Assistive Technology for Older Adults: Challenges of Product Development and Evaluation

James Watzke PhD
Health Technology Research Group, Technology Centre, British Columbia Institute of Technology, Living Laboratory, Downtown Campus, 555 Seymour Street, Vancouver, British Columbia, Canada V6B 3H6
e-mail: James_Watzke@bcit.ca

J. Watzke, Assistive Technology for Older Adults: Challenges of Product Development and Evaluation. Gerontechnology 2002;2(1): 68 - 76. The challenges associated with the development and evaluation of assistive technology (AT) for older adults are many and complex. This paper first explores the AT product development process, including the need for more sources of funding for creation of new AT. In the second part, circumstances under which AT might be evaluated are discussed, with an emphasis placed on AT prototyping, regulatory activities, improvements of existing AT, and market research. The concluding remarks focus on the particular challenges of AT adoption by older adults, with special emphasis given to producing AT that is more affordable.

Key Words: assistive technology, product development, regulations, marketing

INTRODUCTION

In an ideal world, older adults would end up with appropriate assistive technology (AT) in their lives, and such interventions would impact their quality of life positively. This article will provide a selected overview of the major challenges that can and often do occur at several points during what might be thought of as a 'long and winding road' from the creation of assistive technology to the primary desired outcome, i.e., appropriate and successful adoption and use of AT by older adults. To make this topic manageable, a two-part division will be employed. In the first part, the trials and tribulations of product development, as it pertains to assistive devices will be discussed. In the second part, the focus will be on the evaluation of assistive technology, e.g., under which circumstances and for what reasons might such technology undergo detailed scrutiny? Although the primary concern of this article is NOT to discuss the well documented challenges of AT provision and adoption by older adults, in the concluding remarks, there will be a brief discussion of that topic, under the assumption that AT dissemination does impact product development and evaluation of AT. Throughout the article, the filter will consistently be one of 'critical challenges', as well as a Canadian bias, due to the author's country of employment for the last decade or so. It should also be noted that a number of the AT projects mentioned in the article are bound by confidentiality agreements, thus they may not be published, or discussed in detail.

FROM NEED TO PROTOTYPE

Assistive technology can range tremendously, from the lowest tech can-opener designed for persons with limited grip strength (available at several kitchen appliance retailers) to the most technologically sophisticated scooter (typically available at limited specialty medical supply outlets). For this paper, AT is any product that can be reasonably categorized as being 'assistive' to the intended and/or actual users.

When viewed as a product development opportunity, AT is subject to the same forces and challenges of any product development effort. Although there is a rich body of literature on the evaluation and provision, and adoption of AT by older adults, there is almost no formal writing on the product development of AT. A shining exception to this is a chapter by Fernie[1] from the Centre for Studies in Aging at the Sunnybrook Health Sciences Centre, Toronto, Canada. The Fernie chapter is an excellent summary of the standard and special challenges associated with any AT product development initiative. Below is a paraphrasing of some of the poignant principles put forth in that chapter:

(i) A 'need' for a given AT, does not mean a viable market exists.

(ii) A solution to a need (in the form of an AT) only has potential if it is affordable.

(iii) Creative AT solutions will require detailed consumer input, lateral thinking, risk taking, and a resolution to the 'function vs. universality' design challenge.

(iv) When academic researchers and the private sector attempt to collaborate on technology transfer, (in the present case, on AT), differences in approach and mentality can inhibit the chances of success.

Our own research and development experiences with AT in British Columbia support the challenges outlined by Fernie. We have found that there are a few noteworthy phenomena that present additional challenges for any AT in search of the older adult market. These are discussed below.

When compared to the other age segments of the life cycle, AT for the older adult seems to have less system infrastructure to motivate AT product development. This is undoubtedly a complex function of the older adult's orientation to AT (see below), and a system bias towards providing funding and rehabilitation services to citizens that are younger and/or more likely to return to work. In Canada, for example, there are far more clinical rehabilitation settings, research centers, as well as funding agencies (e.g., Workers Compensation Boards, and insurance companies) that are available to facilitate or collaborate on AT product development for persons under the age of 65, than for older adults. It could be argued that such infrastructure is critical to giving entrepreneurs and others the confidence to undertake AT product development for the older adult. Our own R&D work on client lift devices serves to illustrate this dilemma. Although we hope to develop a lift that works better for older adults, the primary goal (dictated by the funding agencies) is to develop a lift that helps prevent back injuries to home support workers.

Another axiom that affects AT product development for older adults is the fact that, as is the case in many fields related to health and medical devices, third party reimbursement drives which products are developed by the private sector. In Canada, a small or large company is far less likely to spend the vast resources required to develop an AT when they know from the outset that there are few funding sources available to pay for that AT. There is a reality that the older adult is the least likely recipient for such formal public AT reimbursement monies. These are of course generalizations that vary from province to province. In Canada, health services, and health products such as AT, are funded on a cost share basis between federal and provincial sources, with the provision of those services and products being the responsibility of provincial governments. If a province has a public AT program, its existence is due to a political decision by the appropriate provincial authorities, usually the Ministry of Health.

Canada has not had the benefit of any targeted, large system initiatives to promote AT development, such as Technology for Inclusive Design and Equality (TIDE) in Europe, Americans with Disabilities Act (ADA) legislation and the National Institutes

for Disability and Rehabilitation Research (NIDRR) in the U.S., and the Handicap Institute in Sweden. However, in the last decade there have been a number of provincial initiatives that included AT development as part of their mandate. Manitoba, Ontario, and British Columbia all had such initiatives. At this point, all three initiatives' formal funding has ended, but a summary of the British Columbia project is illustrative of how such an initiative can impact the AT industry in a smaller geographical region.

The British Columbia Assistive Devices Research & Development Project (ADRDP)

This project received five years of provincial funding based on the following project objectives:

(i) Coordination of the AT community
(ii) Assist in AT business development and resolution of funding issues
(iii) Stimulate student interest in AT design
(iv) Coordinate groups for AT assessment and outcomes research projects
(v) Create a mechanism for the review of AT developed in British Columbia.

In an attempt to affect the above five objectives, 13 separate activities or initiatives were undertaken by the ADRP. Nine years later, several of those initiatives were 'handed off', but are still active, as listed below.

Active ADRP Initiatives

(i) BC Home Medical Equipment Dealers Association
(ii) BC Medical Device Industry Association
(iii) Rehab Equipment Expo (annual event for AT distributors and clinicians)
(iv) Electronic research and business development guide for medical and assistive devices
(v) SOLUTIONS (an annual exposition where post-secondary students exhibit their original AT projects and prototypes)
(vi) PROTOGÉ (an annual program to mentor students on the commercial potential of their original AT inventions)
(vii) Formal applied research on AT helped promote the development of the 'Living Laboratory', a full-scale simulation research facility dedicated to improving person-product-environment fit for older adults and persons with disabilities.

As humble as they may be, the above initiatives do provide a form of infrastructure to promote AT development and have played a role in facilitating ongoing economic prosperity for a number of British Columbian companies manufacturing, distributing, and/or retailing AT.

Other Sources for AT Product Development Funds

Although there are not public funding sources in Canada designated only for AT development, both AT researchers and developers have a number of programs they can apply to for assistance, e.g., the Market Assessment Program and the Industrial Assistance Research Program (both under the National Research Council); National Science & Engineering Research Council, and the Proof of Principle Program (under the Canadian Institutes for Health Research – Health Canada). These programs have economic development, innovation, and/or health promotion mandates in their guidelines. There is also a federally-based Assistive Device Industry Office (part of Industry Canada) that plays an important role in disseminating information about the AT industry, R&D funding opportunities, and other initiatives of interest to AT developers and researchers.

FROM EVALUATION TO MARKET

AT evaluation plays an important role in both the development and provision of effective AT for older adults. Selected activities from our own and collaborators' work will serve to illustrate the primary scenarios under which AT might be evaluated.

Prototyping of Devices

Product evaluation is a critical and often required part of the product development

process. Evaluation with a prototype AT can vary tremendously in terms of scope, formality, and expense. In our AT prototype development activities, typically private industry clients approach us with only an idea or concept, although in recent years, more public agencies seem open to funding AT research & development activities, e.g., through occupational safety agencies, or workers' compensation boards. Once the client is identified, we engage in a detailed interaction which typically includes the following steps: (i) determination of what the goals of the project/product are from the client's perspective, (ii) articulate whether or not we can help the client achieve those goals with his/her concept, (iii) assuming 1 and 2 above are positive, a program or proposal of tasks and deliverables are laid out in writing, which also articulates fees and costs and any issues of intellectual property, confidentiality, and ownership of the prototype, (iv) the above results in a contract, and upon signing of that contract the work schedule begins. The above is of course a summary of our typical prototype development process work. There are many hours of documentation of the work required, as well as constant communication (oral and written) with the client throughout the process. Our group has begun to model our work process after International Organization of Standards (ISO) standards, even though we are not required to be ISO certified.

We have clients that will come to us and simply want an informal one or two hour meeting in order to gain outside input on their concept before they invest too much more time or money. At the other end of the evaluation continuum, we have spent years (calendar time, not actual research time) evaluating an environmental control prototype[2]. That work continues at the present time. We are also currently in year three of evaluating a prototype manual client lifting system for home use. Such AT evaluations usually take place in the 'Living Laboratory', a unique 140 m2 full-scale simulation facility, equipped with a flexible wall system, sophisticated data collection equipment, and an observers' Viewing Theatre[3]. The AT evaluation protocols in the Living Lab typically employ multiple data collection methods, e.g., behavioural observation, human factors, bio-mechanics, psycho-social self-report, and focus groups[4]. To date, in accordance with a strongly felt applied research philosophy, the consumer or intended users of the device under evaluation in the Living Lab have participated in all data collections. In fact, recruiting appropriate users for each evaluation is often one of the biggest challenges of this type of research. As a goal, we also seek funding to take the AT studied in the Lab out to the field for further testing, i.e, a form of validity check on what we feel we learned in the Lab. We believe the approach outlined above is similar to other research groups working on AT-related products, e.g., the TRACE group at the University of Wisconsin, the Sunnybrook Group and Hugh MacMillan Group at the University of Toronto, and the CREATE group at the University of Miami, Florida State University and the Georgia Institute of Technology.

Regulatory Needs and Activities

AT devices that fall more into the medical device category, e.g., hearing aids, prostheses & orthoses, wheelchairs, walkers, are more likely to be required to be subjected to some form of formal testing or evaluation. A number of AT products now have ISO standards, or ones that are under development. The Rehab Engineering Society of America (RESNA) is also responsible for developing such standards. It is also the case that certain products that might be classified as AT fall under the requirements of the U.S. Food and Drug Administration (FDA). If that is the case, a set of very detailed clinical or other trials may be required before a given AT can be sold in the U.S. It is also worth noting that a guideline for standards developers to address the needs of older persons and persons with disabilities was recently published by ISO/IEC[5].

In Canada, our equivalent to the FDA is the Therapeutic Products Directorate (under Health Canada's Health Products & Food Branch), and serves a similar function for new medical or health products enroute to market. The Canadian Standards Association (CSA) is also a significant stakeholder with regard to AT and consumer products that may be used by older adults. They recently published their own Design for Aging guideline[6]. Our team has also been contracted to help CSA with their strategic planning regarding which AT (if any) should be the focus of new standards development. We are also slated to execute pilot projects under a new CSA project that, amongst other things, will identify the most effective and efficient method for assessing the usability and safety of common household products used by seniors.

AT funders in some provinces in Canada are also requiring evaluation activities for selected AT. Similar to the 'approved medical device' lists required by Medicare or Americans with Disabilities Act (ADA) regulations in the U.S., these provincial AT funders require that a manufacturer or distributor of a given AT meet specific standards before their agency or ministry will pay for (or reimburse), or in some cases, allow the product to be sold in their jurisdiction. Often these requirements are based upon established standards, such as those from ISO, RESNA, or CSA. Finally, it is worth noting that in British Columbia, we have a 'provincial AT evaluator'. This person tests assorted AT each year (submitted by manufacturers and distributors on a voluntary basis). The findings from these tests are then made available to the public and AT stakeholders. Often this assists clinicians, and funders to help select the best AT for their clients, or settings.

Impacts and Improvements of Existing Devices

Compared to work on the development of original AT, there is considerably more published material on the impacts of existing AT. The majority of this literature is not based on technical, design, or ergonomic evaluations of AT, but rather on questions such as: (i) How many older adults are using AT, and which AT are they using [7-10]; (ii) What are the impacts of AT[11-12]; and (iii) what factors are associated with AT use, and how can we increase appropriate use of AT by those older adults that should be using AT[13-16].

There is also a rather large body of literature within the falls literature that attempts to address the question of whether or not AT plays a role in falls prevention for older adults[17-21]. The author was contracted by Health Canada to do a review of recent literature on the above question, and concluded that none of the relevant studies showed causal associations between AT use and falls in older adults[22].

Of greater interest to the present article is the much smaller body of literature that is concerned with usability testing of selected AT and the older adult. Illustrative of this kind of research are the following: (i)) environmental control devices[2,23-24]; (ii) wheelchairs[25]; (iii) grab bars[26]; (iv) walkers[27-28], (v) hand held remotes[2,29], and (vi) canes[30-31].

In our own work, we have discovered that injury prevention to health care workers (many that serve older adults) is a vital area for applied research on AT. As mentioned above, we are currently engaged in our third project directed at creating a more portable, and affordable home-based client lifting system to help prevent musculoskeletal injury (MSI) to home support workers[4,32-33]. The majority of such workers' clients are older adults. We have two other current projects where we are trying to improve the design of 'pill crushers', as well as the medication cart. Many residents in long-term care facilities have impaired swallowing capabilities. Therefore, pill crushing is a common activity in these settings. The need for the pill crushing project is three-fold: (i) nurses are acquir-

ing MSIs from their repetitive daily pill-crushing activities; (ii) existing automated pill-crushers are poorly designed (e.g., they are too loud, make the task too complicated, or do not meet sanitation needs), and (iii) in some cases, nurses are ingesting the residual powder from the medications they are administering to their patients. Regarding the medication cart, like many products in institutional health settings, there just simply hasn't been an effort to 'make a better one'. Thus, we were contracted to create a more 'nurse-friendly' ergonomically sound cart.

A second fruitful area of AT research for our group has been to improve the 'accessibility' of existing consumer products that might be classified as AT. The direction for this research has come from the Neil Squire Foundation R&D Group, a primary partner with our group and in the Living Lab. Neil Squire has a 15 year track record of trying to make devices accessible for persons with significant physical disabilities (e.g., persons with spinal cord injury). However, motivated by the partnership, both teams have agreed to collaborate on a number of projects that also include device accessibility issues for older adults[2,34]. Currently the two teams are working on creating accessible interfaces for hand held personal computers, as well as original usability research to produce performance requirements or recommendations for point of sale (debit card) handsets for persons with vision impairments, mobility impairments, and older adults.

An important research strategy has emerged from this collaborative work on commercially available electronic aids to daily living. We have realized that by the time we complete the applied research, many of the devices we have studied are no longer current, or possibly no longer on the market. This means that persons with special needs that might benefit from improved access to the devices are still at a disadvantage. To combat this quickly changing product landscape, we are now writing proposals that will allow us to study technologies and work with companies and manufacturers of these devices very early on in their product design cycles (which may be set 5-7 years in advance of market release).

Market Research

A final form of AT evaluation research we engage in is best termed market research. As mentioned above, in Canada, there are a number of government-based programs that are mandated to help develop new products. Many of these programs insist that a company do external market research on their concept or product as a condition of receiving funding. We have faculty from the business school that team up with our technical staff to do comprehensive market research. Often the marketing experts do what is termed the secondary research (e.g., competitive economic analyses, distribution strategies), and our team will simulate the needed technology or prototype to facilitate an effective usability and/or focus group event. Even when not required by the funding agency, we encourage clients to allow us to execute such market research as part of the R&D activities for them. For example, our most recent market research activities brought 21 caregivers of persons with Alzheimer's Disease to the Living Lab where they engaged in a comprehensive focus group/usability demonstration of a prototype home-based Alzheimer's management system. We will also be conducting similar focus groups for the pill-crusher and medication cart projects mentioned above. As is the case with most of our applied research, the input from the target user groups proves to be invaluable.

PROTOGÉ – A Program to Promote Student Interest in Assistive Devices

Each year across British Columbia, an advisory committee of the PROTOGÉ program identifies approximately 12 post-secondary students, or student groups, that have developed an original AT concept or prototype. These concepts or prototypes were selected because they were deemed to have 'com-

mercial potential'. In the program, the students participate in a 'mentoring program' where with the help of senior level professionals (many from the private AT industry or clinical settings) they execute tasks to explore the commercial potential of their AT. Many of those tasks are focused on marketing issues, since we concluded that is the knowledge the students are least likely to receive in their academic programs, e.g., engineering, industrial design, or occupational therapy. This program just completed its second year. To date, three of the projects have acquired patents, and a few of the participants gained employment at mentors' companies in the AT industry, all very positive outcomes.

CONCLUDING REMARKS

This article focused on only a portion of the challenges associated with assistive technology and the older user, namely those surrounding AT development and evaluation. We are fully aware that the primary outcome, i.e., the successful dissemination, adoption, and use of AT by older adults is an even greater challenge. Here again, we must refer the reader to the significant body of work on this important aspect of the topic cited above. That body of literature suggests the question of why an older adult may or may not use an assistive device is a complex interplay among their own attitudes towards aging, independence, and disability, the suitability of the technology, and their experience with the health care professionals that may be promoting or prescribing the AT to them. There are also excellent examples of manuals that attempt to empower the older AT user; see, for example, the Empowering Users Through Assistive Technology GO FOR IT Manual[35].

In an effort to make an impact on this complex challenge, we are currently responsible for one of three national projects that are mandated to promote positive AT use amongst Canadian seniors and Veterans. One of the projects is focused on laying the groundwork for improved knowledge and AT use (PIs E. Gallagher & V. Scott); while the second project (PIs N. Edwards & D. Lockett) is going to create a grass-roots campaign in selected regions across Canada to help community members approach retailers (e.g., hotels, motels, restaurants, home hardware suppliers, etc.) and educate them to care about (and carry or install) AT in their businesses. Our project (PI J. Watzke) is just starting and will be utilizing the knowledge from the other two projects to create a national television-based public service announcement (PSA) to promote positive AT use by the target population, i.e., seniors and Veterans. To the best of our knowledge, this will be the first national PSA in Canada on the topic of AT promotion. All three projects are employing a population health promotion approach, and have a heavy emphasis on evaluating project outcomes.

Due to our work with companies that are trying to develop AT for the market, we are also fundamentally aware of the importance of pricing structures and affordability of AT, for both the manufacturer and the consumer. Many older consumers would be (and are) shocked to learn why that walker, wheelchair, or hearing aid ends up on the retailer's shelf for a cost approximately three to five times the original manufacturer's cost. There is a set of complex economic and marketing realities that explain why AT, amongst other products, are typically subject to such additive costs enroute to the final consumer. Each stakeholder in the chain (the manufacturer, distributor, and retailer) has their own set of costs to recover. Then of course, each expects to make a profit (often called the 'margin'). For example, the rule of thumb often discussed is that the manufacturer needs a margin of 50%, the distributor needs (or expects) a margin of 25% or more, and the retailer expects a margin of 40-50%. Please note that these margins are added to the product costs above each stakeholder's total costs to conduct their business, which can vary significantly.

Ironically, this results in much AT that is expensive, which in turns gives the older consumer a great reason for not adopting a device they may very well need. Fewer consumers mean the economies of scale (units made or sold) for the manufacturer, distributor, and retailer shrink or stay small, which means that costs remain high. It is a cycle that needs to be changed. One might think this would result in alternative business models, such as having the manufacturer sell directly to the consumer. Indeed some AT manufacturers have employed that strategy, but it has its disadvantages, e.g., how does one assure the consumer is getting the appropriate AT if there is not formal involvement of a prescribing professional? Finally, one might argue that older adults themselves have a critical role to play here. As soon as they, as consumers, advocate for affordable AT (just as they might for better guardianship legislation, pensions, or primary health care), the market forces outlined above will respond. This of course assumes those older adults will have impressive shifts in their own psychology of aging, their voluntary spending on health care products, and their understanding of the cost-benefits inherent in AT use, especially in terms of their own independence.

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References

1. Fernie G. Bringing the product from the design concept to the marketplace. In: Gutman G, editor, Technology Innovation for an Aging Society: Blending Research, Public and Private Sectors. Vancouver: Gerontology Research Centre, Simon Fraser University; 1997; pp 23-39
2. Watzke J. Older adults' responses to an automated integrated environmental control device: the case of the Remote Gateway. Technology and Disability 1997; 7:103-114
3. Watzke J. The Dr. Tong Louie Living Lab: Recent activities involving Human factors. Proceedings of the 17th Annual Meeting of the Association of Canadian Ergonomists, Banff, Alberta; November 2002
4. Raschke SU, Paris-Seeley NJ, Watzke JW, Jones Y, Groves M, Halsted N. Evaluation of portable, low cost transfer devices used by home health care workers. Orthopadei-Technik Quarterly, English Edition, 2001;111:13-15
5. ISO/IEC. Guide 71: Guidelines for standards developers to address the needs of older persons with disabilities. Geneva, Switzerland: ISO/IEC; 2001
6. CSA. Guideline B659-01 Design for aging. Toronto, Canada: Canadian Standards Association; 2002
7. LaPlante MP, Hendershot GE, Moss AJ. Assistive technology devices and home accessibility features: prevalence, payment, need, and trends. Advance Data: Centres for Disease Control 1992; 217:1-11
8. Manton KG, Corder LS, Stallard E. Changes in the use of personal assistance and special equipment from 1982 to 1989: results from the 1982 and 1989 NTLCS. Gerontologist 1993; 33:168-176
9. Watts J, Erickson AE, Houde L, Wilson E, Maynard M. Assistive device use among the elderly: a national database study. Physical and Occupational Therapy in Geriatrics 1996; 4 (1):1-18
10. Forbes WF, Hayward LM, Agwani N. Factors associated with self-reported use, and non-use of assistive devices among impaired elderly residing in the community. Canadian Journal of Public Health 1993; 84:53-57
11. Jutai J, Rigby P, Ryan S, Stickel S. Psychosocial Impact of Electronic Aids to Daily Living. Assistive Technology 2000; 12:123-131
12. Scherer M, editor. Assistive Technology: Matching device and consumer for successful rehabilitation. Washington: American Psychological Association; 2002
13. Gitlin L. Assistive technology in the home and community for older people: Psychological and social considerations. In: Scherer M, editor, Assistive Technology: Matching device and consumer for successful rehabilitation. Washington: American Psychological Association; 2002; pp.109-122
14. Mann W. Assistive technology and older adults. OT Practice 2001; 6(10):13-15
15. Kraskowsky LH, Finlayson M. Factors affecting older adults' use of adaptive equipment: Review of the literature. American Journal of Occupational Therapy 2001; 55(3):303-310

16. Aminzadeh F, Edwards N. Factors associated with cane use among community dwelling older adults. Public Health Nursing 2000; 17(6):474-483
17. Aminzadeh F, Edwards N, Lockett D, Nair R. Utilization of bathroom safety devices, patterns of bathing and toileting, and bathroom falls in a sample of community living older adults. Technology and Disability 2000; 13:95-103
18. Fortin JD, Yeaw EM, Campbell S, Jameson S. An analysis of risk assessment tools for falls in the elderly. Home Healthcare Nurse 1998; 16(9):624-629
19. Gallagher E, Scott V. The STEPS project: participatory action research to reduce fall in public places among seniors and persons with disabilities. Canadian Journal of Public Health 1997; 88(2):129-133
20. Gill TM, Williams CS, Tinetti M. Environmental hazards and the risk of nonsyncopal falls in the homes of community-living older persons. Medical Care 2000; 38(12):1174-1183
21. Sattin RW, Rodriguez JG, DeVito CA, Wingo PA. Home environmental hazards and the risk of fall injury events among community-dwelling older persons. Journal of the American Geriatrics Society 1998; 46(6):669-676
22. Watzke J. Assistive device use by seniors and injuries: A recent literature review. Ottawa: Health Canada; 2001 (Unpublished report to Division of Aging & Seniors)
23. Watzke J, Birch G. Older adults' responses to automated environmental control devices. In: Gutman G, Wister A, editors, Progressive Accommodation for Seniors: Interfacing Shelter and Services. Vancouver: Simon Fraser University Gerontology Research Centre; 1994
24. Mann W. Use of environmental control devices by elderly nursing home patients. Assistive Technology 1992; 4(2):60-65
25. Mann W, Hurren D, Charvat B, Tomita M. Problems with wheelchairs experienced by frail elders. Technology and Disability 1996; 5(1):101-112
26. Sanford J, Megrew M. An evaluation of grab bars to meet the needs of elderly people. Assistive Technology 1995; 7:36-47
27. Pippin K, Fernie G. Designing devices that are acceptable to the frail elderly: a new understanding based upon how older people perceive a walker. Technology and Disability 1997; 7:1-2
28. Glendenning FJ, Slavniek E, Forbes WF. An evaluation of devices to aid movement: Part 2 Walkers. Rehabilitation Digest 1992; (December):21-23
29. Mann W, Ottenbacher K, Tomita M, Packard S. Design of hand-held remotes for older persons with impairments. Assistive Technology 1994; 6(2):140-146
30. Mann WC, Granger C, Hurren K, Tomita M, Charvat B. An analysis of problems with canes encountered by elderly persons. Physical and Occupational Therapy in Geriatrics 1995; 13(1/2):25-48
31. Glendenning FJ, Slavniek E, Forbes WF. An evaluation of devices to aid movement: Part 1 Canes. Rehabilitation Digest 1992; (August):15-16
32. Paris-Seely NJ, Raschke SU, Watzke JW, Jones Y, Halsted N. Evaluation of portable transfer devices to reduce the risk of musculoskeletal injury (MSI) to home care workers and development of performance requirements for such devices. Final Report to Workers' Compensation Board of British Columbia. Vancouver: Workers' Compensation Board; 2000 (March) www.worksafebc.com/about_us/how_we_support_you/library_services/online_publications/wcb_research/assets/pdf/98fs-47.pdf
33. Watzke JR, Paris-Seeley N, Raschke S. Evaluation of portable transfer devices to reduce musculoskeletal injury (MSI) to home care workers. Paper presented at the 52nd Annual Meeting of the Gerontology Society of America, San Francisco, November 1999
34. Birch G, Watzke JR, Bolduc C. Research and development of adaptive equipment for persons with significant disabilities and the elderly: activities conducted by the Neil Squire Foundation. Technology and Disability 1995; 4:169-173
35. EUSTAT Consortium. GO FOR IT! A manual for users of assistive technology. (European Commission, Telematics Applications Programme, Deliverable D05.4). Milano: SIVA; 1999