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Environmental barriers to participation and facilitators for use of three types of assistive technology devices

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\section*{ABSTRACT}

The aim was to compare the presence of environmental barriers to participation and facilitators for assistive technology (AT) use and study the relation between barriers and AT use in three different AT devices. A cross-sectional survey was conducted. Inclusion criteria were at least one year of experience as a user of myoelectric prosthesis (MEP), powered mobility device (PMD), or assistive technology for cognition (ATC) and age 20-90 years. Overall, 156 participants answered the questionnaire on facilitating factors. Non-parametric tests were used for comparisons. Barriers to participation were lowest in MEP users (md=0.12; p>0.001), and highest in ATC users (md=1.56; p>0.001) with the least support for AT use (p>0.001 - p=0.048). A positive correlation between fewer barriers and higher use of MEP was seen (r=0.30, p=0.038). The greatest barriers to participation were Natural environment, Surroundings and Information, and the most support came from relatives and professionals. Support, training and education are vital in the use of AT. These factors may lead to a more sustained and prolonged use of AT and may enable increased participation. Future research should focus on interventions that meet the needs of people with cognitive disabilities.

\section*{Background}

Assistive technology (AT) devices are expected to be used to a high degree, but research shows that they are used in varying degrees, and are some are not used at all (Wessels, Dijkstra, Soede, Gelderblom, & De Witte, 2003). This is an unfortunate fact for individuals and for society, because a large part of health care resources finance these ATs. In rehabilitation, ATs can be prescribed to improve the activity performance of individuals with disabilities, enhance independence, and improve participation in daily life. Being able to participate in everyday activities is defined as a human right (United Nations, 2008). Additionally, participation is an important outcome of rehabilitation interventions (Kielhofner, 2007), and it may be restricted by lack of accessibility. Accessibility can be improved by the use of ATs, but the access to ATs varies between countries. In Sweden, for example, the service delivery process of ATs is governed by laws, ordinances, and regulations that, among other things, regulate who is eligible for AT. Additionally, most ATs are financed by the government, which means that many people in Sweden have access to ATs (Dahlberg, Blomquist, Richter, & Lampel, 2014). Therefore, Sweden is a good place to study the participation in and use of AT.

AT is defined as “any product, instrument, equipment, or technology adapted or specially, whether acquired commercially, modified or customized, that is used to maintain, increase, or improve the functional capabilities of individuals with disabilities” (International Standards Organization [ISO], 2011). For many people with disabilities, participation in daily activities—both at home and in society—depends on well-functioning ATs (Auger et al., 2008; Gramstad, Storli, & Hamran, 2013; Hemmingsson, Lidström, & Nygard, 2009; Lenker, Harris, Taugher, & Smith, 2013; Lidström & Hemmingsson, 2014). Hence, there seems to be a causal relationship among participation in daily activities, AT prescription, and AT use.

Several factors influence the extent of AT use, including environmental factors related to the device, intervention related factors, factors related to the surroundings, and personal factors (Wessels et al., 2003; Widehammar, Pettersson, Janeslätt, & Hermansson, 2017). The concept environment is complex and includes not only the physical and structural environment, but also the social and psychological environment (World Health Organization, 2001). The experiences of environmental factors is subjective and can thus be regarded differently between individuals, either as barriers or facilitators, both by their presence and absence (Pless & Granlund, 2011). When environmental barriers are reduced, people with disabilities are better able to participate in the social, educational, and vocational aspects of life (World Health Organization, 2001). Similarly, a person’s participation in society can be improved by added facilitators, such as support or training in AT use (World Health Organization, 2001).
However, it is not known whether there is a relation between the extent of AT use and environmental barriers to participation.

Different types of ATs are used to various extents, and there is a knowledge gap concerning the relationship between the environmental impact on AT use and the users’ participation in everyday life because most studies only explore one type of AT device or a single type of patient group (Lenker & Paquet, 2003; Lenker et al., 2013). The results of these studies are diverse. In one study, 50% of patients with cognitive impairments chose not to use their prescribed AT (De Joode, Van Heugten, Verhey, & Van Boxtel, 2010). In another study examining myoelectric arm prosthesis (MEP), the non-use varied from 12% to 75% (E. A. Biddiss & T. T. Chau, 2007). The influence of the type of AT and on the user’s ability, age, and context (Wessels et al., 2003). To broaden the perspective, this study considers AT users who have different types of ATs and are at different ages, different stages in life and, thus, in varying contexts. These ATs use MEP, powered mobility devices (PMD), or assistive technologies for cognition (ATC). These ATs were chosen because they are all rather expensive electronic technical devices that require education and training for optimal use (Lenker & Paquet, 2003). The aim of this study was to describe and compare the presence of environmental barriers to participation and environmental facilitators for AT use and to examine the relation among barriers to participation, facilitators for AT use, and the frequency of AT use as experienced by users of these three different types of devices.

Methods

The design of the study was a descriptive and comparative cross-sectional survey. The Regional Ethics Committee in Uppsala approved the study (2012/275).

Participants

In each AT group, the participants used varying types of AT: In MEP, there were users of trans-radial prosthesis (n = 44) or trans-humeral prosthesis (n = 7); in PMD, there were users of scooters (n = 31) or four-wheeled chairs with joystick steering.

Sample and recruitment

The inclusion criteria were as follows: individuals who had at least 1 year of experience as users of MEP, PMD, or ATC; aged 20 to 90 years; and mental and cognitive ability to understand and fill in the questionnaires. The intention was to recruit 50 participants in each of the three groups based on an earlier study of environmental barriers and participation (Larsson Lund & Lexell, 2009). Since we expected a response rate between 40% to 50%, more than 150 people were asked to participate. Participants were enrolled in the study in two different ways. Individuals with MEP were recruited from a department of prosthetics and orthotics in a clinic with national uptake, and individuals with PMD or ATC were recruited from centers for service and delivery of AT in three different counties in central Sweden. For the ATC group, the prescribers of the ATC devices were contacted first to ensure that the intended person was able to understand the questionnaires; if not, the person was not asked to participate. To ensure representation from people of different ages, each sample group was stratified according to age (i.e., younger = 20–41 years; middle-aged = 42–64 years; and older = 65 and above). Depending on the stratum size, every second, third, or fourth person was selected, resulting in an equal number of people from each stratum. The selected individuals received written information via regular mail and gave their informed consent to participate in the study. One reminder was sent to all non-respondents. In total, 156 (61%) persons agreed to participate (Table 1).

<table>
<thead>
<tr>
<th>Total</th>
<th>MEP n = 51 (33)</th>
<th>PMD n = 58 (37)</th>
<th>ATC n = 47 (30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex female/male (%)</td>
<td>56/44</td>
<td>37/63</td>
<td>60/40</td>
</tr>
<tr>
<td>Age mean ± SD (years)</td>
<td>46.0 ± 16.8</td>
<td>41.1 ± 17.4</td>
<td>54.1 ± 15.5</td>
</tr>
<tr>
<td>Diagnosis ICD-10, n (%)</td>
<td>14°</td>
<td>6°</td>
<td>8°</td>
</tr>
<tr>
<td>V. Mental &amp; behavior disorders*</td>
<td>31 (22)</td>
<td>10 (7)</td>
<td>10 (19)</td>
</tr>
<tr>
<td>VI. Diseases of nervous system</td>
<td>47 (33)</td>
<td>39 (75)</td>
<td>8 (21)</td>
</tr>
<tr>
<td>XIII. Diseases of musculoskeletal system</td>
<td>31 (22)</td>
<td>31 (61)</td>
<td></td>
</tr>
<tr>
<td>XIX. Injury, acquired amputation</td>
<td>23 (16)</td>
<td>20 (39)</td>
<td>3 (6)</td>
</tr>
<tr>
<td>Living status, n (%)</td>
<td>2°</td>
<td>1°</td>
<td>1°</td>
</tr>
<tr>
<td>Single</td>
<td>67 (43)</td>
<td>19 (37)</td>
<td>24 (42)</td>
</tr>
<tr>
<td>Cohabitating</td>
<td>73 (47)</td>
<td>29 (57)</td>
<td>28 (49)</td>
</tr>
<tr>
<td>Single together with parents</td>
<td>14 (9)</td>
<td>3 (6)</td>
<td>5 (9)</td>
</tr>
<tr>
<td>Vocational status, n (%)</td>
<td>2°</td>
<td>1°</td>
<td></td>
</tr>
<tr>
<td>Working full or part time</td>
<td>60 (38)</td>
<td>37 (72)</td>
<td>12 (21)</td>
</tr>
<tr>
<td>Student</td>
<td>14 (9)</td>
<td>4 (8)</td>
<td>3 (5)</td>
</tr>
<tr>
<td>Retired</td>
<td>24 (15)</td>
<td>7 (14)</td>
<td>14 (25)</td>
</tr>
<tr>
<td>Disability pension*</td>
<td>56 (36)</td>
<td>3 (6)</td>
<td>28 (49)</td>
</tr>
<tr>
<td>Frequency of AT use, n (%)</td>
<td>119 (76)</td>
<td>41 (80)</td>
<td>37 (64)</td>
</tr>
<tr>
<td>Daily use</td>
<td>17 (11)</td>
<td>3 (6)</td>
<td>12 (21)</td>
</tr>
<tr>
<td>Weekly use</td>
<td>7 (4.5)</td>
<td>0 (0)</td>
<td>6 (10)</td>
</tr>
<tr>
<td>Monthly use</td>
<td>7 (4.5)</td>
<td>4 (8)</td>
<td>3 (5)</td>
</tr>
<tr>
<td>Less than monthly use</td>
<td>6 (4)</td>
<td>3 (6)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Never use</td>
<td>15°</td>
<td>2°</td>
<td></td>
</tr>
<tr>
<td>Experience of AT use</td>
<td>11.6 ± 11.1</td>
<td>22.9 ± 10.9</td>
<td>7.1 ± 5.2</td>
</tr>
</tbody>
</table>

Notes. SD = standard deviation. *Disability pension temporary or permanent; *missing; °Neuro psychiatric disorder (n = 26) and mild intellectual disability (n = 5).
(n = 19); and in ATC, there were time management devices (n = 8) or specialized designed cellphones (n = 36). The amount of experience with AT use varied from 1 to 30 years (Table 1). In total, the participants were frequent users of the prescribed AT. Additional demographic data from the participants are presented in Table 1.

**Questionnaires**

The Craig Hospital Inventory of Environmental Factors (CHIEF) is a valid and reliable instrument that investigates the relationship between participation and the environment of people with disabilities (Whiteneck et al., 2004). The CHIEF instrument can differentiate between people with and without disabilities and between people in different disability groups (Whiteneck et al., 2004). In this study, the Swedish version, CHIEF-S (Larsson Lund & Lexell, 2009), was used. The CHIEF items each represent a barrier, operationalized as, for example, “In the past 12 months, how often has the natural environment—temperature, terrain, climate—made it difficult to do what you want or need to do?” The focus of the CHIEF is on quantification of the barriers experienced, which also represent separate

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**Figure 1.** CHIEF-S item product scores in users of myoelectric prostheses, powered mobility devices, and assistive technology for cognition.
Statistical analysis

Descriptive statistics were used to illustrate the demographic data of the participants and to assess the data distribution. CHIEF-S scores were calculated according to the manual (Whiteneck et al., 2004). Given the highly skewed nature of the CHIEF-S scores, non-parametric statistics were used to analyze both the CHIEF-S scores and the environmental facilitators score. The barriers and facilitators were analyzed both for differences within (sex, age) and between the three AT groups. A Kruskal Wallis test and a 2-tailed Mann-Whitney U test were used to test for significance. Spearman’s rank order correlation test was used both for correlation between barriers to participation and frequency of AT use and between facilitators for AT use and frequency of AT use. The level of statistical significance was set at p < 0.05. Statistical analyses were carried out using the IBM software SPSS statistics version 22.

Results

Environmental barriers to participation

Barriers to participation in the physical/structural domain were most problematic, followed by barriers in services/assistance, and attitudes/support (Table 2).

A comparison between the three groups was made and the differences were significant (p < 0.001) for the total CHIEF-S score and for all domains except work/school. The post hoc analysis revealed that participants who use ATC differed
significantly from the two other groups in the domain attitudes/support, and differed from the MEP users in the other domains with significantly higher scores regarding barriers. In contrast, the MEP users reported significantly less environmental barriers in all domains, except work/school, compared to the other groups, thus indicating a low degree of barriers to participation (Table 2).

The mean product scores of each of the 25 CHIEF-S items (Figure 1) show the influence of barriers in each domain in more detail. As shown in Figure 1, the greatest barriers to participation in each distinct AT group were the items: natural environment and policies government (MEP); natural environment and design of community (PMD); and surroundings and information (ATC).

In the ATC users, there were differences in barriers to participation based on age. The middle-aged (age 42–64) group reported significantly ($p < 0.001 − p = 0.017$) more barriers in all domains, except work/school, and in the total CHIEF-S score compared to the younger ATC users (age 20–41), and the middle-aged group reported more barriers in the attitude/support ($p = 0.012$) and policies ($p = 0.024$) domains, and in the total CHIEF-S score ($p = 0.011$) compared to the older group (age >65). For the MEP users, there was only one difference based on age, with the younger (age 20–41) and middle-aged (age 42–64) MEP users experiencing significantly ($p = 0.023$ and $p = 0.022$) more barriers in the domain attitudes/support than the older MEP users (age >65). Within the group of PMD users, there were no statistically significant differences based on age.

**Relation between barriers to participation and frequency of AT use**

The degree of barriers to participation was unevenly distributed based on the different types of AT devices and the frequency of AT use (Figure 2). Those who reported fewer barriers seemed to use their AT more frequently, except for the ATC users, where daily users reported the most barriers. The correlation analyses between barriers and frequency of use showed that there was a significant positive correlation for the MEP users ($r = 0.30$, $p < 0.038$), with fewer barriers related to higher use.

**Facilitators for AT use**

There were variations in how much support the participants received. Participants reported receiving much support from relatives and professionals highly, whereas support from rules and regulations and authorities and organizations were rated low. When comparing the groups, there were significant differences in four of the seven categories of facilitating factors. Post hoc analyses showed that the users of ATC reported receiving the least support. The results also showed that the users of PMD and ATC differed most, with significant differences in four of the seven items (Table 3).

**Relation between facilitating factors for AT use and frequency of AT use**

Analyses of the relation between facilitating factors for AT use and the reported frequency of AT use showed a significant negative correlation between support received from rules and regulations and frequency of ATC use. The daily users reported no support, whereas participants who used their ATC less frequently reported more support from rules and regulations ($r = 0.29$, $p = 0.050$).

**Discussion**

To our knowledge, this is the first study to show and compare the influence from environmental barriers to participation and facilitators for AT use in three different types of AT devices. The main finding from this study is that there are significant differences in AT use depending on the type of assistive device. Two groups stand out in the comparisons: ATC users and MEP users. Based on the results, it appears that ATC users lack support, and thus do not use their devices to the fullest, leading to barriers related to their participation in society. MEP users report very few barriers to participation, and the users of PMD stand out for getting more support than the other users.

In all domains, except work/school, users of ATC reported a higher degree of barriers to participation compared to users of the other AT devices, and the daily users reported more barriers to participation compared to the less frequent users. These findings are quite unexpected since previous research shows that frequent use provides experiences and skills—factors that are expected to reduce barriers to participation (De Jonge & Rodger, 2006). Less frequent ATC users may have a higher degree of cognitive ability and may thus face fewer barriers, or, barriers are not recognized until ATC devices are used more frequently. Participants with less cognitive ability need more help to structure their daily life, but they appear to lack the support related to AT use that is needed to achieve this structure. Furthermore, the user’s learning ability affects the support and training of AT use (Batavia & Hammer, 1990). Another factor affecting AT use is the product design and functionality of ATC, which is often designed for commercial production (Lidstrom, Lindskog-Wallander, & Arnemo, 2015). The paradox seems to be that the user’s cognitive difficulties affect their learning ability in regard to use of the ATC (Judge, Robertson, Hawley, & Enderby, 2009). In addition, persons related to the user may also have difficulty in understanding the functionality of the ATC and may not be able to provide the support that is needed. Our findings showed that ATC users report that the most support is given by professionals and not by relatives.
Therefore, it is important to provide information to relatives about the device’s functions to achieve the sustained use of ATC over time (Borgestig, Sandqvist, Ahlsten, Falkmer, & Hemmingsson, 2016).

In contrast to the ATC users, users of MEP reported the fewest barriers in all domains, except work/school, thus suggesting a high degree of participation. As we expected, the natural environment was the greatest barrier for MEP users. This item contains climate, terrain, and temperature; hot and cold weather are both well-known problems for prosthesis users in terms of socket comfort and motor control (E. Biddiss & T. Chau, 2007). Further, the degree of barriers seems to be directly related to the amount of time the users wear the MEP; more barriers indicate less use. This finding is in line with the results from a qualitative study in which daily MEP users experienced few barriers to participation (Widehammar et al., 2017). The results from the present study also confirm the findings from the qualitative study in regard to facilitators. In the present study, participants with MEP reported receiving much support from relatives and professionals, similar to the way in which prosthesis users earlier described how support from family and health professionals had a positive impact on prosthesis use (Widehammar et al., 2017). The relationship between use, skill in prostheses use, and performance of daily activities has been shown previously (H. Lindner, Hiyoshi, & Hermansson, 2017; H. Y. Lindner, Eliasson, & Hermansson, 2013). Prosthesis skill may have an impact on performance and, thus, participation. This emphasizes the significance of the health professionals’ role in training, supporting, and educating MEP users.

Another result in line with previous research (Arthanat, Nochański, Lenker, Bauer, & Wu, 2009) is that most barriers for PMD users are seen in the physical/structural domain and more specifically, in the items natural environment and design of community. However, based on our results, it seems as if the PMD users received much support from all aspects of the environment, which may explain the high use of the PMD; all PMD users reported using their PMD to some extent. The participants reported receiving much support from relatives and/or cognitive impairments, and therefore comparable with the PMD and ATC groups in this study.

All participants in the present study reported receiving the least support from authorities and organizations. This may indicate that laws and policies do not constitute any support to people who need AT. Furthermore, the physical/structural domain was the greatest barrier to participation for the entire group. It appears to be society has not succeeded in terms of providing accessibility for everyone. Sweden has laws both for accessibility and against discrimination (Sveriges Riksdag, 2016), but the laws may not be followed. Based on these results, the attitude toward accessibility among people in general needs to change to improve equality in society.

The participants’ reports on support and encouragement differed most between users of PMD and ATC, with
significant differences in four of the seven items. An explanation of these differences may be the service delivery of the ATs. In Sweden (and many European countries), education and training on how to use the PMD in different contexts is mandatory to gain access to the device (Steel & De Witte, 2011). The wheelchair user obtains a “driver’s license” for the PMD after completing the training course. In the service delivery for the MEP users who participated in this study, the Sörbye-concept (Sörbye, 1980) was used. This concept includes structured training (Hermansson, 1991), with an assessment of the capacity for controlling the MEP and practicing MEP use during the performance of daily activities. Regular follow-up with support for both the user and the family is included in this service delivery concept. This may explain why the MEP users in the present study reported daily use to a higher extent than users from other countries (E. A. Biddiss & T. T. Chau, 2007). There is no similar structure for prescription of devices for ATC in Sweden. The prescription, support, and training are different based on the nature of the device and the individuals’ need. The users may need support both to learn how to manage and use the device, and support to adjust the device and adapt it to changes in everyday life. Users of ATC may thus benefit from a service delivery system similar to that of the PMD or MEP, but designed specifically to the needs of these users to ensure the proper use of ATC in different contexts and to reduce the dissatisfaction and abandonment of the devices. In a review of ATC in traumatic brain injury (Brunner, Hemsley, Togher, & Palmer, 2017), the authors concluded that research is necessary to investigate the training interventions that address factors fundamental for success. Further research and development of procedures for support and training for users of ATC is thus needed (Wang, Ding, Teodorski, Mahajan, & Cooper, 2016).

**Recommendations**

Based on the findings from this study, we conclude that training and support are vital for the future use of complex AT devices. We therefore recommend that prescription and training of these devices should be made according to a strict program. First, identification and removal of barriers to AT use (Widehammar et al., 2017), followed by education and structured training (Hermansson, 1991) on how to use the AT device in different contexts (Powell et al., 2015; Radomski, Anheluk, Bartzen, & Zola, 2016; Steel & De Witte, 2011). The assessment of the capacity for controlling the AT device and practicing AT use during the performance of daily activities is also an important part of the prescription (Lindner et al., 2017), as well as regular follow-up with support for both the user and the family (Widehammar et al., 2017). Our suggestions are that the training should be structured, and follow a protocol similar to a protocol for drivers’ license. A checklist with content similar to the users training protocol could be used to give information and assistance to the relatives. The protocol and the training sessions need to be individually adapted depending on the individuals’ characteristics and the design and functionality of the device. We recommend, also, that future research should be made in an attempt to further develop and evaluate specific training programs for users of ATC.

**Strengths and limitations**

A potential limitation of this study is the use of a non-validated questionnaire for studying facilitators for AT use. There are instruments available for examining environmental facilitators (e.g., the Facilitators and Barriers Survey; Gray, Hollingsworth, Stark, & Morgan, 2008; or the Measure of the Quality of the Environment; Bosch, Noreau, & Fougeyrollas, 1997). These questionnaires examine both barriers and facilitators, but they are more extensive, are not available for Swedish conditions, and do not evaluate facilitators for AT use. Therefore, we decided to use the current questionnaire despite its limitations; the questionnaire has also been used before and worked out well in a Swedish context (Janeslått et al., 2015).

Because CHIEF-S is not designed for people with cognitive impairments, the questionnaire could be conducted through a structured interview if the prescriber deemed it necessary. This helps strengthen the study by providing a higher response rate than expected for this category of people (70% response rate), but it also introduces a potential threat to the study’s internal validity because support in completing a survey can have both positive and negative effects. In addition, critiques in the CHIEF (Ephraim, MacKenzie, Wegener, Dillingham, & Pezzin, 2006) indicate a weakness in allowing participants to answer “not applicable” on questions concerning work and school. This answer generates the same score as the answer “no barriers,” and makes it impossible to distinguish whether a person is unable to work due to barriers at work or if the person simply prefers not to work or is retired. In the present study, the “not applicable” alternative resulted in very few valid answers, and thus represented a non-significant portion of the data in the subscale work/school. A strength of the study is the varied sample, which includes participants of different ages and from different contexts. However, not all of the underlying functional limitations of the participants are known. This is a factor that may potentially influence the reported barriers and facilitators. Future research should refine the response options and validate the CHIEF-S for AT use.

A comparison between three different types of AT devices with a focus on environmental factors influence on use of the devices, as in this study, has to our knowledge never been done before. We chose to study expensive AT devices because the prescription of these has a large impact on the providers’ economy. This limits the generalizability of our findings but, since the number in each group was large enough to make comparisons, the results may be useful to understand the difference in environmental impact on the use of these devices. Further studies on the impact of environment on use of simple and cheap AT devices are needed to learn about the impact of cost on the use.

**Conclusion**

In conclusion, this study supports the well-known fact that users of ATC could benefit from a more structured service delivery process with training and regular follow-ups, similar to what many users of MEP or PMD receive. Support and
training in AT use are vital for the use of MEP, PMD, and ATC. Clinicians should recognize the importance of educating relatives so they can support the users on the daily use of the device. This support may increase the chances of achieving a more sustained and prolonged use of most AT devices, particularly ATC, and could thus reduce the barriers to participation. Future research should focus on the interventions needed to meet the needs of people with cognitive disabilities.

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