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REVIEW ARTICLE

MOBILITY DEVICES TO PROMOTE ACTIVITY AND PARTICIPATION: A SYSTEMATIC REVIEW

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Objective: **To determine the effectiveness of mobility device interventions in terms of activity and participation for people with mobility limitations.**

Design: **Systematic review. Search of 7 databases during the period 1996 to 2008.**

Methods: **Controlled studies and non-controlled follow-up studies were included if they covered both baseline and follow-up data and focused on activity and participation. Study participants had to be aged over 18 years with mobility limitations. Mobility device interventions encompassed crutches, walking frames, rollators, manual wheelchairs and powered wheelchairs (including scooter types). Two reviewers independently selected the studies, performed the data extraction, and 4 reviewers assessed the studies' methodological quality. Disagreements were resolved by consensus.**

Results: **Eight studies were included: one randomized controlled trial, 4 controlled studies, and 3 follow-up studies that included before and after data. Two studies dealt with the effects of powered wheelchair interventions and the other studies with various other types of mobility device. Two studies were of high, internal and external methodological quality. Interventions were found to be clinically effective in terms of activity and participation in 6 studies. The results did not, however, give a unanimous verdict on the effectiveness of mobility devices in enhancing the activity and participation of mobility impaired people.**

Conclusion: **Interventions and outcome measurement methods varied between the studies; consequently, it was not possible to draw any general conclusions about the effectiveness of mobility device interventions. However, evidence was found that mobility devices improve users' activity and participation and increase mobility. A lack of high-quality research hampers conclusions about effectiveness. More original, well-designed research is required.**

Key words: assistive technology, mobility devices, systematic review, mobility limitations, effectiveness, participation.

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INTRODUCTION

People with mobility limitations, i.e. those having difficulty walking, or who are unable to walk, can be provided with mobility devices such as canes, rollators, wheelchairs and scooters so as to facilitate mobility and thus enable activity and participation (1–3). The prevalence of mobility devices is highest among the oldest age groups, with the risk of limited walking capacity increasing with advancing age (3–6). There are an estimated 3 million wheelchair users in Europe (7), while some 6.8 million Americans use assistive technology devices to enhance mobility (8).

The provision of mobility devices is generally considered to be of great importance, and the United Nations (UN) as well as the World Health Organization (WHO) recommend assistive technology as important tools in creating equal opportunities for people with disabilities (9, 10). In the Nordic countries, assistive technology, including mobility devices, is mostly provided free of charge if it is considered to have a great impact on a citizen's everyday life (11). Considerable resources are consequently spent on the provision of mobility devices, while an ageing population will realistically result in an increasing need for such interventions. For example, in Sweden spending on mobility devices has increased from approximately EUR 77 million in 2001 to EUR 80 million in 2005 (12). Given the scale of use and importance of mobility devices, their effectiveness needs to be investigated and described.

Existing reviews in the area of mobility assistive devices have focused mainly on outcome aspects other than activity and participation. One critical review has assessed the research literature concerning the effectiveness of seating interventions only, such as wheeled mobility devices (13). Another narrative review dealt with factors concerning powered wheelchairs (14), and one has reviewed the literature on smart wheelchairs (15), but none of these specifically addressed outcomes relating to activity and participation, even though this is the overall aim of mobility device provision. However, a recently published systematic review by Auger et al. (16) investigated powered mobility for middle-aged and older adults and included all kinds of outcome studies as well as appraising the levels of evidence that characterized the available research. The review identified

19 studies encompassing 52 different categories of outcomes of power mobility devices. Nine of the identified studies reported outcomes relating to activity and participation as defined in the International Classification of Functioning, Disability and Health (ICF) (17). The review showed very low grades of evidence in most of the research designs (Grade scoring used).

The ICF is a commonly used framework within rehabilitation, which identifies and classifies the domain of activity/participation as one of its health-related domains. The ICF defines activity as the execution of a task or action by an individual and participation as involvement in a life situation (17). However, the ICF is not distinct in discriminating between activity and participation, which means that each study sets its own specific definitions (18). In the ICF, mobility, including walking etc., is seen as a subcategory of activities and participation; however, mobility can also be a prerequisite for activity and participation and may be seen as a necessity for the person's real aims, for example to shop, work, take care of oneself, and visit friends and family, rather than as an end in itself (1). In this review, when mobility is an aim in its own right it is not included in the primary outcome dimension studied, that is the domain of activity and participation, but is considered to be a secondary outcome dimension.

The effectiveness of an assistive device is the extent to which it produces a beneficial outcome in a routine setting (19). An effectiveness study looks at whether an intervention works under ordinary day-to-day circumstances (19). Context has an impact on a person's activity and participation. According to the ICF, environmental factors include the physical, social and attitudinal environments in which people live and conduct their lives (17). Therefore, it can be argued that outcomes for mobility devices geared to activity and participation should not be evaluated without connection to real-life contexts.

This systematic review assesses the evidence for the effectiveness of any kind of mobility device interventions in terms of activity and participation in real-life contexts for people with mobility limitations.

METHODS

Search strategy

We performed a search without language restrictions for studies on mobility device interventions from the following databases: CINAHL; HTA/CRD; Ovid MEDLINE; PreMedline; PsychInfo; EBM Reviews – Cochrane Central Register of Controlled Trials; and SweMed. The Ovid MEDLINE search strategy we used is presented in Appendix I. This strategy was modified for the other database searches, while the 20 keywords were based on the inclusion criteria. We searched the bibliographies of original studies also for possible secondary sources. The search covered the years 1996–2008. In addition, we manually searched the conference proceedings of the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) and Association for the Advancement of Assistive Technology in Europe (AAATE) conferences as well as the *Technology and Disability Journal.*

Inclusion criteria and study selection

We included all kinds of controlled studies and all types of follow-up studies on mobility device interventions, which included both baseline and follow-up data. Both quantitative and qualitative designs were allowed, but we excluded studies that were conducted only in laboratory settings. We did not limit the number of participants, and included participants aged over 18 years with mobility limitations due to injury, disability, ageing or chronic illness. Mobility devices encompassed crutches, walking frames, rollators, manual wheelchairs and powered wheelchairs (including scooter types). In controlled studies, all kinds of control interventions were allowed. We considered activity and participation as a primary outcome, and mobility, frequency of use, mobility without personal assistance, user satisfaction, quality of life and adverse effects as secondary outcomes. Only articles that studied the primary outcomes were included. In cases where secondary outcomes were also studied, these were reported in this review.

The search yielded 1304 documents for consideration in the systematic review. The main reason for the large number of documents was the broad list of keywords. A pair of reviewers independently reviewed the title, keywords, and abstract to determine whether the study potentially met the inclusion criteria regarding design, participants and intervention. If there was disagreement between reviewers about whether to include a study, at this stage it was solved by including the document. Most of the documents were either descriptive studies or dealt with outcomes relating to service provision, the mobility of blind people, product development, theoretical issues, and body function and structure. Therefore 1261 documents could be excluded at this stage. This process resulted in 43 documents remaining, which were further screened by researcher pairs to see whether the study met the inclusion criteria. Disagreements were discussed within the group of reviewers (4 reviewers). At this stage we excluded a number of studies that measured outcomes at the level of body function and structure in laboratory settings, such as oxygen intake with the 6-minute walk test (6MWT); we also excluded 8 further studies as it transpired that they did not have any intervention or baseline data, resulting in 9 articles (Fig. 1).

Data extraction and validity assessment

For each of the 9 documents included, a pair of reviewers extracted data, assessed its validity, and verified each other's work. Any discrepancies were resolved through discussion. Moreover, we combined 2 articles (20, 21) into one study, because these articles derived from the same study.

Data extraction encompassed a description of the studies and the outcomes. We used a standardized form for data extraction. The descriptive analysis included the following: number, age and percentage of male participants, diagnosis, type and severity of mobility limitation, study design, exclusion and inclusion criteria, follow-up time, intervention and control intervention, and funding. Furthermore, outcomes were described with regard to the following: activity and participation, frequency of use, mobility, mobility without personal assistance, user satisfaction, quality of life, and adverse effects.

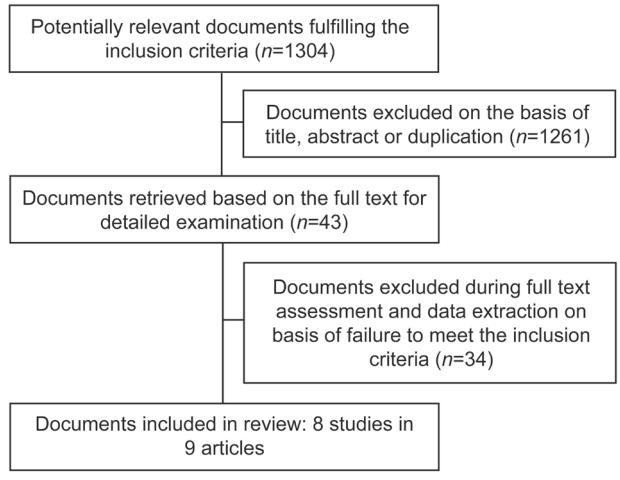

Fig. 1. Flowchart of the article selection process for the review.

Table I. *Participants, interventions, designs and outcomes in the identified studies*

Reference	Patient characteristics	Intervention and control intervention	Study design and follow-up time	All outcomes and instruments used in the study*
Ding et al. 2008 (26)	$n=15$, male 80%, mean age 38.3 + 10.5 years Dg: SCI (from C-3 to C-7 tetraplegia) Mobility limitation: tetraplegia C-3 to C-7 injury level, able to propel manual wheelchair. Inclusion criteria: Age 18–65 years, full-time manual wheelchair user for at least one year, tetraplegia, free from pressure sores and shoulder pain, no cardiopulmonary disease.	PAPAW. Control: User's own wheelchair (2 lightweight and 13 ultra-lightweight). Users were instructed to use either device during the day.	Cross-over design Follow-up: 2 weeks with possibility to use PAPAW	Mobility: Datalogger, SSQ Community participation, satisfaction: SSQ Psychosocial impact: PIADS
Hellbom & Persson 2003 (30)	$n=90$, male 26%, mean age 78 years Dg: NR Mobility limitation: People with mobility problems. Inclusion criteria: Persons with mobility problems living at home or in service houses; age > 18 years; intellectual and cognition ability for participation in an interview.	Walker or manual wheelchair or PWC	Before and after study Follow-up: 3 months	Activity-related problems: IPPA and PIRS QoL: EQ-5D Cost of assistive devices: Cost Cost/QoL: Cost
Hoenig et al. 2007 (25)	$n=53$ originally randomized. $n=43$ completed the study (22 intervention/21 control), male 86.4% intervention group, 71.4% controls. Mean age 67.2 ± 9.4 years intervention group controls; 58.2 ± 11.7 years Dg: Knee osteoarthritis 19/21 + 3 RA in intervention group. Mobility limitation: > 60% had difficulty walking on level ground and 86% had difficulty climbing stairs. Inclusion criteria: Able to walk independently > 15 m; Osteoarthritis of the knee or rheumatoid arthritis with knee pain; approval by primary care physician or rheumatologist; no cardiac disease; stable rheumatological disease, no change in medication in 3 months; no surgery planned; valid driver's licence; Mini-Mental State Examination > 26/30; ownership of automobile.	Intervention: A motorized scooter and a lift to transport the scooter. Control: Regular exercise programme and medication	RCT Follow-up: 3 months	Mobility (need for assistance, scooter use, visits to locations): SSQ Performance: Six-minute walk distance (6MWD) Satisfaction: SSQ Scooter accidents: SSQ Pain:VAS
Persson et al. 2007 (31)	$n=205$, male 35% in entire study/$n=23$, male 30% in part of study, mean age 78 years (31–99) Dg: Various. Mobility limitation: NR. Inclusion criteria: First time rollator use; ability to communicate and answer questions.	Rollator	Before and after study Follow-up: 3 months	Activity-related problems: IPPA Need for assistance: SSQ QoL: EQ-5D (2 separate items for mobility and social life) Cost: cost
Petterson et al. 2007 (20, 21)	$n=40$, male 69%, mean age 67 years (range 43–85 years) Dg: Stroke. Mobility limitation: Need of PWC, difficulty in standing for a long period or walking a long distance. Inclusion criteria: Stroke, going to be prescribed a PWC for outdoor use. Able to take part independently in an interview, e.g. no or only slight communication or cognitive problems. First time ever having a PWC for outdoor use.	PWC for outdoor use	Before and after study Follow-up: Mean 4 months (3–5 months)	Activity-related problems: IPPA, WHODAS II Life events: SSQ Importance of and satisfaction: SSQ QoL: PIADS, EQ-5D
Trefler et al. 2004 (27)	$n=34$, male 19%, mean age 82.4 + 9.8 years Dg: Fear of falling, frailty, arthritis, paralysis. Type and severity of mobility limitation: NR. Inclusion criteria: Persons living in 3 long-term care facilities. ≥60 years. Daily use of wheelchair system for 6 h or more. Able to understand simple commands and answer questions. Able to propel the wheelchair. No decubitus ulcer or dementia.	Individually fitted manual wheelchair systems Control: Own wheelchair.	Pilot study with a cross-over design. Follow-up: 3 months	Independent mobility: Timed driving test Forward and lateral reach: Reach test Health: SF-36 Satisfaction: QUEST
Trudeau et al. 2003 (28)	$n=6$, male 83%, mean age 79 years Dg: Alzheimer's disease. Mobility limitation: FIM: At least moderate assistance with ambulation. Inclusion criteria: FIM: Need for maximal to total assistance with ADL and at least moderate assistance with ambulation.	The Merry Walker (walker with wheels) Control: No Merry Walker.	Pilot study with a cross-over design Follow-up: 2 weeks	Activity participation (interacting, walking, sleeping) and engagement: The Scale for Observed Agitation in Person with Dementia

Table I. *Contd.*

Reference	Participants	Intervention and control intervention	Study design and follow-up time	All outcomes and instruments used in the study*
Uustal & Minkel 2004 (29)	$n = 20$, male 80%, mean age 43.7 years (age range 27–67 years) Dg: SCI (4 tetra, 9 para) 13, SCI with knee amputation 3, NMD 4 Mobility limitation: Manual wheelchair, powered wheelchair or scoter main means of mobility. Inclusion criteria are very detailed, among other things: Persons residing in the community, currently using manual wheelchair or PWC or scooters with seat width 35.5 –50.8 cm as their primary means of mobility. Weight ≤ 113.6 kg. Able to operate a joystick, propel faster than walking speed and travel in a wheelie position for 3.05 m. Able to bend knees to fit on a regular footrest and to bend hips to sit in a wheelchair with a regular upright back. Willing to ride in the passenger seat of the van or bus when using private or public transport during the 2-week trial.	The Independence IBOT 3000 Mobility System (4 functions: standard, 4-wheel drive, stair climbing, balance). Control: User's own device.	Cross-over design Follow-up: 2 weeks	Activities: Telephone reporting of type and number of daily activities, Safety: Telephone reporting falls and adverse effects Effective use (independent functional mobility skills in a community environment, stair climbing): Community Drive Test, SSQ

ADL: activities of daily living; Dg: diagnosis; FIM: Functional Independence Measure; NMD: neuromuscular disease; NR: not reported; PAPAW: push-rim-activated power-assist wheelchair; PWC: powered wheelchair; RCT: randomized controlled trial; SCI: spinal cord injury.
*For abbreviations of instruments and scales used, see Table II.

By means of a modified criteria list adopted from Borghouts et al. (22) we assessed the internal validity of the studies in terms of a sufficient description of the population selection, the inclusion and exclusion criteria, prognostic factors, whether the study size was sufficient (over 10 patient years), whether the follow-up time was sufficiently long (4 months or more), whether the proportion of drop-outs was not too large (less than 20%) and if they were described, whether outcome measures and data presentation were congruent with the study aims, whether confounder control was performed and, finally, whether the psychometric properties of the instruments were reported. In our modification, the 2 latter criteria substituted for the original criteria "appropriate analysis techniques" because we considered these 2 as more important. Criteria for study size, follow-up and drop-outs were applied as relevant to the field.

External validity and clinical applicability were assessed based on 4 questions on whether the description of the participants, interventions and setting were sufficiently detailed, whether all clinically relevant outcomes were measured and reported, and whether the effect size was clinically important, as adapted from Schekelle et al. (23). From the original Schekelle criteria we deleted one question that dealt with treatment benefits in relation to adverse effects. A gain of 10% was derived from research related to back pain and functionality (24).

Finally, all 4 reviewers (ÅB, AS, KS and OT) read all of the final articles and arrived at a full consensus concerning the data extraction and validity assessment. The detailed data that was derived from original publications was compressed into 3 tables.

RESULTS

We screened 1304 references and assessed the full text of 43 documents. Eight studies in 9 articles met our inclusion criteria.

Description of the included studies

One study was a randomized controlled study (25), 4 were controlled studies (26–29), and 3 were follow-up studies that included before and after data (20, 21, 30, 31). Two studies investigated powered wheelchair interventions (20, 21, 25), one rollators (31), one focused on individually adjusted wheelchairs (27), one on a push-rim activated wheelchair (26), one on a special brand of walker (28), and one on a special brand of powered wheelchair (29). In one study, 3 mobility device types were investigated (30). In the main, the sample sizes were rather small, with only one study having more than 100 participants (31). All studies were relatively recent, dating from 2003 at the earliest. Three of the studies were carried out in Sweden (20, 21, 30, 31). All studies except Hellbom & Persson (30) and Trudeau et al. (28) reported their funding sources. This is especially important in the field of assistive technology where there are commercial interests involved. The studies are presented in Table I.

Instrument diversity

The 8 studies included in this review used 21 different instruments for measuring the effectiveness of mobility devices (Tables I, II and IV). Seven of these were study-specific questionnaires (SSQs). Eighteen of the instruments were administered only once across all studies. EuroQol 5D (EQ-5D) and Individually Prioritised Problems Assessment (IPPA) were used in 3 of the studies, all Swedish. The Psychosocial Impact of Assistive Devices Scale (PIADS) was used in 2 of the studies.

Table II. *Outcome evaluation instruments used*

Instrument abbreviation	Instrument full name	Objective/domain(s)	Scale
EQ-5D	EuroQol 5D	Quality of life including 5 dimensions;, mobility, self-care, usual activities, pain/discomfort, anxiety/depression, Self estimated Health (VAS).	0–1.0: 1.0 = maximum good health 0–100: 100 = best imaginable health
IPPA	Individually Prioritised Problems Assessment	Assessment of the extent to which problems identified by an individual assistive technology user have been diminished.	1–175: 175 = maximal identified problems that are very important and too difficult to carry out.
PIADS	Psychosocial Impact of Assistive Devices Scale	The impact of assistive devices on users' quality of life.	From –3 = decreased to +3 = increased
PIRS	Problems Impact Rating Scale	The impact on daily living due to disability.	0–100: 100 = my problems affect daily life totally (worst imaginable state)
QUEST	The Quebec User Evaluation of Satisfaction with assistive Technology	User satisfaction and user's perceived importance of assistive technology.	1.0–5.0: 5 = very satisfied
SF-36	The Rand Short Form-36	Health status, 8 components. Role limitations due to physical health: physical functioning, role-physical, bodily pain and general health. Role limitations due to mental health: vitality, social functioning, role-emotional and mental health.	Eight subscales transformed into 0–100 for each scale: 100 = best health.
–	The Scale for Observed Agitation in Persons with Dementia	Observation of subject agitation: Mood, subject engagement (VAS), activity participation (duration).	Mood: 2 = happy, 1 = indifferent, 0 = unhappy. Subject engagement: 0 = apathetic; 100 = engaged Activity participation: 5-min interval
SSQ	Study specific questionnaire	Vary in different studies.	
WHODAS II	World Health Organization Disability Assessment Schedule II	Overall assessment of disability: assessment of activity limitations and participation restrictions in the everyday life of adult persons. Conceptually compatible with the ICF.	Six domains. 0–100 = higher scores more disability
6MWD	6-minute walk distance	Walking distance.	

ICF: International Classification of Functioning, Disability and Health; VAS: visual analoque scale.

For activity and participation related outcomes, 8 different instruments were used: Problems Impact Rating Scale (PIRS), IPPA, the Scale for Observed Agitation in Persons with Dementia, The Rand Short Form-36 (SF-36), World Health organization Disability Assessment Schedule II (WHODAS II), and 3 SSQs.

Methodological quality of the included studies

The quality scores are presented in Table III. Two studies (20, 21, 25) obtained a high score for both internal and external validity compared with the other studies. Apart from these, all of the studies included had shortcomings in terms of their descriptive information as well as their internal and external study validity. Three of the studies reported on the psychometric properties of the instruments used (20, 21, 25, 26). Interventions, such as the intervention process or the contexts of device use, or the control intervention were not described in sufficient detail in most of the studies to allow similar interventions to be provided in another setting.

Summary of the reported effects

Since both interventions and outcome measurement methods vary between studies, it was not possible to draw any general conclusions concerning the effectiveness of mobility device interventions. Instead, we must examine individual studies in order to draw conclusions about the outcomes of mobility devices regarding the activity and participation of mobility impaired people.

The effect size was considered clinically important (at least 10% gain) in all studies, but was only statistically significant in 4 of the outcomes measured (activity/participation, mobility, user satisfaction, and quality of life).

Two studies showed the positive effects of mobility device interventions on individually prioritized problems in activity and participation (20, 21, 31). A positive effect on engagement and interaction in society was also reported (28) as well as an increased range of activities performed after the intervention (29). Individual studies also demonstrated significant effects on quality of life (20, 21, 31). The best study in methodological terms (20, 21) showed that powered wheelchairs clearly increased activity and participation as well as quality of life in stroke patients. Three studies reported adverse effects, i.e. difficulty in disassembly (26), low accident rate (25) and slightly increased falls (29). The outcomes are presented in Table IV.

DISCUSSION

Principal findings

The objective of this review was to identify and evaluate the effectiveness of mobility device interventions in terms of the activity and participation of people with mobility limitations. Having performed a thorough literature search, we found only

Table III. *Summary of internal and external validity and applicability assessment of included studies*

	Internal validity assessment of included studies (Borghouts et al. 1998 (22))											External validity and applicability assessment of included studies (Shcekelle et al. 1994 (23))			
Reference	Selection of population described	Inclusion and exclusion criteria described	Prognostic factors described	Study size > 10 patient years	Follow-up > 4 months	Drop-outs < 20%	Description of drop-outs	Outcome measures congruent with aims	Data presentation congruent with aims	Confounders adjusted in the analysis	Psychometric properties of instruments reported	Study participants described in detail[1]	Intervention and setting described in detail[2]	All clinically relevant outcomes measured and reported[3]	Size of the effect clinically important in term of activity and participation (at least 10% gain)[4]
Ding et al. (26)	1	1	0	0	0	1	1	1	1	0	1	1	1	1	0
Hellbom & Persson (30)	0	1	0	1	0	0	0	1	1	0	0	0	0*	1	1
Hoening et al. (25)	1	1	0	1	0	1	1	1	1	0	1	1	1	1	0
Persson et al. (31)	0	1	0	1	0	0	1	1	1	1	0	0	0*	1	1
Petterson et al. (20, 21)	1	1	1	1	1	1	1	1	1	1	1	1	1*	1a	1
Trefler et al. (27)	1	1	0	0	0	0	1	0	0	0	0	0	0*	0	1
Trudeau et el. (28)	0	0	1	0	0	1	1	0	0	0	0	0	0*	0	1
Uustal & Minkel (29)	0	1	0	0	0	1	1	1	1	0	0	1	0*	1	1

If the study fulfilled the criterion it was assigned "1", if not "0".

*Interventions were only partly described, a based on Individually Prioritised Problems Assessment outcomes.

[1]Are the patients described in detail so that you can decide whether they are comparable to those that you see in your practice?

[2]Are the interventions and control interventions and treatment settings described sufficiently well to enable you to provide the same for your patients?

[3]Were all clinically relevant outcomes measured and reported?

[4]Is the size of the effect clinically important (at least a 10% gain)?

a few studies that fulfilled our inclusion criteria, most of which displayed methodological shortcomings. The selected studies had a different focus and the instruments used were diverse, making it impossible to draw overall conclusions, even though single studies demonstrated some evidence of positive effects of mobility device interventions that targeted mobility impaired adults in their activities and participation. This literature review of mobility device research has revealed what little effectiveness data are available that are of sufficiently high quality.

The available evidence

As an intervention, assistive technology is complex to investigate and therefore controlled studies are difficult to perform. The results rely on several aspects, such as environmental support, personal expectations, and the prerequisites of the device itself (32). Designing an intervention involves skilled assessment of these aspects, so as to reflect the circumstances of device use. Environmental factors constitute an especially important role in mobility device use, since even with a high-quality device it is difficult to be active and participate if the environment is not accessible and supportive.

One reason for the lack of randomized studies could be the ethical difficulty in using controls for a group of people who are in need of mobility devices, amounting to withholding these devices. In addition, locating a homogenous group of individuals in need of a specific type of assistive device may be difficult. Furthermore, evaluating the effects on activity and participation, which are very individually related to personal needs, habits and social and physical contexts, may be difficult, complicating the application of controlled studies in this field (e.g. 33, 34).

The methodological gaps in the available evidence may be due to the reasons above and the fact that research on the outcomes of assistive technology is still in its infancy (35). If we had included all types of outcome studies, as in the review by Auger et al. (16) in addition to the actual effectiveness studies, i.e. studies with before and after data, the results would have been more voluminous. Furthermore, the review's focus on activity and participation, although being the traditional core of occupation within occupational therapy (36), is generally relatively new, since this focus within the field mainly emerged after the launch of the ICF classification (17). In addition, the decision to include studies in real-life contexts only limited the number of included studies even if in most of the studies in a laboratory setting the outcome domain was at the body level.

Strengths and limitations of the review

The strength of our review is that we have applied the generally accepted criteria for a systematic review (19, 37). We have conducted a comprehensive literature search in order to obtain all relevant published articles (as well as conference proceedings) and have carefully assessed the available studies.

In this review, we faced the conceptual difficulty of mobility in relation to activity and participation. Even if within the ICF classification (17) mobility is seen as coming under activity and participation, and walking as coming under mobility, in daily life mobility of itself is rarely the aim. A mobility device is required to enhance the ability of persons to move about their homes, travel to work or school, and be mobile in the community (1). More work is required to develop a conceptual framework within the ICF as well as to develop measures focusing on activity and participation level outcomes.

Table IV. *Effectiveness of mobility devices*

Reference	Intervention mobility device: type, frequency of use	Activity and participation, Mobility and mobility without personal assistance (baseline/follow-up)*	Quality of life and User satisfaction (baseline/follow-up)*
Ding et al. 2008 (26)	PAPAW Frequency of use: PAPAW for 10.4 ± 4.7 days, personal WC 9.0 ± 5.5 days out of 14 days. *p*-value NR.	Number and variety of places visited (SSQ): PAPAW 7 ± 3 places for total of 14 ± 7 times, personal WC 7 ± 4 places for total of 15 ± 8 times NS difference. Distance travelled (logger): PAPAW 1518.3 m, personal WC 711.7 m NS difference. Speed (logger): PAPAW 0.74 ± 0.31 m/sec, personal WC 0.60 ± 0.23 m/sec (p=7030.03).	Difference between personal WC/PAPAW in: Competence (PIADS): 1.1/1.8 NS Adaptability (PIADS) 1.1/1.7 NS Self-esteem (PIADS) 0.8/1.5 NS For subjects who needed assistance with PAPAWs only (n=4): 1.8/0.8; 1.8/0.9; 1.4/0.4. *p*-value not possible to compute. Satisfaction (SSQ): Comfort 71.9/77.2 NS Manoeuvrability 65.4/82.0 NS Accessibility 79.4/84.6 NS
Hellbom & Persson 2003 (30)	Walker or manual wheelchair or PWC Frequency of use: NR	Activity-related problems (PIRS): improved ES (gain) total 0.74; men 0.16; women 0.94. Activity-related problems (IPPA) improved ES (gain) total 1.92; men 1.44; women 2.13. Data at baseline and follow-up not reported. *p*-value NR except difference between genders (p=0.05).	Utility (EQ-5D): mean gain/person 0.10; men 0.023; women 0.15. Data at baseline and follow-up NR QoL (EQ-5D): mean gain/person: 1.14; men 0.18; women 1.49. Data at baseline and follow-up NR
Hoenig et al. 2007 (25)	Motorized scooter Frequency of use: Scooters were used several times/week, 41% reported daily scooter usage.	Number of places visited (SSQ): Scooter: baseline 9.2 ± 2.4, at 3 m. 9.0 ± 2.2. Control: baseline 8.7 ± 3.2, at 3 m. 9.3 ± 3.4 *p*-value NR. Some places were visited more and some less using the motorized scooters, a clear increase in use of scooter particularly in food stores and going to the doctor. Walking distance (6MWD): No statistical difference between the 2 groups.	Satisfaction (SSQ): 73% found scooters very helpful
Persson et al. 2007 (31)	Rollator Frequency of use: NR	Indoor mobility (n=144) did not change. Use of handicap transportation (n=116): increased 31%/39% (statistically significant), and number of trips increased NS. Activity-related problems (IPPA n=20): improved 86.1/76.4 (p=0.001). Need for help in home (n=117) increased significantly from 30% to 40%.	QoL (EQ-5D): improved 0.57/0.64 (p<0.001)
Petterson et al. 2007 (20, 21)	PWC Frequency of use: In summer 50% use every day, nearly 50% once a week	Activity-related problems (IPPA): improved 97% had a 9.7 change and 3% (n=1) had a 2.3 score change (*p*-value NR). 86% of 118 problems (IPPA) were solved/ diminished; 12% were unchanged; 3 increased. Self-care: (IPPA) NS (WHODAS II) improved ES 0.84 (p<0.001). Domestic life (IPPA): improved ES 1.61 (p<0.001). Interpersonal interactions and relationships (IPPA): ES 1.4 (p<0.001). Understanding and communicating (WHODAS II): ES 0.16 (p=0.091). Getting along with people (WHODAS II): ES 0.20 (p=0.287). Community, social and civic life (IPPA): ES 2.4 (p<0.001). Major life areas (IPPA): ES 5.9 (p=0.066). Overall functioning (WHODAS II) ES 0.26 (p=0.025). Getting around (WHODAS II): ES 0.41 (p=0.021). Life activities (WHODAS II): ES 013 (p=0.443). Participation in society (WHODAS II) ES 0.18 (p=0.095).	Psychosocial impact (PIADS): Positive impact in 7 items, post measurement only. QoL (EQ-5D): usual activities positive change (p=.03), no change in other domains. Satisfaction (SSQ): 50% extremely satisfied at follow-up.

Table IV. *Contd.*

Reference	Intervention mobility device: type, frequency of use	Activity and participation, Mobility and mobility without personal assistance (baseline/follow-up)*	Quality of life and User satisfaction (baseline/follow-up)*
Trefler et al. 2004 (27)	Individually fitted manual wheelchair system, including cushion, back component, seat belt, position components. Frequency of use: NR	Social functioning (SF-36) increased: Group A 83.8/ 89.4 (dropped to 77.3 after 6 months) and Group B 65.0/77.7 ($p=0.009$). Driving test: The speed in straight driving and straight driving with right hand turn increased in both groups ($p=0.03$).	QoL in aim and conclusion, but not in instrumentation and in results. Satisfaction (QUEST): Group A 3.72/4.65 and Group B 2.72/4.72
Trudeau et al. 2003 (28)	The Merry Walker Frequency of use: NR	Engagement increased: Experiment 63.97/control 40.45 ($p=0.009$). Interaction increased: Experiment 220.16 min/control 69.99 min ($p=0.014$). Sleeping decreased: Experiment 1.37 min/ control 19.59 min ($p=0.007$). Walking increased: Experiment 268.55 min/control 11.75 min ($p=0.000$).	–
Uustal & Minkel 2004 (29)	The Independence IBOT 3000 Mobility System, including assessment and training in use. Frequency of use: All were full-time users.	Daily activities increased (SSQ): 162 activities with the IBOT 3000, 115 activities when using their own device ($p<0.003$). Community driving (SSQ): Total score improved overall ($p<0.001$) and for subgroups (skilled manual wheelchair users, slow manual wheelchair users, power wheelchair users ($p<0.016$ for all 3 groups). Need for assistance: reported in detail for each subject, but no quantitative data at group level was provided. Need for assistance was reduced for all subgroups when using the stair climbing function ($p<0.016$–0.031). In the other 2 functions, the results were not uniform between groups or items, but the general tendency was reduced need for assistance when using the IBOT 3000.	–

ES: effect size (mean change); NR: not reported; NS: non-significant; PAPAW: push-rim-activated power-assist wheelchair; PWC: powered wheelchair; S: significant; WC: wheelchair.
*For abbreviations of instruments and scales used, see Table II.

In this review, we used 8 outcome dimensions. It may be that the use of fewer outcome dimensions would increase the repeatability of the review (22). Publication bias is always a potential weakness of any literature review especially when commercial interests are involved.

The methods for assessing the study quality used in this review were adopted from the traditions of systematic reviews found in medicine, which were adapted slightly (22, 23). The future criteria of the quality assessment could benefit from further consideration, rendering them more suitable for the evaluation of assistive technology related research. For example, we combined the criteria for reporting of an instrument's psychometric properties with Borghouts' (22) criteria of internal validity assessment. We did not include an evaluation of co-interventions, which would be essential in any intervention study (38). On the other hand, we considered the lack of diagnosis as a methodological weakness, which may not be a fair judgement, since many elderly people using mobility devices do not have a specific diagnosis as a reason for obtaining the device. Nevertheless, a description of the studied group should include some kind of medical description or, more importantly, a description of any functional limitations in order to enable the generalization of the study results with respect to other clinical settings.

Implications for future research

A systematic quality assessment of the included studies clearly demonstrated the methodological challenges of the research with respect to the effectiveness of assistive technology. Even if the effect of mobility devices as well as other assistive technologies is often quite obvious, there is a need for outcomes research in order to provide the most appropriate solutions to people with activity and participation limitations and for decisions on societal prioritizations (39). Furthermore, there is a need to evaluate the effect on peoples' daily lives as well as to compare this type of intervention with other interventions and also one product with another.

Quite a few studies in the field of assistive technology (AT) are follow-up studies based on user satisfaction with a specific kind of device (40). These studies are valuable in considering users' opinions on AT function and delivery services. However, these kinds of studies should be complemented with studies on device effectiveness concerning the users' daily lives (1). AT-interventions should include a description of the device intervention process in order to make the results more comparable across studies. In addition, it would be important to understand whether study participants have other assistive devices for activity and participation, since the devices and thereby their effects interact with each other. Further studies should also focus on only one AT-type to demonstrate the effectiveness of a specific type of device (41). Furthermore, study-specific questionnaires should

be avoided; in order to increase the comparability of the evidence, the psychometric properties of the used instruments should be thoroughly investigated and reported in studies (42), and some consensus on the use of the instruments should be sought. Also, it is necessary to use designs such as comparative studies with before and after measurement (19), and with sufficiently long follow-up times. Follow-up studies do not show effectiveness.

The need for well-designed and long-term studies on the effects of mobility devices on the activity and participation of mobility-impaired people is clear. The motivation and selection of assistive devices should be based on research evidence, which should be used for the benefit of people with disabilities and for the provision of better-informed and efficient services.

This systematic review has been necessary to show the state-of-the-art of outcome research on mobility devices and thus to put forward the developments within outcomes research on assistive technologies. We hope that this will stimulate further research and the development of more valid and appropriate study designs.

CONCLUSION

The few identified studies all indicated that mobility devices increased the activity and participation of mobility-impaired users' activity and participation. The studies were rather recent, the studied interventions and outcomes were diverse and, for most studies, the methodological quality had shortcomings that hampered the drawing of any overall conclusions concerning the effectiveness of the interventions. There is clearly a need for more research of a higher quality.

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APPENDIX I. Search strategy. Database: Ovid MEDLINE(R) < 1996 to November Week 3 2006 >

1	exp mobility limitation/ (122)
2	exp locomotion/or motor activity/or running/or walking/ (80484)
3	dependent ambulation/ (4)
4	Patient Satisfaction/ (31800)
5	(independence or participation).tw. (67706)
6	(mobility or locomotion or ambulation).tw. (72677)
7	1 or 2 or 3 or 4 or 5 or 6 (240540)
8	self-help devices/ or exp wheelchairs/ (4438)
9	exp canes/ or exp crutches/ or exp walkers/ (855)
10	(wheelchair$ or rollator$ or cane? or crutch$ or walking stick? or walking frame?).tw. (4965)
11	((mobility or locomot$ or ambulat$) adj2 aid?).tw. (269)
12	((mobility or locomot$ or ambulat$) adj2 device?).tw. (336)
13	((mobility or locomot$ or ambulat$) adj2 equipment?).tw. (34)
14	((mobility or locomot$ or ambulat$) adj2 product?).tw. (34)
15	8 or 9 or 10 or 11 or 12 or 13 or 14 (8710)
16	exp "Outcome Assessment (Health Care)"/ (331992)
17	(outcome? or impact? or effectiveness or efficac$ or efficien$).tw. (1195841)
18	(score? or scoring or scale? or instrument?).tw. (429115)
19	(evaluation or assessment).mp. [mp = title, original title, abstract, name of substance word, subject heading word] (1120615)
20	16 or 17 or 18 (1670405)
21	7 and 15 (1890)
22	20 and 21 (676)
23	limit 22 to "all adult (19 plus years)" (519)
24	exp Clinical Trials/ (201963)
25	clinical trial.pt. (470405)
26	controlled clinical trial.pt. (78416)
27	randomized controlled trial.pt. (244089)
28	(random$ or rct?).mp. [mp = title, original title, abstract, name of substance word, subject heading word] (508839)
29	((control$ adj5 trial$) or (control$ adj3 stud$)).mp. [mp = title, original title, abstract, name of substance word, subject heading word] (524742)
30	24 or 25 or 26 or 27 or 28 or 29 (935894)
31	exp consensus development conferences/ or exp consensus/ or exp consensus development conferences, nih/ (3030)
32	(consensus development conference or NIH consensus development conference).pt. (5507)
33	consensus.ti,ab. (57254)
34	congresses.pt. (46997)
35	31 or 32 or 33 or 34 (107442)
36	exp Evidence-Based Medicine/ (23641)
37	evidence-based.ti,ab. (18062)
38	36 or 37 (32283)
39	exp double-blind method/ or exp single-blind method/ (104550)
40	((singl$ or doubl$ or trebl$ or tripl$) adj5 (blind$ or mask$)).ti,ab. (90959)
41	39 or 40 (126202)
42	Research design/ (47651)
43	technology assessment, biomedical/ (6058)
44	(technology adj2 assessment).mp. [mp = title, original title, abstract, name of substance word, subject heading word] (6885)
45	30 or 35 or 38 or 41 or 42 or 43 or 44 (1103690)
46	(volunteer? or placebo$ or control or prospective).mp. [mp = title, original title, abstract, name of substance word, subject heading word] (1632697)
47	(guideline$ or recommendat$).mp. [mp = title, original title, abstract, name of substance word, subject heading word] (193641)
48	exp Longitudinal studies/ (580632)
49	(followup or follow up or "over the past").tw. (382405)
50	multicenter study.pt. (86943)
51	exp Cross-over studies/ (19853)
52	exp Comparative study/ (1387095)
53	Questionnaires/ (154750)
54	46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 (3442233)
55	45 or 54 (3890733)
56	22 and 55 (457)
57	limit 56 to "all adult (19 plus years)" (362)
58	limit 57 to "review articles" (5)
59	57 not 58 (357)
60	*self-help devices/ or *wheelchairs/ (3041)
61	*canes/ or *crutches/ or *walkers/ (458)
62	*locomotion/ or *walking/ (9634)
63	60 or 61 or 62 (12943)
64	59 and 63 (165)
65	23 not 64 (354)