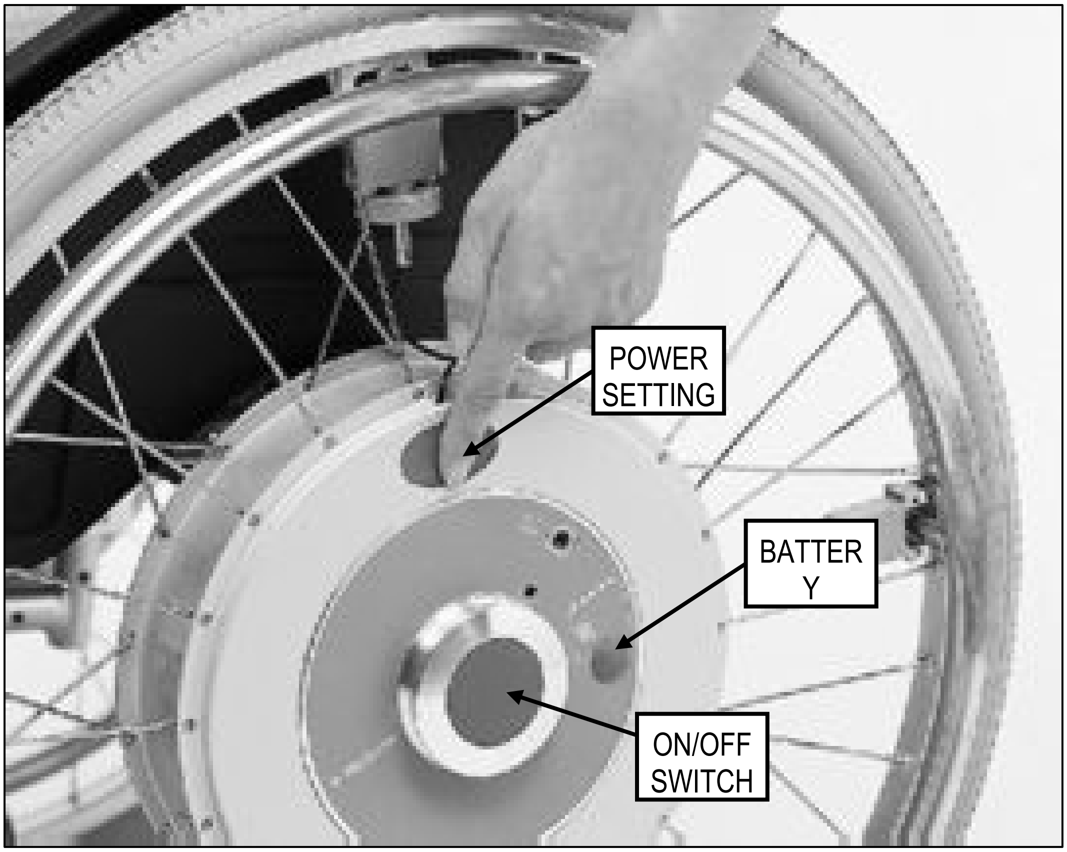
Extending the Range of the PAPAW

The batteries in the PAPAW do not last as long as those in your power wheelchair. The way you use your wheelchair will affect how long the batteries stay charged. Under normal circumstances, the range of the PAPAW is approximately 8 km.

- The **Indoor (low) power setting** (see "Changing the Power Setting") uses less energy than the Outdoor (high) setting. If you only need a moderate amount of power assist, use the Indoor setting and the battery charge will last longer.

- In particular, moving around in a confined area (with frequent stop and go) while the PAPAW is in Outdoor mode takes a lot of power from the batteries. Try to use the Indoor setting whenever you have to maneuver around in a tight space.
- Try to propel your wheelchair with smooth, even strokes. Short, quick push strokes use more power. Let the motors carry you a distance before pushing on the rims again.
- Try not to ‘hang’ on to the pushrim, this can cause the PAPAW to start braking, which slows the wheelchair down and uses more battery power.
- Making frequent adjustments (pushing on one wheel to keep the wheelchair going straight) uses more battery power.
- Going over bumpy surfaces, up and down inclines, and use in windy conditions will decrease the range of the PAPAW.
- If the tires are not fully inflated, more power is used from the batteries. Ensure that the tires are fully inflated and that the wheelchair is in good working condition.

Using the PAPAW



Turning the PAPAW on and off.

1. Pushing the **large, flat, blue button** in the **middle** of the wheel hub will turn the PAPAW on. You will hear a “beep” when this happens. Immediately following this, you will hear another one or two “beeps”, indicating what the current power setting is at.
2. If you push the blue button a second time, the PAPAW will “beep” again and turn off (and it will operate like a regular manual wheelchair).

Changing the Power Setting

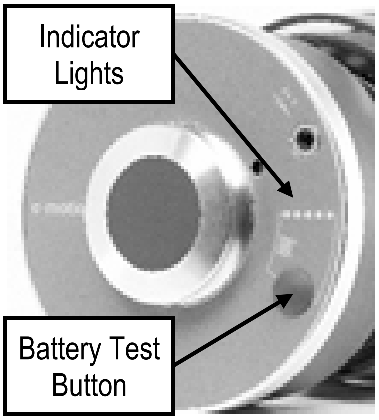
The PAPAW can operate at two different power settings: **Indoor (low) and Outdoor (high)**.

The **Indoor** setting provides some assistance when you are propelling your wheelchair, but the PAPAW is not as sensitive and it is easier to manage in small or narrow spaces. This setting is often used indoors, when you are going short distances and want to maneuver around obstacles. Use the Indoor setting whenever possible, to increase the range of the PAPAW. You may want to use the Indoor setting for the first day or two, or until you feel comfortable with using the PAPAW.

The **Outdoor** setting provides much more assistance when you are propelling your wheelchair, so you go faster and don’t have to push as often. This setting is often used outdoors, in large open spaces, when having to go up an incline or ramp, or when rolling over thick carpet. The PAPAW is more sensitive in the Outdoor setting, so when you try to move a small distance in tight spaces, it can have a tendency to ‘lurch’ or ‘take off on you’, and therefore is more difficult to control in tight spaces or narrow hallways.

1. To change the Power Setting, press the **raised button** located near the **outer edge** of the wheel hub. This button is clear in colour, but is located on a blue oval shape.
2. Each time you press the Power Setting button, the PAPAW will flip between the Indoor and Outdoor settings. When you hear **two “beeps”,** the PAPAW is in the **Outdoor** setting (full power). When you hear **one “beep”,** the PAPAW is in the **Indoor** setting (partial power).

Checking the Battery Level



The battery in each PAPAW wheel has a button to check the level of power left. This button is a **small, round, blue button** near the **edge** of the removable battery. When you press this button, the **indicator lights** will come on next to the button. The chart below tells you approximately how much charge is left in the battery. If you are running very low, the PAPAW wheel will alert you with a series of 4 warning "beeps". The PAPAW will continue to give this warning until the battery charge is too low, and the PAPAW will then automatically shut off, signaled by one long, continuous "beep". This protects the batteries from permanent damage, but the PAPAW cannot be turned on again until the batteries are recharged. If you are down to one blinking red light, you should try to get to your battery charger as soon as possible.

Lights turned on	Power left
2 green lights on	60 – 100%
2 orange lights on	20 – 60%
1 solid red light	10 – 20 %
1 blinking red light	Less than 10%

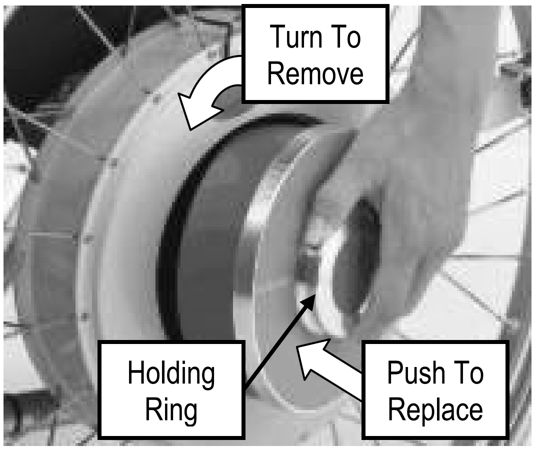
Charging the Batteries

A. Removing & Replacing the Batteries

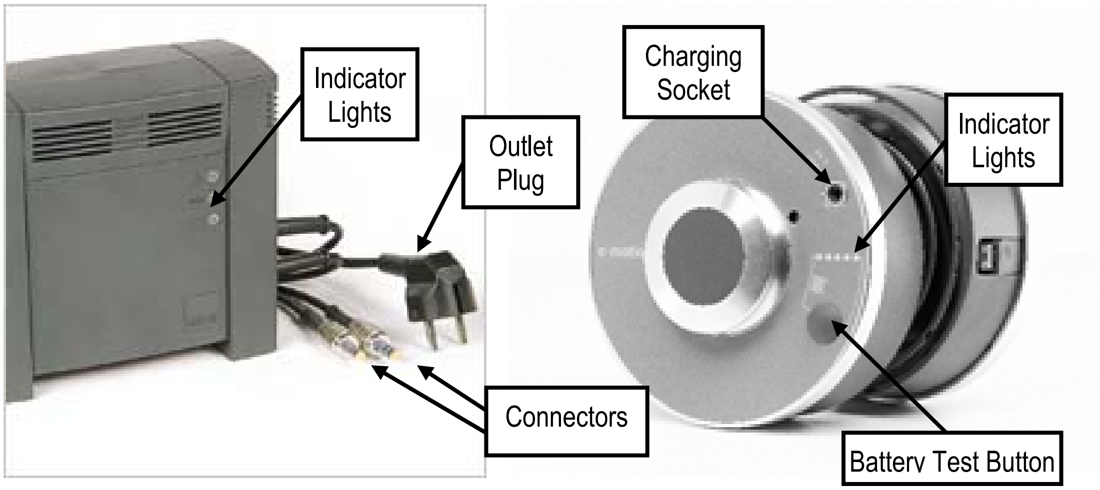
You can charge the batteries while they are still in the PAPAW wheels, or you can remove them – it makes no difference.

If you want to **remove** a battery, grasp it by the holding ring, turn it counter-clockwise (from right to left) and **gently** pull. The battery should easily pop off. Place the battery in the black plastic cover to protect it from damage and dirt.

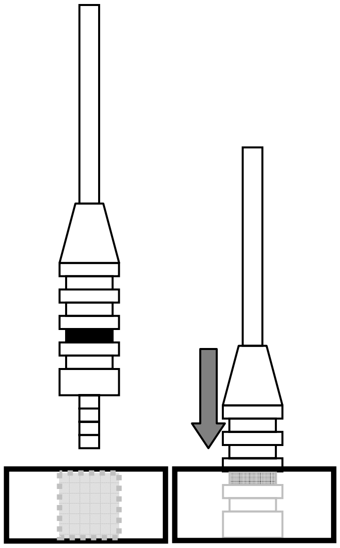
To **replace** the battery, grasp it by the holding ring and gently, but firmly, insert it into the wheel hub. You should hear a "clicking" noise as it engages. If the battery does not insert correctly, remove it and repeat the process (ensuring the blue release handle is lying completely flat). You should not have to **force** the battery.



Using the Battery Charger



1. Plug the battery charger into a wall outlet. Wait until the red indicator light comes on.
2. Remove the blue rubber plug from the charging socket on the battery.
3. Insert one of the battery charger connectors into the charging socket on the battery. Push it far enough into the socket that the red ring on the connector cannot be seen (see diagram to right).
4. The indicator light on the battery charger will change from red to yellow. This means the unit is starting to charge.
5. Repeat this process (steps 2 – 4) with the second battery.
6. When the charging unit indicator light turns green, the batteries are both fully charged. You will not damage the batteries by leaving the charging unit plugged in.
7. Replace the batteries when you are ready to use the PAPAW again.



Things to Remember

- **Check the Battery Level** on each battery **often** (by pressing the round blue Battery Test Button). This will help to prevent a situation where the batteries are not ready when you need them (for example, when only one battery is charging because of a loose connection).
- **While the batteries are charging,** check the battery indicator lights to monitor that the battery is indeed charging. When fully charged, the indicator lights will turn off. You can check them by pressing the blue button. If the batteries are not charging, remove and re-insert the connectors into the battery charging socket.

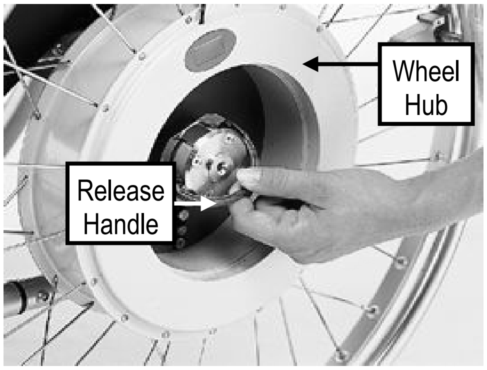
- Keep the **inside surface** (silver metal rings) of the battery **protected** – do not touch it or rest in on your lap, especially on your skin. If you remove it from the wheel hub, use the black plastic protector rings.
- **Do not store or charge** the batteries where they may be exposed to high temperatures or direct sunlight.

Transporting the PAPAW

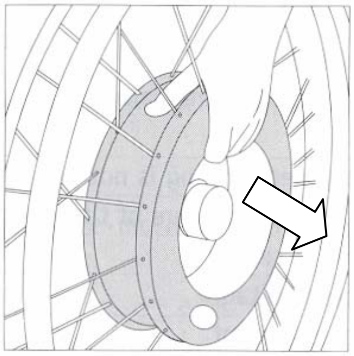
The PAPAW can be taken apart and transported in the same way your manual wheelchair is. Remove and replace *one wheel at a time*.

Disassembling the PAPAW

1. Turn the PAPAW power off.
2. Remove the battery as described in the "Removing and Replacing Batteries" section, and place it in the plastic protection cover.
3. Inside of the wheel hub, lift the blue, bow-shaped Release Handle so it is pointing straight out towards the side of the wheelchair. This unlocks the wheel from the axle. This handle should flip up very easily and stay in place. Do not force it or you may damage the mechanism. If it does not lift easily, make sure the wheel is pushed all the way into the wheelchair frame. You may need to disengage the wheelchair brake to do this.



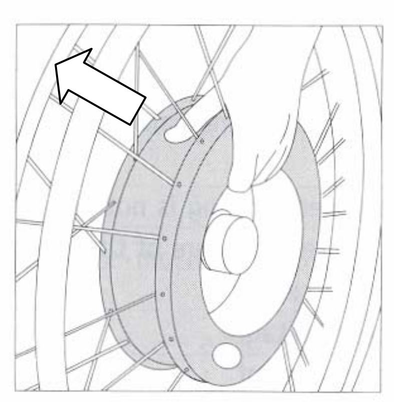
4. Make sure the wheelchair brake is off before proceeding further.
5. Grasp the wheel by the grey, metal hub and pull it sideways off of the wheelchair frame. You may have to tip the wheelchair away slightly, so that the PAPAW wheel is not touching the floor. DO NOT PULL THE WHEEL BY THE BLUE RELEASE HANDLE OR BY THE SPOKES – use the grey wheel hub only (see picture to right).



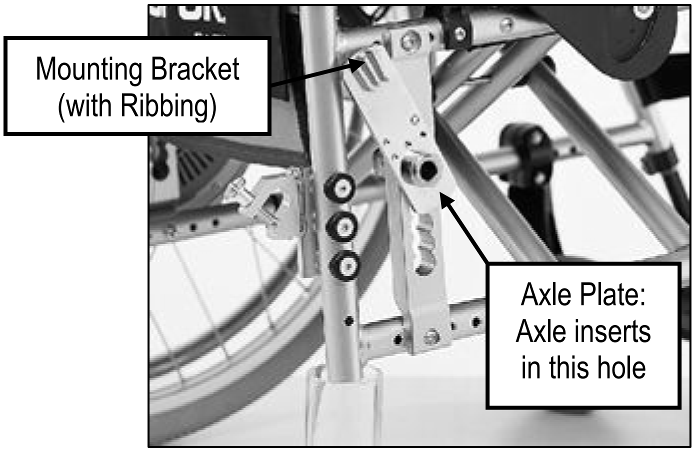
6. Once you have removed the wheel, you can gently lower the wheelchair frame to the floor, where it can rest on the anti-tipper device.
7. Repeat steps 2 through 6 for the remaining PAPAW wheel.
8. Collapse the wheelchair as you normally would for transport.
9. Carefully pack the wheelchair frame, PAPAW wheels and batteries in your vehicle. Be careful not to damage the PAPAW wheels, particularly the axles and the inside of the wheel hub (where the battery inserts). Do not allow the disassembled pieces to get wet during transport.

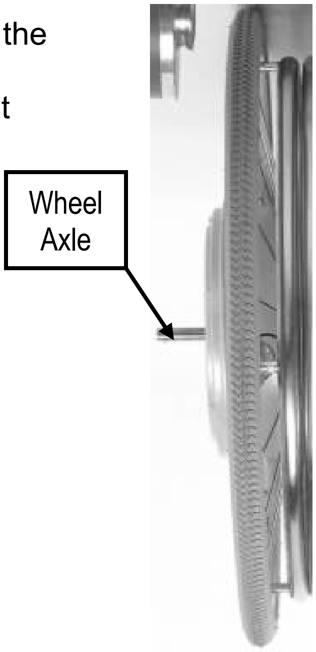
Reassembling the PAPAW

1. Return the wheelchair frame to its normal configuration (i.e., fully unfolded).
2. Make sure the wheelchair brake is in the “off” position, so it does not get in the way when you replace the wheel.
3. Take one PAPAW wheel and set it down next to the wheelchair frame.
4. Inside of the wheel hub, lift the blue, bow-shaped Release Handle so it is pointing straight out towards the side of the wheelchair, taking the same precautions as with disassembling the PAPAW. The axle needs to be unlocked (i.e., blue handle “up”) for the wheel to go back on the frame.
5. Grasp the wheel by the grey, metal hub and insert the axle (i.e., long, thin rod) into the round hole (axle plate) on the side of the wheelchair frame. Remember to hold the wheel only by the grey hub.
6. Carefully, but firmly, push the wheel towards the wheelchair frame until the axle is **fully engaged**. The “**ribbing**” on the back of the PAPAW motor should interlock with the ribbing on the mounting bracket located on the wheelchair frame. You may have to tip the wheelchair away slightly, so that the PAPAW wheel is not touching the floor.



7. Flip the blue, bow-shaped Release Handle down, so that it lies flat against the inside of the wheel hub. This handle should flip down very easily and stay in place. Do not force it or you may damage the mechanism. If it does not flip easily, make sure the wheel is pushed all the way into the wheelchair frame. Ensure that the brake is disengaged, and is not getting in the way.
8. Insert the battery as described in the “Removing and Replacing Batteries” section, remembering to remove the plastic protection cover.
9. Apply the wheelchair brake on the wheel you have just replaced.
10. Repeat steps 2 through 9 with the remaining wheel.





Appendix L

Focus Group Checklist

Preparation:

- ☐ Have receipt book for parking/transit costs
- ☐ Have petty cash on hand to reimburse for parking/transit
- ☐ Have gift certificates for participation
- ☐ Have refreshment laid out (coffee, juice, water, cookies, fruit)
- ☐ Meet people at the elevator and take them to the room
- ☐ Have name cards/tents prepared for table
- ☐ Set up tape recorder – already reserved (a second back-up tape recorder?)
- ☐ Set up room for sufficient space for 4 power wheelchairs to fit around table

Session:

- ☐ Welcome
- ☐ Refreshments available – help yourself or ask
- ☐ Washroom location
- ☐ Turn off cell phones if possible
- ☐ Should last 60 – 90 minutes
- ☐ Introduce second investigator (thesis supervisor)
- ☐ Identify purpose of session: "*You all have a common experience – using the PAPAW in this research study. We want to gather more information about your individual and group experience; to allow you a chance to say what couldn't be said on questionnaires; to find out more about your opinion regarding PAPAW and power mobility."*
- ☐ First (or second) of two focus groups
- ☐ Previously given consent
- ☐ Will be audiotaped – transcribed – will received a copy to confirm accuracy
- ☐ Names will be removed (anonymity)
- ☐ Ask you to also respect confidentiality of what is said here today – to allow participants to be honest in their answers
- ☐ "Ground rules":
    1. Your experience may be similar or different to those of others.
    2. There is no right or wrong answer, and you don't need to agree.
    3. We should respect each individual's opinion.
    4. There will be an opportunity for everyone to talk.
    5. We encourage you to talk to each other, as well as to the facilitators.

Appendix M

Focus Group Summary

You participated in a research study that compared the use of a **pushrim activated power assist wheelchair** and your **current power wheelchair** for specific activities that you perform with your power wheelchair. You completed several questionnaires asking you to evaluate each wheelchair, and rate how well it worked for you. Afterwards, you participated in a focus group with other study participants. Two focus groups were held, December 1st and December 5th, involving seven of the eight study participants. The focus groups were recorded on audio tape, and later typed out word for word. This is a summary of what was discussed during the two focus groups. The comments of the participants have been sorted into common 'themes'. All references to individual study participants have been removed.

The comments fell into a number of general categories. Participants talked about the advantages and disadvantages of the two devices used in this study: the **power wheelchair/scooter (PWC)** and the **pushrim-activated power assisted wheelchair (PPW)**. The participants identified how the physical environment affected the performance of each device (PWC & PPW), including their experiences of poor accessibility in general. Finally, participants indicated a process for evaluating each device in a real-life setting before choosing which device best met their needs. The rest of this document provides a more detailed summary of these themes.

The Power Wheelchair/Scooter (PWC)

There was general agreement in both focus groups that the PWC provided some very clear advantages in terms of providing easy mobility with very little physical demand or effort. Operating the PWC was identified as being physically easy, and did not require significant strength or coordination. This ease of operation allowed the user to travel considerable distances without being concerned about getting tired. For people who had limited strength or endurance, the PWC eliminated these physical demands. The PWC also allowed the user to go fast and arrive at their destination in a fairly short period of time. The PWC was efficient and convenient to use, and did not require any pre-planning (how long will it take, how tired will I be, how much assistance might I require).

Several participants identified other advantages of the PWC. Some people identified that it was convenient to be able to operate the PWC with one hand (using the joystick), and allowed them to keep their other hand free to reach things or perform tasks. Some people identified a social or 'fun' aspect of the scooter, specifically when playing with children or grandchildren.

The Pushrim-Activated Power Assist Wheelchair (PPW)

Many of the participants said they found the experience of using the PPW a positive one. Most indicated a sense of excitement or curiosity around exploring a new option for mobility, and the impact it might have on their participation in life activities. A number of participants indicated they enjoyed the experience of doing activities in the PPW more than when they used the PWC. They suggested that although the PWC was an efficient form of transportation to get from one point to another, the PPW allowed them to interact more in what was going on around them and made the process of getting to the destination more pleasurable. Similarly, several participants suggested that using the PPW provided a sense of accomplishment in performing activities. The PWC was compared to an automobile where the user 'rides it' to get to a destination. The PPW provided an opportunity for the individual to contribute to their mobility, to feel like they were moving the chair them self, even if it was not as efficient as using the PWC. Some participants also identified the benefits of physical exercise when using the PPW.

Another area of general agreement was the advantages of the PPW over a standard manual wheelchair (MWC). While this was not the main focus of this research study, participants indicated the PPW was much easier to push than a MWC and they could go faster and further than with their MWC. Participants indicated this led to an improvement in function and level of participation, and allowed them access to new environments and experiences, compared to using the MWC. In particular, inclines and ramps were much easier to manage using the PPW, which they saw as an important achievement. Some participants identified the need for assistance from others when using their MWC (for example, when trying to get into a location that did not accommodate their PWC) and suggested that the PPW might reduce or eliminate the need for assistance in these situations.

Focus group members also identified certain features about the PPW that made it difficult to use. Several people identified that the PPW still required a lot of arm strength to push, and could be tiring after a long period of use. There was general agreement that pushing the PPW also required coordination. To hold the pushrim securely, the user needed good hand function, and a lot of coordination was required to provide an equal push on each wheel. If the user did not coordinate the push on both wheels, the PPW would veer to one side or 'fishtail'. This also made braking and managing downward slopes difficult. In particular, the high speed (full assist) mode was identified as much more challenging, and a number of participants chose not to use the PPW in high speed mode. Most participants were frustrated with the short length of time before the battery charge ran down, and expressed concern about being 'stranded' if the batteries ran out. They also noted it was much harder to push the PPW without the power assist turned on. Several participants also identified difficulty with some parts of the PPW, such as inserting and removing batteries, pressing the buttons, and getting through narrow spaces because of the extra width of the chair.

The Environment

Participants identified a number of issues in the environment that affected using the wheelchairs in real-life activities. Most participants indicated that the PWC was useful for outdoor environments, particularly over rough terrain. Inclines, roads and sidewalks, grass, and unpaved surfaces were locations that were well suited to the PWC. On the other hand, the large size and weight of the PWC made it difficult to use in small or confined places, especially indoors. The large size of the PWC also made it difficult to transport, whether by automobile or when flying (on vacation, for example). Other environmental obstacles, such as curbs, steps, or narrow entrances, made it virtually impossible to access some locations when using the PWC. The smaller size and weight of the PPW made it much easier to access confined or small environments, particularly indoors. A number of people indicated the PPW made it much easier to access outdoor environments, compared with the traditional MWC. In particular, some participants were able to manage inclines and curbs, which they could not do with their MWC. Wind was an environmental issue that affected pushing the PPW, but did not affect using the PWC.

Most participants reported that there are physical barriers in their community that consistently hamper participation. Focus group members reported many experiences where they found sidewalks inaccessible due to disrepair; buildings that did not have ramped access or had ramps that were inadequate; and surfaces that were rough and uncomfortable to drive one no matter what wheelchair they were using. Participants also identified social issues in the environment. They found major differences in how receptive non-disabled people were to making environments accessible. Participants often found environments that were 'pseudo-accessible' – where some physical accommodation has been made and identified as handicap accessible, but in reality, the modification was not sufficient to actually allow them access in their wheelchair. Winter weather was also identified as an environmental condition that was a barrier to both the PWC and PPW.

Device Evaluation and Choice

Participants indicated that when choosing between wheelchair alternatives, they needed to consider the advantages and disadvantages of each product in the context of the environment where they would be using it. With the PPW, participants clearly indicated that this process of evaluation required some time. Many participants identified the need to make adjustments to the PPW to best match their needs. They also indicated the need for the user to adjust their own performance to the device. This process of adjusting the PPW and adjusting **to** the PPW often took considerable time and modification. The participants felt there was a 'learning curve' to get the best fit and best performance with the PPW, and some participants felt they could have used more time and adjustment to achieve this.

Based on their exposure to the PPW in this study, participants generally agreed that the PPW did not replace their PWC, and prefer the PWC for environments that are accessible. Participants did comment that the PPW provided a good alternative when access to the environment was unknown or difficult for the PWC. Several participants suggested the PPW would be an excellent option for people who did not have a PWC. Furthermore, because the PPW was so much easier to push and less tiring than a MWC, participants suggested that others might find the PPW to be an excellent alternative to a MWC, and would allow them to participation in activities and environments they cannot participate in with their current MWC.

Appendix N

PAPAW Study: Wheelchair Usage Hours

Participant Study #: ________________

	PPW Stream			**PWC Stream**		
Ending week number …	**1**	**2**	**3**	**1**	**2**	**3**
Average hours **daily** in PW or PPW this week						
Average hours **daily** in MWC this week						
Average total hours daily in any WC this week						
Total hours this **week** in Occupation 1						
Type of W/C used						
Total hours this **week** in Occupation 2						
Type of W/C used						
Total hours this **week** in Occupation 3						
Type of W/C used						
Total hours this **week** in Occupation 4						
Type of W/C used						
Total hours this **week** in Occupation 5						
Type of W/C used						
Total hours this week in Occupations 1-5						

Legend	
Power Wheelchair	PWC
PAPAW	PPW
Manual Wheelchair	MWC

Appendix O

Detailed descriptions of Categories identified in qualitative analysis

Theme	Detailed description	Theme	Detailed description
AC	Sense of accomplishment	LC	Learning curve for PPW
AD	PPW requires individual adjustment	ND	No difference between PPW and PWC
BA	Battery life is limited with PPW	NE	New environments/experiences using PPW
BI	PPW requires bilateral operation	OH	Used PWC outside home
BR	PPW difficulties with braking	OP	Lacked opportunity to try PPW in a particular environment
BU	Button operation or other aspects difficult to manage	PB	Physical benefit from using MWC/PPW
CD	PPW control is difficult	PH	Physical environment impacts PWC use
CO	Coordination required between hands with PPW	PI	PWC used indoors
CT	Cost is an issue with PPW	PO	PPW used outdoors
DE	PPW difficult to use on a decline	PR	Prefer PWC if the environment accommodates
DI	PWC used for distance (strength/fatigue)	RA	Assistance required for participation
DR	PPW doesn't replace PWC	RT	PWC used for outdoors/rough terrain
EE	More enjoyable experience with PPW	SI	Scooter easier to use on inclines
EF	PWC used as efficiency/convenience	SM	Small size of MWC/PPW increases accessibility
EN	Environment affects PPW use	SP	Liked the speed with PPW
EX	Excitement, interest, curiosity about PPW	ST	PPW still requires strength
EZ	PPW easier to push than MWC	TB	Scooter is too big for some environments
FA	PWC is fast (MWC is slow)	TL	Took longer/more difficult in PPW
FN	PPW increases function vs. PPW	TR	PWC difficult to transport
FU	Scooter is fun/social	TW	PPW is too wide/too heavy
HA	Interface of rims/hands is an issue	UE	MWC/PPW for unpredictable environments
HS	High speed difficult to control with PPW	UN	Uncertainty with PPW - stranded/out of control
ID	PPW/MWC used indoors	WI	Winter is an issue for use
IE	Inaccessible environment is an issue globally	WP	PPW is a good alternative for those without PWC
IN	PPW effective on inclines	WT	PWC is heavy