Technical report

for the Guidelines for the prescription of a seated wheelchair or mobility scooter for people with a traumatic brain injury or spinal cord injury

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Technical report for the Guidelines for the prescription of a seated wheelchair or mobility scooter for people with a traumatic brain injury or spinal cord injury

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First edition 2011
A guideline review is scheduled for 2016

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Executive summary

Providing a wheelchair or scooter is a complex therapy intervention which aims to enhance a person's functioning. The *Guidelines for the prescription of a seated wheelchair or mobility scooter* relate to two health conditions—spinal cord injury and traumatic brain injury. The guidelines have been developed using a rigorous methodology of searching for, appraising and grading the research evidence in conjunction with a working party. The topics covered were generated by the concerns and clinical questions raised by the working party. The guidelines are intended to inform and guide the therapist on clinical actions and decisions, but do not replace the need for clinical supervision or clinical judgment.

The guidelines provide recommendations that range from topics on the goals and evaluation, assessment and review, capacity and performance of the client, upper limb capacity and risk of injury, wheelchair features, through to propulsion, training, transport and maintenance. Resources have been developed to support the use of the guidelines and include checklists on key areas such as shoulder injury prevention, long-term needs, training, transport and maintenance.

This technical report provides information on the development process, methodology, tables of evidence and the working party.

1 Purpose

Prescribing a wheelchair is a complex therapy intervention. Complex therapy interventions:[39, 119]

- have a number of inter-dependent and independent components
- are delivered across inpatient, outpatient and community settings
- are influenced by the potential wheelchair user's context, including environmental and personal factors.

The *Guidelines for the prescription of a seated wheelchair or mobility scooter for people with a traumatic brain injury or spinal cord injury* provide recommendations to assist and guide occupational therapists, physiotherapists and other professionals such as rehabilitation engineers, who are involved in the prescription of a wheelchair. They are not intended to be rigidly prescriptive or to replace clinical judgment, but rather to inform and guide the health professional towards better practice in the prescription of a wheelchair or scooter.

When to consult the guidelines

The guidelines relate to two health conditions: spinal cord injury and traumatic brain injury. Some of the recommendations in the guidelines may be applied to other health conditions. Care should be taken if the graded recommendations are applied to health conditions that are not included in the research study sample on which the recommendations are based.

The population and applicable health conditions

- adults with traumatic brain injury
- adults with spinal cord injury

The definition of adult for these guidelines is 16 years and older.

Spinal cord injury (SCI)

Spinal cord injury is defined as damage to the neural tissues as a result of trauma or a non-progressive disease process, resulting in temporary or permanent sensory deficit, motor deficit, or bladder/bowel dysfunction. Non-progressive diseases include: transverse myelitis, compression by infective process, canal stenosis, haemorrhage or vascular occlusion. Spinal cord injury does not include progressive conditions such as demyelination, genetic disorders, degenerative conditions of the spinal cord and compression by metastatic lesions.

Traumatic brain injury (TBI)

Traumatic brain injury is an insult to the brain following birth, caused by an external force that produces diminished or altered states of consciousness, which can result in a complex range of temporary or permanent neurological impairments in the cognitive, physical, behavioural and emotional domains.

Related publications

The publications in this series include:

- Guidelines for the prescription of a seated wheelchair or mobility scooter for people with a traumatic brain injury or spinal cord injury
- Summary of the guidelines for the prescription of a seated wheelchair or mobility scooter for people with a traumatic brain injury or spinal cord injury
- Consumer information for the guidelines for the prescription of a seated wheelchair or mobility scooter for people with a traumatic brain injury or spinal cord injury
- Technical report for the guidelines for the prescription of a seated wheelchair or mobility scooter for people with a traumatic brain injury or spinal cord injury.

The resources developed for the guidelines are also available as separate documents.

2 Development process

A working party of representatives from key organisations and consumer groups and a part-time project officer developed the guidelines over 2.5 years. Table 1 outlines the development process.

Table 1 Guidelines development process

Phase of guideline development process[93 96]	Activity
Defining the topics and issues to be included	Lifetime Care & Support Authority (LTCSA) and EnableNSW Department of Health identified the need for evidence-based clinical guidelines on the prescription of wheelchairs for specific populations. Objective: To devise evidence-based guidelines with best practice recommendations for therapists to identify the individual's goals and assess their needs, capacity and performance in their own context and prescribe the appropriate wheelchair or scooter.
Preparing the work plan: establishing procedures and time frames; establishing the Guideline multidisciplinary working party	Project brief finalised including: scope of the guidelines, target population, potential users, consultation process, working party membership, trial of the guidelines, methodology, authorship, projected time frames, and initial ideas on dissemination and implementation. The need for two guidelines was considered, but discounted due to content overlap. Working party established with representation from key stakeholders. Each working party member signed a conflict of interest declaration. Working party agreed on the process and meeting dates. After two meetings, the working party was split between the two health conditions. The rehabilitation engineer, LTCSA and EnableNSW representatives, and the project officer attended both working party meetings.
Scoping and developing the health care questions	The working party identified the key clinical areas and topics within the proposed scope. Clinical questions on wheelchair prescription were developed and discussed until consensus reached. Relevant existing Australian and International guidelines identified and reviewed. These guidelines were appraised using the Appraisal of Guidelines Research and Evaluation (AGREE) tool[119].

Developing the guidelines	Key personnel within services specialising in seating were contacted to find potentially relevant publications. Copies of relevant conference abstracts were sought through personal contacts. Experts from NSW and interstate were consulted. Systematic searches of the literature were conducted on multiple databases. Two working party members appraised the research literature and graded the strength of the evidence. The evidence and recommendations were discussed with the working party and the evidence graded in accordance with NHMRC grades.[95] Where available literature was limited, the working party reached a consensus decision and recommendation. Consumer opinion was obtained about the patient information sheet via feedback from consumer organisations and working party members.
Validating the guidelines	Consultation and opportunity for feedback on the draft. Formal endorsement by key stakeholder organisations. Editing by technical editor.
Implementing the guidelines: strategies include distribution, dissemination, audit and feedback mechanisms, support and guidance to knowledge brokers in units.	LTCSA/Enable NSW publication, distribution and dissemination via email to key stakeholders and other organisations and individuals. The guidelines, resources, patient information and technical report made available on LTCSA and EnableNSW websites. The guidelines and resources promoted in various newsletters (consumer, professional association). Hard copies distributed through LTCSA and Department of Health. Related professional conference presentations made in NSW and interstate. Workshops to occupational therapy groups and consumer groups. Workshops and support to key personnel from specialist and general therapy units to adopt a knowledge broker approach and strategy for adaptation and implementation at the local level.
Evaluating the guidelines	To be determined at a future date after implementation.

Funding

The guidelines were developed as a joint project, with funding provided by the Lifetime Care & Support Authority and EnableNSW. The project officer was contracted to and hosted by LTCSA, but was not an employee. Both organisations were involved and provided support throughout. Printing and distribution of the guidelines was jointly funded.

Framework

The guidelines have been informed by two key documents:

The World Health Organization International Classification of Functioning, Disability and Health (ICF).[138] This framework defines a person's functioning based on the bio-psychosocial model of health.

The United Nations Convention on the Rights of Persons with Disabilities (CRP).[122] The CRPD reinforces the principle that the user must be actively involved and thereby placed at the centre of the therapy intervention and specifically refers to supports and assistive devices.

Editorial Independence

The document was written by the project officer. The views and interests of the LTCSA and EnableNSW did not influence the final recommendations.

Conflict of interest

At the beginning of the guidelines development process the working party members were required to declare any real or perceived conflict of interest. One member declared the potential for a perceived conflict of interest because a family member was employed by a supplier. It was anticipated that only wheelchair features would be discussed, not suppliers or brands. Nevertheless, the working party decided and documented that if those topics arose, the party member with the potential conflict of interest would be excluded from the discussion. However, those subjects were not discussed and no conflict of interest occurred.

Guidelines update

A review of the evidence is planned for 2016 when a systematic search for new research published from 2011 to 2016 will be undertaken. A working party will review the recommendations in light of any new research and changes made accordingly. Whether new clinical questions will be explored at this time is not known, but standing wheelchairs may be included in the wheelchair features discussed in Section 8 of the guidelines.

3 Methodology

3.1 Clinical questions

The clinical questions were developed by the working party and are listed in Appendix 1. The questions were discussed and refined over a period of four monthly meetings, with email communication and written feedback between working party members throughout this time. None of the existing guidelines precisely answered the clinical questions or provided recommendations that could be adapted. However, some of the existing guidelines' recommendations and research evidence was used to supplement updated and additional research to formulate a new recommendation.

3.2 Search strategies

Systematic searches for relevant published literature were conducted using key terms and a number of databases. It was anticipated that there would be a paucity of high quality research evidence related to the clinical questions. In order to capture relevant evidence, the working party agreed that the search would be conducted on relevant literature published in the previous twelve years (1998 to May 2011).

Literature searches on clinical questions used key words for search terms to find relevant literature—rather than a participant intervention comparator outcome (PICO) format as for simple interventions—because of the complexity of the clinical questions, many of which would not likely have relevant randomised controlled trials.

National and international guidelines search

Bibliographic databases were systematically searched for existing relevant published guidelines. Only guidelines published since 1999 were included. Manual searches were also performed to identify relevant guidelines. Details of the search terms are provided in Table 3 in Appendix 2. The websites are also listed in Appendix 2.

Systematic reviews

A search for systematic reviews on the Cochrane and DARE databases was conducted in 2009.

Clinical questions and published studies

Appendix 3 lists the search terms used for each clinical question. The databases systematically searched for research studies for all clinical questions were:

CINAHL
EMBASE
MEDLINE
PsychINFO

Inclusion criteria

- Studies in English
- Adults
- Humans
- Papers published between 1998 and May 2011

Methodological filters such as 'clinical trial' or 'randomised controlled trial (RCT)' were not used. The reference lists of key papers were searched manually. Some of the experts contacted also identified relevant research papers.

Exclusion criteria

- Studies involving children (with the exception of training)
- Papers or guidelines in foreign languages
- Papers published before 1998

Articles that were considered of limited relevance or poor quality have not been cited in the evidence tables.

3.3 Appraising the evidence: guideline and article appraisal

The research was assessed for relevance and critically appraised by two reviewers. Research study appraisal was based on the National Health and Medical Research Council (NHMRC) levels for the strength of evidence (levels I–IV) and grading system for guideline recommendations.[57, 58, 95] The literature included reviews and studies of wheelchair user's experiences and perspectives. Qualitative and single case studies were also considered in order to strengthen the body of evidence. The research evidence was presented to the working party.

Clinical Guidelines were appraised using the Appraisal of Guidelines for Research and Evaluation II (AGREE II)[119].

Research articles were appraised according to study design:

- Quantitative studies were assessed using an expanded version of the (NHMRC) appraising the evidence checklists[94] for prognostic and prediction studies, and intervention studies. The partitioned PEDro scale was also used for intervention studies.[104]
- Qualitative studies were evaluated with the McMaster's University qualitative appraisal checklist, Letts et al (2007).[75]
- Single case studies were reviewed using the Single Case Experimental Design (SCED) scale.[117]
- Systematic reviews were not appraised.

3.4 Grading the evidence

The strength of the body of evidence for each recommendation was determined using the NHMRC grades for recommendations[95] with adaptations. The NHMRC grades use a hierarchical model of quantitative research methods. Systematic reviews or meta-analysis of randomised controlled trials are considered to be the most robust evidence.

The NHMRC grading does not incorporate good qualitative research or single case studies, but these methodologies may be relevant to a number of questions raised by therapists for these guidelines. Given the complexity of the intervention, the clinical questions and the context variables posed by the working party, it was important to include qualitative research in grading recommendations.[132] The qualitative research was appraised and included in the determination of the grade for each recommendation. The way in which qualitative research was incorporated within the NHMRC recommendations is outlined in Table 2. Single case studies were not included in grading the recommendations although they are included in the tables of evidence where relevant.

The views or interests of EnableNSW and the Lifetime Care and Support Authority did not influence the final recommendations. All the research on which the recommendations are based is included in the evidence tables in this report.

Table 2 Grade of recommendation

Grade of recommendation	Description
A	Body of evidence can be trusted to guide practice. • One or more level I or several level II studies with low risk of bias and all studies consistent, or inconsistency can be explained. • The clinical impact is very large. • The population(s) studied in the body of evidence are the same as the target population for the guidelines. • Directly applicable to the Australian healthcare context.
B	Body of evidence can be trusted to guide practice in most situations. • One or two level II studies with a low risk of bias or a systematic review/several level III studies with a low risk of bias with most studies consistent or inconsistencies can be explained. • Clinical impact is substantial. • Population studied in the body of evidence is similar to the guideline population. • Applicable to Australian healthcare context with few caveats.
B^{Q}	Body of evidence can be trusted to guide practice. • As above for quantitative studies. • Qualitative studies have been included in the body of evidence so there is one or more qualitative studies of high quality and rigour[58] (credibility, transferability, dependability, confirmability).
C	Body of evidence provides some support for recommendation but care should be taken in its application to individual clinical and organisational circumstances. • One or two level III studies with low risk of bias or level I or II studies with a moderate risk of bias. • Some inconsistency reflecting some uncertainty. • Clinical impact is moderate. • Population studied in the body of evidence differs from the guideline population but it is sensible to apply it to target population. • Applicable to Australian health care context with some caveats.
C^{Q}	Body of evidence provides some support for recommendation(s) but care should be taken in its application to individual clinical and organisational circumstances. • As above for quantitative studies. • Qualitative studies have been included in the body of evidence so there is one or more qualitative studies of reasonable rigour (credibility, transferability, dependability, confirmability).

D	Body of evidence is weak and recommendation must be applied with caution. • Level IV studies or level I to II studies/systematic reviews with a high risk of bias. • Evidence is inconsistent. • The clinical impact is slight. • Population studies in the body of evidence differ to target population and hard to judge whether it is sensible to apply it to the target population.
Consensus	Consensus based recommendation. A systematic review of the evidence was conducted as part of the guideline research strategy. In the absence of high quality evidence, the working party utilised the literature available in combination with the best available clinical expertise and practices to reach a consensus on the recommendation. Consensus recommendations may be context sensitive in some cases.

Some recommendations are not based on evidence or expert opinion. They involve compliance with professional ethics, standards or statutory requirements. These recommendations are referred to as principles (professional best practice) or requirements (regulatory or statutory requirements).

P (Principle)	A principle provides the standard required for a best practice therapy intervention. The working party reached agreement on the wording of the principle.
R (Requirement)	This recommendation is guided by a legal requirement, regulation or rule established by a statutory authority (e.g. Roads and Traffic Authority).

4 Existing guidelines

A systematic search for clinical guidelines found few that were relevant to wheelchair or scooter prescription (refer to Table 3 in Appendix 2). Those that were used in the development of the guidelines are listed in the table of evidence in Section 5.7.

The Spinal Cord Injury Rehabilitation Evidence (SCIRE)[113] is not a clinical guideline. Although it does provide evidence on key topics and makes key points arising from the research, these are not framed as recommendations. The WHO Guidelines on provision of wheelchairs in low resource settings (2008)[139] is also not a clinical guideline, although it has elements relevant to prescribing wheelchairs in certain settings. The document focuses on design and production, service delivery and training. Neither SCIRE[113] nor WHO (2008)[139] could be appropriately assessed using the AGREE tool.[39]

5 Evidence tables

All research studies used in the development of the guidelines were appraised for quality. The evidence tables only include the results of research studies used for recommendations graded A through D (including qualitative studies). They exclude appraisal information for studies that were only used in the commentary for each section (e.g. upper limb injury and pain prevalence studies). Recommendations graded as a Principle, Requirement or Consensus used other sources of information and thus were not appraised.

The evidence tables include the following information:

- Author and year
- Level of evidence[95]
- Study description and type of study, e.g. RCT, case control
- Study objective or question
- Population or study sample, e.g. participants, method, length of follow up
- Study results or findings, size of summary measure, confidence interval or P value
- Comments, e.g. importance, quality, relevance, generalisability, applicability.

5.1 Assessment and review evidence tables

5.1.1 Assessment and review

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Kittel et al (2002)[68]	n/a	Qualitative study, phenomenological and thematic analysis	Identify factors which influence individuals with a SCI to abandon their first wc before 5 years of use	Adults with SCI n=3	The lack of experience in wc use and selection, the functional limitations encountered with the design of the wc, the manner and timing of the prescription process combined led to dissatisfaction and abandonment.	Theoretical perspective linked to adult learning. Semi-structured interview. Small sample, sampling described, role of researcher and relationship with participant not identified, triangulated data, high rigour with credibility, transferability, dependability, confirmability. Experience in home environment highlighted. Contact with peers who use a wc enhanced knowledge. More time to practice helped.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Mortensen & Miller (2008)[87]	n/a	Qualitative study, grounded theory	Explore the intricacies of the procurement process from the perspectives of clients and therapists. Investigate the perspectives of prescribers, individuals who use wc and their associates on the procurement process; how the desired outcomes are negotiated; and the factors that facilitate or hinder the process.	Two semi-structured interviews, with feedback on previous interview (summary and themes identified across all participants) requested in second interview n=13 wc prescribers n=14 wc users n=7 caregivers or family	WC procurement is a complex negotiated and iterative process. Five themes identified: who decides, expert knowledge, form versus function, fitting in, and (re)solutions. Goals and environmental factors play a critical role throughout process.	Limitations: in-depth interviews were the only source of data. Standpoint theory identified diverse sampling, in depth interviews plus re-interview. Data and analysis clearly described, use of reflective journals, good rigour with credibility, transferability, dependability, confirmability.
Samuelsson & Wressle (2008)[109]	IV	Case series, post-test	Determine any difference in satisfaction between users of two different types of mobility products	Questionnaire sent to a random sample on the database (n=510) n=262 respondents included in data analysis	A standardised follow-up will give rehabilitation professionals continuous and valuable information about the effect of and satisfaction with assistive devices.	Cross-sectional follow up, respondents already grouped from allocation equipment type.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Verza et al (2006)[130]	III-3	Historical control study	Demonstrate whether an inter-disciplinary approach to evaluating and prescribing AT reduced equipment abandonment	Persons with MS. First two years AT prescription by physician based on physical therapist recommendation. The intervention over next 2 years involved standardised protocol implemented by an interdisciplinary team. Protocol aimed to ensure that equipment truly needed and met needs, by involving them and their families in process. n=54 subjects n=151 AT devices (67 during pre-intervention, 84 with the intervention)	A comparison of the number of devices obtained pre-intervention with those obtained during intervention showed equipment abandonment rate decrease from 37.3 to 9.5%.	Groups similar at baseline, all aids for all subjects reported, all received either pre- intervention or intervention.
Wielandt & Strong (2000)[137]	n/a	Literature review	Examine the post-discharge compliance of individuals with prescribed adaptive equipment	Databases CINAHL and Medline; 31 articles included	Five categories of factors that affect compliance: medical-related, client-related, equipment-related, assessment-related and training-related. Assessment-related factors included evaluation of client's environment and personal needs, not just diagnosis.	No study appraisal conducted, studies were surveys of compliance. Outcome of studies considered included nature of 'use', the time of follow-up and sample sizes.

Abbreviations: wc – wheelchair; SCI – spinal cord injury; AT – assistive technology; MS – multiple sclerosis

5.1.2 Reasons for non-use

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Cowan et al (2009)[19]	III-1	Cross over trial appraised as pseudo-randomised	Examine the impact of surface type, wheelchair weight and rear axle position on older adult propulsion biomechanics	Convenience sample, older adults with minimal wc experience n=53	There is decreased self-selected velocity and increased peak force when surface resistance increases. Anterior axle positions decrease forces particularly on high carpet. Effects of weight and axle position independent, with greatest reductions in peak forces with lighter wc and anterior axle position.	Trial involved randomisation of different surfaces and wc so appraised as RCT, although no controls. Concealment of allocation or blinding to conditions not possible. Outcomes measured for all subjects.
Di Marco (2005)[31]	III-3	Comparative study	Investigate the factors that influence wc users' sitting posture, comfort, wc skills, maintenance knowledge, satisfaction with and abandonment of their prescribed wc over a 5 year period	Adults with SCI n=120	The study identified complex and interrelated factors influencing the outcomes of wc prescription among people with SCI over time.	Interrupted time series, no control. Eligibility criteria not described, but post description of subjects. One group only, outcome measures varied from 78% to 90% for participants, ratings of satisfaction by subjects was limited to 78% of total. There was reporting of group comparisons for satisfaction and comfort. Measures only frequency, no point measures and measures of variability.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Edwards & McCluskey (2010)[37]	IV	Cohort study	Investigate the characteristics of adults who use power wc and scooters, explore the process of power-mobility provision and examine the benefits and challenges of use	Convenience sample, surveys n=202	Power-mobility devices have many benefits for users, but can have negative outcomes like accidents, resulting in injuries. Further research is needed.	Cross-sectional survey. Approximately 650 surveys distributed through councils, personal contacts and disability organisations. No confounders identified, comparisons made between wc and scooter users on outcome measures, group similarity n/a.
Evans et al (2007)[38]	n/a	Qualitative study, phenomenological analysis	Study older indoor/outdoor wc users' satisfaction with the chair and service providers	Men and women between 60-81 years n=17	The wc service was useful to older people with disabilities, although those with wc only used it moderately. Limited use related to an infrequent need for outings, feelings of insecurity, and lengthy waiting times for chair delivery and required modifications.	Participants described. Site and participants, researcher assumptions, and role and relationship to researcher clearly described. Minimal information on procedures for translation and a priori development of the topics.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Garber & Bunzel (2002)[46]	IV	Case series, post-test	Determine the extent to which wc prescribed during rehabilitation are used and perceived as satisfactorily meeting individual mobility, functional, psychological and social needs of veterans who have had a stroke	Veterans with stroke n=49	Continued use was associated with improved physical function and use of alternative mobility aids, medical and psycho-social problems unrelated to need for wc were common, e.g. socialisation, occupation, depression. There is a need for re-evaluation of mobility and psychosocial needs during the years following rehabilitation.	Cross-sectional descriptive study, participants described. Only one group, only 54% of participants provided outcome data. Statistical reporting of comparisons n/a only one group. Points measures and measure of variability provided.
Kittel et al (2002)[68]	n/a	Qualitative study, phenomenological and thematic analysis	Identify factors which influence individuals with a SCI to abandon their first wc before 5 years of use	Adults with SCI n=3	The lack of experience in wc use and selection, the functional limitations encountered with the design, and the manner and timing of the prescription process combined lead to dissatisfaction and abandonment.	Theoretical perspective linked to adult learning. Semi-structured interview. Small sample, sampling described, role of researcher and relationship with participant not identified, triangulated data, high rigour with credibility, transferability, dependability, confirmability. Experience in home environment highlighted. Contact with peers who use a wc enhanced knowledge. More time to practice helped.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Mortenson & Miller (2008)[87]	n/a	Qualitative study, grounded theory	Explore the intricacies of the procurement process from the perspectives of clients and therapists. Investigate the perspectives of prescribers, individuals who use wc and their associates on the procurement process; how the desired outcomes are negotiated; and the factors that facilitate or hinder the process.	Two semi-structured interviews, with feedback on previous interview (summary and themes identified across all participants) requested in second interview n=13 wc prescribers n=14 wc users n=7 caregivers or family	WC procurement is a complex negotiated and iterative process. Five themes identified: who decides, expert knowledge, form versus function, fitting in, and (re)solutions. Goals and environmental factors play a critical role throughout process.	Limitations: in-depth interviews were the only source of data. Standpoint theory identified diverse sampling, in depth interviews plus re-interview. Data and analysis clearly described, use of reflective journals, good rigour with credibility, transferability, dependability, confirmability.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Mukherjee & Samanta (2005)[89]	IV	Case series	Survey the fate of the donated wc and the difficulties encountered by the users by identifying the cause of rejections, and to evaluate the performance by assessing physiological strain on the recipients during their routine ambulation using cardio-respiratory parameters	Donated wc recipients in India n=162 (159 male)	Hand rim propelled manual wc are unsuitable for outdoor ambulation due to low speed and high physiological demands, they are also of little use indoors – difficult to manoeuvre given environmental conditions & architectural restraints. WC should not be recommended without proper assessment of the user's activity level & requirements.	Subjects interviewed and simple field test. Grouped to occasional users and regular users (some comparisons between groups) between group comparisons made including points measures and measures of variability (SD and P values).
Papadimitriou (2008)[100]	n/a	Qualitative study, phenomenological analysis	Document the process of learning to use a wc and making it a part of one's embodied existence	Convenience sample n=30	The process involves the negotiation of past and new habits, abilities and ways of doing, the competence and abilities required to achieve embodiment is a situated accomplishment with social and political consequences.	Interviews and ethnographic descriptions used. Linked to bio-psychosocial model (body as a socio-cultural and biological entity). Subjects described in detail. Results presented as a lived experience or a life story, rather than in a reductionist or mechanistic way. Rigour: good credibility, transferability, less dependability and poor confirmability.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Pape et al (2002)[101]	n/a	Literature review	Examine the development of individualised meanings assigned to assistive technology and how these influence the integration of assistive technology into daily activities	81 publications used	Successful integration of assistive technology into daily lives requires potential device users to explore the meanings they assign to the devices, their expectations, anticipated social costs and ways to understand that disability is not the only feature to define identity.	
Samuelsson & Wressle (2008)[109]	IV	Case series, post-test	Determine any difference in satisfaction between users of two different types of mobility products	Questionnaire sent to a random sample on the database (n=510) n=262 respondents included in data analysis	A standardised follow-up will give rehabilitation professionals continuous and valuable information about the effect of and satisfaction with assistive devices.	Cross-sectional follow up, respondents already grouped from allocation equipment type.
Samuelsson et al (1999)[110]	n/a	Case study and description of method	Present a method applying practical knowledge to the prescription, adjustment and adaptation of wc	Case study n=1	Assists with decision making and evaluation in the individual cases.	
TranSPOT (2010)[121]	n/a	Guidelines	Transport safety guidelines for people with a disability	n/a		Procedural guidelines and information for best practice on safety.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Weiss-Lambrou et al (1999)[135]	IV	Case series	Evaluate user satisfaction with wc seating aids	n=24	The results support the value of consumer opinion and challenge the assumptions of assistive technology professionals, underscore the appropriateness of assessing consumer satisfaction.	Post-test only. French version of QUEST outcome measure. Evaluations took place in subjects' natural setting, e.g. home or institution. Descriptive analysis.
Wessels et al (2003)[136]	n/a	Literature review	Discuss the determinants that affect the degree of non-use of provided assistive technology	n/a	Discussion and grouping of factors.	
Wielandt & Strong (2000)[137]	n/a	Literature review	Examine the post-discharge compliance of individuals with prescribed adaptive equipment	Databases CINAHL and Medline; 31 studies included	Five categories of factors that affect compliance: medical-related, client-related, equipment-related, assessment-related and training-related. Assessment-related factors included evaluation of client's environment and personal needs, not just diagnosis.	No study appraisal conducted, studies were surveys of compliance. Outcome of studies considered included nature of 'use', the time of follow-up and sample sizes.

Abbreviations: wc – wheelchair; RCT – randomised controlled trial; SD – standard deviation

5.2 Capacity and performance evidence tables

5.2.1 Cognition and perception

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Cullen (2008)[21]	II	Prospective cohort study	Investigate the rates of powered wc use and level of user-rated functional performance at 1 month follow up and whether psychological variables were prospectively predictive of outcome	Adults with impaired mobility recruited from power wc clinics n=103	Those with indoor chairs were less frequent users. Those with indoor/outdoor chairs 72%. Rates of indoor use were predicted by measures of verbal recall, figure copying, and global cognition. Powered wc use predicted by cognitive measures. P values provided. Forward regression model. Executive function measures taken did not predict functional power wc use, but the measures may have lacked sensitivity.	Follow up 79%. Some confounders reported such as confidence, educational level.
Dawson & Thornton (2003)[23]	n/a	Single case study	Evaluate the potential use of an indoor electrically powered wc with two people with unilateral neglect, whether training improved accuracy to drive	Single incident right hemisphere lesion following stroke. Study over 8 weeks, ABA single subject design, driving accuracy measured each weekday. Two weeks of training, 30 minutes each weekday. n=2	Participants leaned to drive the powered wc despite persisting neglect. Task specific training should be used. Unilateral neglect should not rule out patients being considered for power wc. Further research is needed.	

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Higuchi et al (2009)[56]	III-2	Case control study	Determine whether wc users showed enhanced ability to estimate the space required for locomotion with familiar and unfamiliar wc	Participants had to make a determination at a distance from 2.8 m as to whether a door opening was passable or impassable n=7 participants with tetraplegia n=7 matched able-bodied controls	Adaptation to altered body dimensions occurs in a short time only under a well-learned, familiar form of locomotion. The findings suggested individuals are likely to rely more on visual memory of a passable space than somato-sensory information on the wheelchair dimensions.	Eligibility criteria not specified, no randomisation or blinding of assessors, or subjects. All subjects used in analysis, statistical comparisons between groups made. Point measures and measures of variability provided.
Letts et al (2007)[76]	IV	Case series	Determine reliability and validity of power mobility community driving assessment (PCDA)	Phase I: Occupational therapists who pilot tested PCDA contacted (n=110), low response rate of n=7. Method: therapists use PCDA, and provide feedback. Phase II: Adult drivers of power mobility (n=38). Method: treating therapists rated driving performance, research assessors assessed client using PCDA and other tests.	PCDA has good content validity, reasonable reliability, but not construct validity for visual perceptual and cognitive skills of the driver. Therapists need to assess driving performance rather than rely on tests of perception, cognition or environmental accessibility to pre-determine whether someone will receive power mobility.	Some blinding: therapist scored driving performance without knowing results of any other study assessments.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Massengale et al (2005)[79]	IV	Cohort study	Determine to what extent visual perception, visual function, cognition and personality traits affect power wc use in adults	Standardised instruments used, participants undertook a power wc performance test (developed by authors – power mobility road test). Adult power wheelchair users (minimum 3 months driving experience). n=62	Visual perception, visual function, and cognitive skills are important skills for power wc drivers and impact on performance. The data assist clinicians identify factors to consider when evaluating and training for power wc use.	No confounders reported, no group to compare, high follow up, no assessor blinding reported.
Nilsson & Eklund (2006)[98]	n/a	Qualitative study, grounded theory	Investigate the relationship between characteristics connected to power wc use and trainees' success or failure in developing conscious joystick use	Adults and children with profound cognitive disabilities and multivariate additional disability or at risk of developing the condition. n=45	Findings showed high predictability and usability of powered wc use facilitated successful achievements in the earlier identified process of growing consciousness of joystick use. The implications are that it is meaningful to engage people with profound cognitive disabilities in training of joystick use in a powered wc, but the wc needs to provide high predictability and usability of functions.	Aims and results clearly reported. Multiple sources of data: video-recordings, field notes, open interviews with concomitant analysis. Theoretical sampling with subjects recruited over 12 years. Overall rigour with credibility, dependability, decision trail not as well reported, difficulties as study evolved over protracted period of time.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Tefft et al (1999)[118]	IV	Case series	Identify and document the skills necessary to operate a powered wc functionally, which cognitive skills correlate with powered mobility driving skills, identify when a child has the cognitive skills necessary to operate a powered wc safely	Children aged 20-36 months with physical disabilities, cognitively assessed, and participated in wc mobility training and assessment program. Children with diagnosis typically associated with severe cognitive and/or sensory motor impairments excluded. n=26	Cognitive domains of spatial relations and problem solving were significant and accounted for 57% of the variance in wc skills.	Different diagnosis and different stages. Sensitivity and specificity chosen with higher cut off point on sensitivity, lower specificity – to determine degree of mastery that a child needed for spatial relations and problem solving domains. Small sample size, considered preliminary results.

Abbreviations: wc – wheelchair; ABA – (three phases: A=baseline conditions, B=intervention, A=return to baseline conditions)

5.2.2 Upper limb capacity (recommendations and risk factors)

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Akbar et al (2010)[3]	III-3	Retrospective cohort study	Evaluate the prevalence and risk of pathological changes in the weight-bearing shoulder girdle of paraplegic patients who have been wc dependent for more than 30 years in comparison with able-bodied	n=100 people with paraplegia n=100 matched able-bodied volunteers	Structural and functional changes of the shoulder joint are more severe and the risk of development of shoulder girdle damage is significantly higher in individuals with long-term paraplegia than in age-matched controls.	Both shoulders of each subject measured. Eligibility criteria reported. Groups similarity reported and risk factors for shoulder tear identified, confounders not linked to causal or risk. Group comparison. Odds ratio and P values provided. Radiologists (assessors) blinded to group. Outcome data for all subjects.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Beekman et al (1999)[6]	II	Randomised trial	Compare wc propulsion in light and ultra-light wc in people with different levels of SCI	People with SCI, most subjects male, 5 female n=74 (44 paraplegia, 30 tetraplegia)	The ultra-light wc improved the efficiency of propulsion in the subjects.	Comparison of two wc randomised but method of randomisation not documented. Unlikely any blinding. All subjects had all outcome measures.
Boninger et al (1999)[9]	IV	Case series	Gain a better understanding of the mechanisms behind carpal tunnel syndrome in manual wc users	People with paraplegia who used wc for mobility, all had paraplegia below T3 n=34	Subject weight (but not body mass index) related to push rim forces and median nerve function. Independent of weight, push rim biomechanics were also related to median nerve function.	Subjects recruited from wc vendors, and discharge records of inpatient rehabilitation programs. 97% of subjects with outcome measurements.
Boninger et al (2003)[10]	IV	Longitudinal cohort study	Investigate the relationship between push rim forces and the progression of shoulder injuries in manual wc users	Subjects with SCI n=14 (8 men, 6 women)	Pushing with greater percentage of force directed towards the axle was at increased risk of findings on MRI. Clinicians should instruct wc users in effective propulsion techniques, in particular women, reducing forces during wc propulsion may reduce likelihood of injury.	Subjects not at same stage therefore not appraised as prospective. Small sample. MRI changes were identified and then sample dichotomised. Confounders not reported. Radiologist (assessor) was blinded, all subjects were measured.
Collinger et al (2008)[11]	IV	Case series	Descriptive analysis and comparison of shoulder kinetics and kinematics during wc propulsion at multiple speeds and investigating the effect of pain	Manual wc users with paraplegia n=61	Body weight maintenance and other interventions should be designed to reduce the force required to propel a wc, should be implemented to reduce the prevalence of shoulder pain and injury among manual wc users.	Recruitment and exclusion criteria provided, no group allocation, group similar information, some subjects' outcome measurement not reported (82% loss).

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Consortium for Spinal Cord Medicine (2005)[13]	n/a	Guideline	Preservation of upper limb function following spinal cord injury	n/a	n/a	Refer to Section 5.7 for AGREE rating.
Cowan et al (2009)[19]	III-1	Cross over trial appraised as pseudo-randomised	Examine the impact of surface type, wheelchair weight and rear axle position on older adult propulsion biomechanics	Convenience sample, older adults with minimal wc experience n=53	There is decreased self-selected velocity and increased peak force when surface resistance increases. Anterior axle positions decrease forces particularly on high carpet. Effects of weight and axle position independent, with greatest reductions in peak forces with lighter wc and anterior axle position.	Trial involved randomisation of different surfaces and wc so appraised as RCT, although no controls. Concealment of allocation or blinding to conditions not possible. Outcomes measured for all subjects.
DallMeijer et al (1998)[22]	IV	Cohort study	Investigate the effectiveness of force application, power output and energy expenditure, and timing parameters of wc propulsion	Adults with SCI n=29	Tetraplegia showed a significantly lower effectiveness of force application in the frontal plane. Power output/energy expenditure as an indication of mechanical efficiency was lower in tetraplegic subjects and associated with effectiveness of force application.	Inclusion/exclusion criteria reported, males and females, age range, minimum 1 year since injury, pre-test on technique performed for analysis of technique parameters.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Desroches et al (2006)[28]	IV	Case series	Determine the effect of system tilt angle (STA) and seat-to-back rest angle (SBA) changes on the load sustained by the shoulder during manual wc propulsion	Adults, mixed diagnosis, mean age 68 years n=14	No significant differences between shoulder joint moments for the various combinations. Shoulder load was maintained at the same level when changing seat angle but keeping wheel-axle position. Thus seat angle can be determined with user comfort and goals, and pressure modulation at seat interface for alleviating pressure without increasing risk of overuse shoulder injuries.	Subjects randomly allocated order of tests. No blinding of subjects or therapists.
Desroches et al (2010)[27]	IV	Diagnostic	Describe upper limb joints dynamics during manual wc propulsion using joint coordinate systems	People with SCI, lesion below C7 and manual wc for > 1 year, no previous upper extremity pain past 6 months n=9	Stabilisation configuration at the upper limb joints couple partly explains the lower mechanical efficiency of manual wc propulsion and could give insight about injury risk at the wrist, elbow and shoulder joints.	Diagnosis or screening used as most appropriate – purpose was to investigate joint dynamics for manual wc propulsion but not validate method. No reference standard although validity of method, tools and procedure linked to previous research in the literature. Subjects not in own wc.
Dubowsky et al (2008)[36]	III-2	Validation study	Present and validate a rigid-body musculoskeletal model of the upper limb for calculation of shoulder joint forces throughout wc propulsion	n=2 subjects with paraplegia n=1 able-bodied	The measured forces at the push rim and 3-D propulsion kinematics drove the model and computationally calculated muscle activities were compared with experimental muscle activities. Present work validates method.	Diagnosis or screening appraisal used as most appropriate method to appraise. Comparison with reference standard (AnyBody Modeling system), not blinded.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Forslund et al (2007)[40]	IV	Cohort study	Investigate how men and women with SCI perform transfers from table to wc with regard to timing and magnitude of force generation beneath the hands and associated body movements	Subjects with thoracic SCI n=13 (7 men, 6 women)	The forces beneath the trailing hand were larger than those in the leading, if there is weakness or pain in one arm, this arm should be selected as the leading. To avoid excessive load on the arms, technical aids and environmental factors should be very well adapted.	Subjects at different stages of disease, grouped by sex. No confounders identified, similarities not examined, group comparisons not reported, all outcome measures for all subjects reported.
Gagnon (2008)[42]	IV	Cohort study	Quantify and compare the triaxial net shoulder and elbow joint forces and shoulder flexor and adductor moments, elbow moments when the dominant upper limb is in three different roles: lead, trailed or lifted during transfers	Convenience sample of SCI n=13	Sitting pivot transfers are among the most mechanically challenging wc related activities in shoulder and elbow joint forces, moments routinely performed. The transfers and weight-relieving lifts were found to expose the shoulder joints to substantial posteriorly and superiorly directed forces.	Subjects at different stages of disease. All subjects completed both types of transfers, conditions not randomly presented. Neither subject comparisons nor blinding reported.
Gagnon et al (2008)[43]	IV	Case series, post-test	Examine the kinematic requirements of sitting pivot transfer	Adult males with SCI n=10	Sitting pivot transfers are characterised by substantial angular displacements and velocities at the trunk and upper extremities.	Eligibility criteria documented. Order of transfers remained same, although not reported, it is assumed that all subjects completed all transfers and all data obtained.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Gagnon et al (2009)[44]	IV	Cohort study	Determine if upper limb muscular demand is reduced when individuals with SCI perform a sitting pivot transfer in the preferred direction compared with non-preferred	Adults with SCI, levels from C6 to S1 n=14	Direction preference expressed by individuals with SCI when transferring between seats of even height is not explained by relative muscular demand differences.	Subjects at different stages of disease, eligibility criteria detailed, order of direction of transfers not randomised, always preferred first, some confounders identified, group allocation not relevant, appears all outcome data for all subjects.
Gagnon et al (2009)[45]	IV	Case series, post-test	Examine the EMG activation patterns of upper extremity muscles in males with SCI and to compare them across sitting pivot transfers performed toward seats of different heights	Males with SCI n=10	Coordinated and higher muscular efforts were generated at the trailing deltoid, pectoralis major when transferring to a high target seat compared to one of similar height, and in the leading biceps when transferring to a high seat compared to a level one. Lowering target seat with respect to the initial seat had no favourable effect on muscular demand.	Eligibility criteria reported. Allocation of seat height not randomised (same order), no blinding reported, assumed all outcome measures for all subjects, and 3 transfer levels. Between group statistical comparisons reported.
Grieve & Dickerson (2008)[49]	n/a	Literature review, commentary	Identify evidence on the mechanism of fatigue and injury associated with overhead work in the context of ergonomic design	n/a	Reports on the mechanisms of exposure to overhead work and their associated negative health and performance outcomes.	Methods not described. Summarises knowledge regarding overhead work, proposes evidence-based considerations for evaluation of tasks, and identifies research areas that lack guidelines.
Gutierrez et al (2005)[50]	IV	Case series	Quantify the effect of seat fore-aft on shoulder muscle activity during wc propulsion	Males with SCI n=13	Reduction in the intensity of the primary push phase muscles during high-demand activities of fast and graded propulsion may reduce the potential for shoulder muscle fatigue and injuries.	Order of conditions consistent.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Hatchet et al (2009)[55]	III-3	Comparative study	Determine the impact of gender on shoulder muscle strength and community wc usage in individuals with paraplegia	Men and women recruited from outpatient clinics n=67	Community wc propulsion speed was similar between men and women, but men were stronger, thus daily mobility requires higher relative effort for women's shoulder muscles, which may increase susceptibility to fatigue and development of shoulder pain.	Excluded those with shoulder pain, blinding not possible, allocation by sex, all subjects had outcome measurements.
Koontz et al (2002)[69]	IV	Case series	Examine the kinematics and kinetics of the shoulder during wc propulsion at a slow and moderate speed	Spinal cord injury subjects with paraplegia n=27 (10 women, 17 men)	Peak forces occurred at the near end of the propulsion phase at same time shoulder was maximally flexed and minimally abducted. Shoulder positioning and associated peak shoulder loads during propulsion may be important indicators for identifying wc users at risk of developing shoulder pain and injury.	Subjects underwent all conditions, some subjects had difficulty with speed 2, but outcome measures for all. Between groups statistical reporting (P values and SD).
Kotajarvi et al (2004)[71]	II	Randomised trial	Examine the effect of a seat position on hand rim biomechanics	Experienced manual wc users (> 6 months), SCI injury level between T5 and L3, males and females n=13	A shorter distance between the axle and shoulder (low seat height) improved push time and push angle. Axial and radial forces were highest in the lowest seat position, whereas propulsion efficiency did not change with seat position.	Randomisation of order of different axle positions per subject, appraised as randomised trial, no blinding reported, exclusion criteria listed, data collected for all seat conditions for all subjects.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Kulig et al (2001)[72]	IV	Case series	Study the effects of SCI level on shoulder kinetics during manual wc propulsion	People with SCI n=69	The superior push force in the tetraplegic group coupled with weakness of thoraco-humeral depressors increases susceptibility of the sub-acromial structures to compression.	Eligibility criteria provided. Confounders not identified causal or risk (e.g. level of SCI), group similarity and statistical differences between groups provided. Subjects at different stages of disease. Allocated according to level of SCI (4 groups). Method of recruitment not cited.
Lal (1998)[74]	II	Prospective cohort study	Assist to identify high risk SCI individuals and ultimately develop preventive strategies	People with SCI (18 female) n=53 (33 tetraplegia, 20 paraplegia)	The study demonstrated a correlation between individuals with higher level of wc activity, higher age, female gender, and more prone to develop degenerative changes in the shoulders particularly affecting the acromio-clavicular joint.	Prospectively followed during outpatients, all at same stage of disease. Grouping based on level of SCI, subjects had been outpatients to rehabilitation facility. Follow up was for a minimum of 5 and maximum of 15 years. Baseline characteristics not reported, confounders, group comparisons not applicable. X-rays at follow up for 60% of cases.
Mercer et al (2006)[82]	IV	Cohort study	Examine the relationship between shoulder forces and moments experienced during wc propulsion and shoulder pathology	Subjects recruited from wc vendors and discharge records inpatient SCI rehabilitation unit, injury below T1 n=33 (23 males, 10 females)	Specific joint forces and moments were related to measures of shoulder pathology and may indicate the need to reduce the overall force required to propel a wc to preserve upper limb integrity.	Exclusion criteria listed. Confounders identified as marker of risk (injury and degenerative changes, kinetic data from Smartwheel and surface EMG), all 33 subjects with outcome measures, testing did not appear to be independent.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Morrow et al (2010)[86]	IV	Case series	Investigate the shoulder joint kinetics over a range of daily living and mobility tasks associated with manual wc propulsion to characterise demands placed on the shoulder during the daily activity of manual wc users	Manual wc users n=12 (11 SCI, 1 spina bifida)	Activities identified that result in higher shoulder kinetics when compared to standard level propulsion. Weight relief required high forces, and large moments during ramp propulsion.	Statistical reporting of group comparisons – differences P value provided, blinding not reported, some data only 85% of subjects, others less than this.
Mulroy (2004)[90]	IV	Case series	Determine the influence of SCI level on the timing and relative intensity of shoulder muscle activity and therefore demands on upper extremity, during wc propulsion	Convenience sample, outpatients clinics, mix of tetraplegia and paraplegia n=69	The level of SCI significantly affected the shoulder muscle recruitment patterns during wc propulsion. Despite slower propulsion, those with tetraplegia has similar or higher electromyographic intensity and duration for most muscles.	Mean time in wc since injury 6 to 10.5 years. Excluded if previous shoulder pain, none participated in competitive wc sports.
Mulroy et al (2005)[91]	IV	Case series	Document the effect of fore-aft seat position on shoulder joint kinetics	Males with paraplegia n=13	A posterior seat position reduced the superior component of the shoulder joint resultant force, this intervention potentially diminishes the risk for impingement of sub-acromial structures.	Eligibility criteria reported. Test wc but used own cushion. Pre- and post-data collected. No group comparison or blinding reported.
Newsam et al (1999)[97]	IV	Case series	A comparison of upper extremity motion during wc propulsion at 4 levels of SCI using three dimensions	Subjects with SCI n=69 (17 low paraplegia, 19 high paraplegia, 16 C7 tetraplegia, 17 C6 tetraplegia)	Compared with paraplegic subjects, those with tetraplegia differed primarily in the strategy to contact the wheel, with greater wrist extension and less forearm pronation.	Subjects had minimum 1 year of wc use. Subjects used same wc, with some modifications to be consistent with their own wc, brief practice in test wc. Group similarity reported, number of subjects with outcome measures not reported.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Price et al (2007)[105]	IV	Cross-sectional bio-mechanic study	Compare upper limb joint power magnitude and distribution between shoulder, elbow and wrist during maximal acceleration versus steady-state, self-selected speed manual wc propulsion	Adults with SCI, more than 1 year post-injury, manual wc users with injury below T1 n=13	Power at the shoulder was larger than at other joints. Peak shoulder joint power larger during maximal acceleration versus self-selected speed, whereas elbow and wrist power fractions were smaller for maximum speed and self-selected speed propulsion. Higher joint power present under maximal acceleration may predispose wc users to injury at the shoulder.	No allocation with order of conditions assessed, blinding not possible, outcomes for all subjects and all subjects underwent both conditions. Group statistical comparisons provided P values. Forest plot provided.
Sabick et al (2004)[108]	IV	Case series	Use an ergonomics-based rating that characterises both demand on and capacity of upper extremity muscle groups most at risk for pain or overuse injury in a relatively demanding wc propulsion task	Adult manual wc users with complete T6-L2 paraplegia n=16	A relatively benign ramp (2.9 degrees) places a large demand on the musculature of the upper extremity.	All participants had been using wc for primary mobility for four years. Considered confounders, used own wc to minimise changes to propulsion, no comparison group, all data for all subjects.
Sawatzky et al (2005)[112]	IV	Cross-sectional cohort study	Compare the prevalence of shoulder pain in adult wc users who began using their wc during childhood (immature skeleton) with those who began using their wc as adults (mature skeleton)	Subjects' conditions SCI and spina bifida. n=53 (22 adult onset, 31 child onset)	Higher prevalence of overall pain and shoulder pain in adult onset group. The immature skeleton can possibly respond to the repetitive forces of wheeling better than that of those who begin using a wc after their skeletal structure is completely developed.	Group comparisons made. Co-variables identified, confounders linked to causes, group comparisons reported and statistical differences, measures presumed to be taken for all subjects (not reported).

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Van der Woude et al (2009)[124]	II	Randomised trial	Evaluate the effects of wc seat height on wheeling efficiency and technique during rehabilitation	Subjects with recent SCI (study occurred during their rehabilitation) n=12	Optimisation of seat height during spinal cord injury rehabilitation may lead to more efficient and less straining conditions for manual wheeling.	Randomisation of order of seat height per subject, appraised as randomised trial.
Van Drongelen et al (2005)[125]	III-2	Case control study	Estimate the differences in gleno-humeral contact forces and shoulder muscle forces between able-bodied subjects and those with paraplegia and tetraplegia during wc related activities of daily living	Male subjects n=17 (5 able-bodied, 8 paraplegia, 4 tetraplegia)	Gleno-humeral contact forces were significantly higher for weight-relief lifting and highest over the 3 tasks for the tetraplegia group. More muscle force was estimated for tetraplegic subjects.	Allocation by diagnosis, statistical reporting between groups. Groups different – paraplegia group older than able-bodied and tetraplegia group. Outcomes for all subjects obtained. Group comparisons not used to explore confounders. Intervention study appraisal used as best fit because of control group. Inclusion criteria reported.
Veeger et al (1998)[128]	IV	Case series	Study wrist joint angles and their relationship with wrist and finger activity during the push phase of wc propulsion	n=5 non-impaired controls n=4 wc users	Large deviation and extension angles, and especially those occurring simultaneously with wrist flexor activity are serious risk factors for carpal tunnel syndrome.	Small sample, no baseline comparisons reported, nor confounding factors. Some of the non-impaired controls had prior wc propulsion experience. Most subjects used a different wc but one had to use his own wc. All subjects' outcome measures reported.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Veeger et al (2002)[129]	IV	Case series	Assess the mechanical load on the gleno-humeral joint and on shoulder muscles during wc propulsion at everyday intensities	Male wc users, all participated in wc sports weekly n=3	Low intensity wc propulsion does not appear to lead to high contact forces, the muscles forces in the rotator cuff are high, which might indicate a risk for muscle damage and development of subsequent shoulder injuries.	Small sample size, SD provided. Outcome measures for all subjects taken.
Wei (2003)[134]	IV	Case series	Investigate wrist kinematic characterisation at various wc seat positions	People with disabilities, wc users n=11	Seat was found to be a critical factor affecting the temporal parameters of movement and wrist kinematic properties, wrist joint angles and wrist flexion-extension range of motion varied according to seat height, ideal seat height not indicated.	Combinations of horizontal positions and vertical seat height. Subjects poorly defined, sequence of testing randomised but no details of method, no blinding reported, not all subjects' outcome measures reported but assumed all were measured.

Abbreviations: wc – wheelchair, SCI – spinal cord injury; SD – standard deviation; MRI – magnetic resonance imaging; RCT – randomised controlled trial; EMG – electromyogram

5.2.3 Cardiovascular fitness

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Abel et al (2008)[1]	III-2	Non-randomised trial	Evaluate the energy expenditure of wheelchair dependent individuals	Endurance test involving basal metabolism evaluation, incremental exercise test until exhaustion and an endurance test n=10 wc racers n=17 hand bikers (two athletes with bilateral leg amputations)	Energy expenditure of hand biking and wc racing is high enough to maintain fitness and probably help to prevent cardiovascular disease even at a moderate intensity.	Subjects were competitive athletes. Confounders recognised (age, body mass, sport activity).

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Cowan & Nash (2010)[20]	n/a	Monograph and literature review	Summarise the SCI specific profile of 3 cardiovascular disease risk factors: fasting dyslipideameia, post prandial lipidaemia and vascular inflammation; how exercise might be beneficial	n/a	No analysis, although studies were grouped by cardiovascular risk factors and types of exercise.	Descriptive, search strategy not provided, no quality appraisal of literature used, not able to determine homogeneity/ heterogeneity of studies.
Devillard et al (2007)[29]	n/a	Literature review	Review the literature on the efficiency of training programs for SCI	n/a, searched MEDline only	Reconditioning training programs after SCI have a direct impact on function and quality of life, permitting participation in physical activities in addition to daily living activities.	Limited to one database, search strategy identified. Methodological quality reviewed but criteria for this not specified. Descriptive presentation of results, no analysis other than grouping by intended effect of training. No tests of similarity applied.
Fukuoka et al (2006)[41]	IV	Pre- and post-test case series	Assess the effects of training on pulmonary oxygen uptake for people with SCI	SCI participants, none had performed exercise in the past 3 months n=8	In SCI participants there was an acceleration of VO2 kinetics at the onset of exercise observed over a short term.	Small sample size, no group allocation, all received same treatment, no drop outs. Between time points analysis provided.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Jae et al (2008)[60]	IV	Cross-sectional case control	Test hypothesis that physically active people with SCI do not have increased sub-clinical atherosclerosis compared with an age-matched able-bodied group	n=28 wc athletes with SCI n=24 recreationally active age matched able-bodied control group	Participation in regular exercise may preserve arterial function in individuals with SCI when compared with age-matched able-bodied participants.	Participants with SCI all at different stages, group similarity on several factors.
Janssen et al (2001)[63]	IV	Case series	Examine the physical capacity, gross efficiency and physical strain of hand cycle users in a race (on a treadmill)	Male subjects, some with upper limb impairments, SCI, two with spina bifida, one with amputation, one with lower limb amputation and joint problems. The race was 10 kilometres, all subjects used a hand cycle system attached to their wc. n=16	Results suggest that hand cycling is well suited for aerobic training for most groups of wc users.	Group similarities made, similar at baseline, all subjects completed race. Allocation and blinding n/a, minimal loss to f/up, statistical analysis and comparisons with standard deviations provided.
Janssen et al (2002)[62]	IV	Case series	Develop normative data and determinants of physical capacity in individuals with tetraplegia and paraplegia	Data from 5 previous studies re-analysed n=166 adults	Values and percentiles for physical capacity measures developed.	Approximately 40% of subjects were athletes, which would influence the values. Also some over 70 years and some less than 18 years, or unable to propel manual wc.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Mukherjee et al (2001)[88]	IV	Case series, pre- and post-test outcomes	Observe the effect of endurance training on novice users of arm-propelled three-wheeled chair, powered by asynchronous arm crank propulsion, in actual locomotive conditions	Study conducted in an outdoor setting, with a continuous endurance training program, subjects propel themselves at a free chosen speed for 15 minutes daily. Data collected at two-week intervals, measures included propulsion speed, peak heart rate, oxygen uptake. n=12 male paraplegics	Self-ambulation at free chosen speed regularly for 10-12 weeks provides efficiency and improves fitness status required for wheelchairs driven by an asynchronous arm crank propulsion technique and no special exercise program is required. May be due to different propulsion technique compared to standard wc propulsion.	No loss to follow up, exclusion criteria listed. Randomisation and blinding n/a, no adverse incidents, P value over time, point measures, standard deviations.
Tordi et al (2001)[120]	IV	Case series, pre-and post-test outcomes	Investigate the effects of a short interval training program specifically designed for patients with SCI	Two types of maximal tests performed before and after training: progressive test and constant load test. Training and test used a wc ergometer. Four week training (upper body) program. n=5	There was a significant improvement in the fitness level and endurance capacity of paraplegic patients with short training period, appropriate combination of different types of training, duration, intensity and frequency exercise. Training slowed down the development of fatigue; respiratory accessory muscles play a role.	One treatment group only (thus no blinding of subjects or therapists), point measures and measures of variability provided.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Valent et al (2008)[123]	II	Prospective longitudinal cohort study	Investigate the influence of hand cycling on outcome measures of physical capacity during and after rehabilitation in persons with SCI (C5 or lower)	Study across three rehabilitation centres in the Netherlands. Outcome measures included peak oxygen uptake and power output during a peak exercise test, peak muscle strength of the upper extremities and pulmonary function. Measures taken at the start and end of clinical rehabilitation and 1 year after discharge. Hand cycle use was monitored retrospectively via questionnaire. n=162 population with a recent SCI	Regular hand cycling (once per week or more) appeared to be beneficial for improving aerobic physical capacity for those with paraplegia.	Considered confounders (level/frequency of hand cycling, muscle strength. No difference found in hand cycling group and the non-hand cycling group during and after clinical rehabilitation, except for age of those with tetraplegia. 20% loss to f/up. Standardised outcome measures.

Abbreviations: wc – wheelchair; SCI – spinal cord injury; f/up – follow up

5.3 Wheelchair features evidence tables

5.3.1 Ride and comfort

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Hughes et al (2005)[59]	III-3	Cross over trial, comparative study	Compare the energy efficiency of straight line wheeling using Spinergy wheels compared with standard steel-spoke wheels, and comparison of comfort, wheeling preference during turns and surfaces	People with paraplegia n=20	Spinergy wheels provide a more comfortable ride, but did not differ. Comfort may have important implications in patient management of pain and spasticity.	Non-blinded participants but blinded assessors, randomised. Small sample size. Inclusion/exclusion criteria specified, all subjects measured on all outcomes. No parallel control group. Study measured outcomes pre- and post-intervention.
Sawatsky et al (2004)[111]	II	Randomised trial	Establish the rolling resistance characteristics of pneumatic and solid tyres and also identify the energy expenditure related to rolling resistance at various tyre pressures, to establish the link between maintenance of tyre pressure and fatigue experienced by wc users and associated upper extremity repetitive strain injuries	Adult subjects with paraplegia (T5-T12) n=15	The study shows the benefits to clients and staff using pneumatic tyres far outweighs the minimal cost in time to maintain adequate tyre inflation.	PEDro score 4/8. Conditions randomised, interventions appraisal considered most appropriate. Author states blinded study – presumed this refers to subjects and assessors. Rolling resistance testing without human subjects, new wc tyres. No group allocation. All subjects completed tests with measures.
VanSickle et al (2001)[127]	IV	Cohort study	Apply current vibration standards to wc users for the development of instrumentation and techniques to measure dynamic acceleration and to determine potential health problems for wc users	People with physical disabilities with mobility impairment n=16	Vibration may be a contributing factor to fatigue among manual wc users, which could lead to injury.	Inclusion criteria specified. Subject characteristics specified. Two conditions: field test with usual activities and a simulated road course. No comparison between mobility conditions. No control of potential confounding factors (size, athleticism).

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Vorrink et al (2008)[131]	IV	Cohort study	To investigate whether Spinergy wheels would absorb vibration, reduce perceived spasticity in people with SCI	Stage 1: non-disabled subjects n=22 (men and women) Stage 2: subjects with SCI n=13 (10 men)	In the current experimental setup the Spinergy wheels neither reduced vibration or perceived spasticity nor improved comfort in people with SCI more than the conventional steel-spoked wheels.	Two stages, the first regarding spinergy wheels, the second whether spasticity triggered by rough terrain was reduced. First stage: limited information on subjects, no group comparisons e.g. weight. Second stage: data from one participant absent. Subjects with SCI used own wc.

Abbreviations: wc – wheelchair; SCI – spinal cord injury

5.3.2 Tilt in space

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Consortium for Spinal Cord Medicine (2000)[12]	n/a	Guideline	n/a	n/a	n/a	Refer to Section 5.7 for AGREE rating
Desroches et al (2006)[28]	IV	Case series	Determine the effect of system tilt angle (STA) and seat-to-back rest angle (SBA) changes on the load sustained by the shoulder during manual wc propulsion	Adults, mixed diagnosis, mean age 68 years n=14	No significant differences between shoulder joint moments for the various combinations. Shoulder load was maintained at the same level when changing seat angle but keeping wheel-axle position. Thus seat angle can be determined with user comfort and goals, and pressure modulation at seat interface for alleviating pressure without increasing risk of overuse shoulder injuries.	Subjects randomly allocated order of tests. No blinding of subjects or therapists.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Dewey et al (2004)[30]	n/a	Qualitative study	Explore and compare the experiences of tilt in space wc use and conventional wc use in severely disabled clients with multiple sclerosis and significant spasticity	n=23 (7 tilt in space and 16 conventional wc users)	The majority of tilt in space users were satisfied were satisfied with their wc, particularly in terms of comfort.	Descriptive phenomenological (qualitative) approach, used interviews appropriate to lived experience questions, inclusion criteria reported. Theoretical perspective not reported, researchers' biases and assumptions not made explicit. Appropriate rigour for credibility, transferability, dependability and confirmability.
Dicianno et al (2009)[32]	n/a	Position statement and literature review	Describe the typical clinical applications and provide evidence from the literature supporting the application of tilt, recline and elevating leg rests	n/a	n/a	No quality appraisal of studies.
Ding (2008)[33]	IV	Cohort study	Examine the usage of powered seating functions among a group of wc users during their typical daily activities	Adult power wc users n=12	Subjects consistently accessed the seating functions throughout the day and spent most of their time in a tilted and/or reclined position, but did not re-position themselves as frequently as guidelines recommend.	Inclusion criteria reported. Result not reported for 1 of the 12 subjects. Used own wc. Data collected for 2 weeks.
Dreier et al (2010)[35]	n/a	Position statement	Tilt, recline and elevating leg rests for wheelchairs	n/a	n/a	

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Lacoste et al (2003)[73]	IV	Cohort study	Characterise the use of powered tilt and recline systems		Most of the subjects (97.5 %) were using their powered tilt and recline system every day and their satisfaction was high.	Different diagnoses. Grouped according to basis of wc features (power tilt, power recline, both). Similarities not reported, confounders not reported, no assessor blinding. Questionnaire developed for purpose. Mainly descriptive.
Michael et al (2007)[83]	n/a	Systematic review	Determine the effects of tilt in space seating on outcomes for people with neurological or neuromuscular impairment who cannot walk	19 studies included	Posterior tilt can reduce pressures at the interface under the pelvis.	Two independent reviewers completed appraisals for quality.
Pellow (1999)[103]	IV	Case series	Assess the effect of tilt and recline positioning and various wc cushions and pressure relieving techniques in the prevention of pressure sores	People with tetraplegia C5 and above n=2	The general trend observed is a reduction of pressure readings at the ischial tuberosities with tilt and recline positioning. Individual and ongoing assessment is essential to provide the best cushion and pressure relief techniques.	Pilot study, pre- and post-test measures. Convenience sample. All measures for both subjects.
SCIRE (2010)[113]	n/a	Evidence synthesis	Review, evaluate and present a synthesis with key points for clinicians	Studies relate to spinal cord injury	n/a	Reviews of research on 27 topics relevant to spinal cord injury.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Sonenblum et al (2009)[114]	IV	Cohort study	Monitor and describe the use of power tilt systems in everyday life, and whether tilt used to perform regular pressure relieve lifts	Full-time power wc users n=16	Differences in tilt use illustrated the variability in function and activity among users, and diverse benefits of a tilt system for different users.	Monitored for 1-2 weeks on daily occupancy, typical position and 3 other parameters for tilt. Use of recline function excluded from study, single group analysis, results for all subjects reported.
Sprigle et al (2010)[116]	III-2	Comparative cohort study	Quantify the magnitudes of loading on the seat and back during phases of tilt, recline and standing and show that the amount of force reduction at the seat would differ across these 3 methods within their respective clinical ranges	n=6 able-bodied n=10 spinal cord injured	Standing and recline offered similar seat load reductions at terminal positions, the results indicate that tilt, recline and standing systems should be considered as a means of weight shifting for wc users.	Inclusion criteria reported. Order of positions randomised (5 positions). Group similarities reported, SCI group heavier. Blinding not reported. Measures on all outcomes except for one able-bodied subject who was subsequently excluded.

Abbreviations: wc – wheelchair; SCI – spinal cord injury

5.3.3 Elevating leg rest

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Aissaoui et al (2000)[2]	III-2	Non-randomised trial	Investigate the effects of elevating leg rest on posture and pressure distribution in a group of able-bodied subjects sitting in a manual wc	Two leg rests tested n=10 participants	The use of conventional leg rest modifies the subjects posture and induces an increase of pressure under ischial tuberosities in procline position.	Blinding not reported, no loss to follow up, statistical reports of between group comparisons
Dicianno et al (2009)[32]	n/a	Position statement and literature review	Describe the typical clinical applications and provide evidence from the literature supporting the application of tilt, recline and elevating leg rests	n/a	n/a	No quality appraisal of studies.
Dreier et al (2010)[35]	n/a	Position statement	Tilt, recline and elevating leg rests for wheelchairs	n/a	n/a	

Abbreviations: wc – wheelchair

5.3.4 Elevating seat

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Arva et al (2009)[5]	n/a	Position paper	Provide an overview of the literature supporting the use of seat-elevating devices for wc users	n/a	Seat elevations are often medically necessary for enabling wc users to reach, improve mobility related activities of daily living, facilitate or enable transfers, provide peer height at different ages, enhance independence and productivity, delay or prevent pain and secondary complications of upper limb.	
Ding (2008)[33]	IV	Cohort study	Examine the usage of powered seating functions among a group of wc users during their typical daily activities	Adult power wc users n=12	Subjects consistently accessed the seating functions throughout the day and spent most of their time in a tilted and/or reclined position, but did not re-position themselves as frequently as guidelines recommend.	Inclusion criteria reported. Result not reported for 1 of the 12 subjects. Used own wc. Data collected for 2 weeks.
Moldrup et al (2010)[85]	n/a	Conference proceedings	Review of the RESNA position paper on seat elevation	n/a	Additions to the paper include: it is an important feature to maintain the ability to get into standing and facilitate the function of the arms as long as possible, important to look at conditions at diagnosis and if condition progressive when choosing a wc with seat elevation.	
RESNA (2005)[106]	n/a	Position paper	Provide a definition and statement of the typical clinical applications for seat elevation and to assist with decision making and justification	n/a	Set elevators are often medically necessary to assist individuals accomplish mobility related activities of daily living tasks.	

Abbreviations: wc – wheelchair; RESNA – Rehabilitation Engineering & Assistive Technology Society of North America

5.4 Propulsion evidence tables

5.4.1 Power assisted

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Algood et al (2005)[4]	II	Randomised controlled trial (conditions)	Test the differences between a push rim-activated power assisted wc and a traditional manual wc while performing common driving activities and to assess their relative merits for people with tetraplegia	Two conditions randomly assigned to participants, multiple measures taken for heart rate, time to complete the course, and a visual analogue scale post-test trials to determine the ease of each course. n=15 participants	Power assisted wc have the potential to improve functional capabilities during certain ADLs especially when propelling up ramps over uneven surfaces and over thick carpet.	Order of wc and level of resistance randomised. Eligibility criteria specified, group similarity n/a. All participants received treatment, statistical reporting between group comparisons and variability with P values and SD, most key outcomes measured. PEDro score 5/10.
Cooper (2001)[15]	II	Randomised controlled trial	Evaluate a novel push rim activated power assisted wc for compliance with wc standards, metabolic energy, cost during propulsion and ergonomics during selected activities of daily living	A three-phase study, with repeated measures in the second and third phases. Order of conditions randomised. Participants full-time community-dwelling manual wc users with SCI or multiple sclerosis. n=11	The power assisted wc is compliant with standards, reduces the energy demand placed on the user, and subjects rated the ergonomics favourably when compared with their personal wc. Power assisted wc may provide manual wc with a less physiologically stressful means of mobility with few adaptations to the vehicle or home environment needed.	Same group, the number of subjects with the outcome variable not reported. No of subjects with outcome variable not reported. P values and SD provided. PEDro score 4/10.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Ding et al (2008)[34]	II	Randomised controlled trial (order of each intervention)	Evaluate the impact of push rim activated power assisted wc on mobility, community participation, satisfaction and psychosocial impact among individuals with tetraplegia	Order of use of each wc randomised. Completed a 4 week protocol (2 week manual, 2 week power assisted), with mobility levels recorded by a data-logger. Additional outcome measures, psychosocial impact scale and daily questionnaires regarding community participation. Participants manual wc users with tetraplegia. n=15	Participants chose to use both wc similarly. No differences in community participation, satisfaction or psycho-social impact. However there was a statistical difference with power assisted wc travel faster. Power assisted could be a viable mobility option of individuals with tetraplegia especially for outdoor.	Only one group, some participants did not entirely complete trial. Statistical reporting on between group comparisons and SD. All ICF domains considered. PEDro 5/10.
Giacobbi et al (2010)[47]	n/a	Qualitative study, grounded theory analysis	Assess wc users' perceptions of and experiences with power assist wheels using qualitative interview methods	Qualitative interviews conducted before, during and after use of a power assisted wc. Participants had one or more physical conditions (paraplegia, tetraplegia, amputees, spina bifida, multiple sclerosis, stroke and SCI). Experienced wc users. n=20	Power assist seems to offer physical and social benefits for most wc users. Clinicians should consider user's home environment and overall life circumstances before prescribing.	Overall rigour high on credibility, transferability, dependability, confirmability, used open and focused coding, presented both primary and secondary evaluations.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Giesbrecht et al (2009)[48]	III-2	Comparative study, concurrent mixed methods using a cross-over trial with concurrent controls	Evaluate push rim activated power assisted wc performance among dual-users in their natural environment to determine whether the power assisted wheelchair would serve as a satisfactory alternative to the power wc for community-based activities	Randomisation of participants into 'order of treatment' groups – alternatively assigned in order of enrolment. Participants aware of intervention. Multiple outcome measures used including number of hours reported using the different wc, user satisfaction, psychosocial and function. n=8	For some individuals requiring power mobility, the power assisted wc may provide an alternative to the power wc.	P values provided, median, and range for all measures.
Lighthall-Haubert et al (2009)[77]	III-2	Non-randomised trial	Compare spatio-temporal propulsion characteristics and shoulder muscle activity in persons with cervical SCI propelling a manual wc and a push rim activated power assisted wc on a stationary ergometer	Comparison of control wc with power assisted, convenience sample, adult males with tetraplegia n=14	For people with complete tetraplegia, push phase shoulder muscle activity was decreased in the power assist compared with standard push rim wc indicating a reduction in demands.	Outcome measures assumed to be done with all participants, not stated. Comparisons between wheelchairs and speed, with P values, variability and point measures.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Nash et al (2008)[92]	II	Randomised controlled trial	Test the effects of push rim activated power assisted wc on the energetics and perceptual responses to steady-state and intensity-graded wc propulsion in persons with paraplegia, and tetraplegia having chronic shoulder pain	Males over 19 years, all chronic and motor complete paraplegia and tetraplegia n=18	Use of power assisted by persons with paraplegia and tetraplegia having shoulder pain significantly lowers energy cost, perceived exertions compared to manual wc propulsion, which increases distance propelled.	Range of measures used for metabolic analysis, all subjects completed all conditions. All had outcome measures completed. Comparison between wc types, with P values and SD. PEDro 6/10.

Abbreviations: wc – wheelchair, ADL – activities of daily living; SD – standard deviation; SCI – spinal cord injury; ICF – International Classification of Functioning

5.4.2 Drive wheel position

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Denison & Grayton (2002)[26]	n/a	Report on wc tests	Determine the merits and weaknesses of front, centre and rear wheel drives, explain the factors which contribute to wc performance and provide clinicians with the information	Used standard test laboratories and comparison tests on various wc.	Definitions provided, factors influencing wc performance, manoeuvrability (e.g. turning radius, shape of space).	
Koontz et al (2010)[70]	IV	Case series	Determine the minimum space required for wheeled mobility device users to perform 4 manoeuvrability tasks and to investigate the impact of selected design attributes	Convenience sample n=109 manual wc n=100 power wc n=14 scooter users	Between 10% and 100% of users would not be able to manoeuvre in spaces that meet current accessibility guidelines.	Groupings based on design features. Between group analysis. Point measures and measures of variability reported.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Minkel (2005)[84]	n/a	Expert opinion and consumer advice	Essential elements to consider when obtaining wheeled mobility	n/a	n/a	
Pellegrini et al (2010)[102]	III-3	Comparison study without controls, post-test	Determine whether manoeuvrability varied between electric wc	Tested wc users with three different powered indoor/outdoor wc n=12	Differences in manoeuvrability exist between electric wc belonging to the same category. Practical and standard tests provide complementary and concordant information.	Randomisation of order of wc, participants trained for 60 mins, indoor and outdoor tests. Non-parametric statistics used. Median and inter-quartile range.

Abbreviations: wc – wheelchair

5.5 Training evidence table

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Best et al (2005)[7]	II	Randomised controlled trial	Test whether wc skills training of community-based manual wc users is efficacious, safe and practical	Community based wc users, half with muscular dystrophy, half with neurological disorders n=22 (15 males)	WC skills training of community-based manual wc users is efficacious, safe and practical.	PEDro score 8/10, statistical comparisons between groups, groups similar at baseline, blinding not reported, trainer appears to have done both groups. Outcome measures for 91% of subjects.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Bonaparte (2004)[8]	III-1	Pseudo-randomised controlled trial	Test whether during wheelie training, adding the proactive balance strategy to the conventional reactive balance strategy increases success rate, decreases training time, and lessens postural sway during the wheelie	wc users, included able-bodied subjects n=22	The additional strategy did not improve wheelie success rate, training time or postural sway. Older wc users require more training time. Many such users can learn this skill if given the opportunity.	PEDro score 5/10. Random allocation but balanced groups for gender, age, diagnosis. Specific randomisation method not reported, blinding not reported. There were (6 drop-outs) 78% subjects with outcome measures. Possible confounders of unfamiliarity with wc for able-bodied participants.
Consortium for Spinal Cord Medicine (2005)[13]	n/a	Guideline	Preservation of upper limb function following spinal cord injury	n/a	n/a	Refer to Section 5.7 for AGREE rating
Coolen et al (2004)[14]	II	Randomised controlled trial	Test whether a brief formalised period of wc skills training, added to the standard curriculum, results in significantly greater overall improvement in wc skills than a standard undergraduate occupational therapy curriculum alone	University students n=22	The wc skills training program is an effective way to improve the wc skills performance of OT students.	PEDro score 7/10. Randomly allocated to groups by numbers, no significant difference between groups, blinding not reported. Initial outcome measures for 87% of subjects for wc skills training 1, but only 355 for wc skills training 3. Outcome measures for all subjects, statistical comparisons between groups.
Cooper et al (2002)[16]	IV	Case series	Determine the driving characteristics of electric powered wc users during unrestricted community activities and compare the activity levels among an active group and a group of regular users	Mixed diagnosis n=17	Power wc users most active in the afternoon and evening, little variation in speed or distance driven per day. Veterans more active during a typical week at home, maximum theoretical distance is less than 8 km.	Grouped according to place of recruitment, one group recruited when attended veteran wc games. Some between group comparisons for two groups. No blinding reported. Appears data for all subjects.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Cooper et al (2005)[17]	n/a	Descriptive overview	Outline virtual reality environments as a possible training tool for wc user training	n/a	Outlines use of virtual reality for key parameters e.g. joystick tuning interface and assessment, virtual driving simulation, mobility training for those with visual impairment.	
Corfman (2003)[18]	IV	Case series comparison study	Measure the response of a test dummy while traversing common obstacles encountered by users of electric-powered wc to determine whether optimal wc fit, use of seatbelts and driving speed affect the frequency and severity of power wc tips and falls	Test dummy used	Persons who use power wc should use seatbelts and leg rests while driving their power wc and clinicians should include common driving tasks when assessing the proper power wc set-up.	Repeated post-test measures. No blinding reported, 4 different wc used with same test dummy. Outcome data for all combinations, statistical reporting of between group comparisons, only point measures, no variability as outcome measure was dichotomous.
Dawson & Thornton (2003)[23]	n/a	Single case study	Evaluate the potential use of an indoor electrically powered wc with 2 people with unilateral neglect, whether training improved accuracy to drive	Single incident right hemisphere lesion following stroke. Study over 8 weeks, ABA single subject design, driving accuracy measured each weekday. Two weeks of training, 30 minutes each weekday. n=2	Participants learned to drive the powered wc despite persisting neglect. Task specific training should be used. Unilateral neglect should not rule out patients being considered for power wc. Further research is needed.	Small sample result, considered preliminary. Score 9/11 on SCED scale, observer bias inter-rate reliability not reported, independence of assessors not reported (likely to be occupational therapist).

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
De Groot et al (2008)[25]	II	Randomised controlled trial	Evaluate the effect of 7 week low intensity hand rim wc training on the sub-maximal metabolic cost, mechanical efficiency and propulsion in able-bodied participants	Able-bodied males n=21	A low intensity 7 week training protocol has a beneficial effect on the mechanical efficiency and metabolic cost of wc propulsion in able-bodied subjects. Improved mechanical efficiency seems to be the result of changes in propulsion technique.	PEDro 7/10, randomisation to group although method not stated. Not known whether allocation concealed, no statistical differences between groups, subjects not informed of purpose, assessors and therapist blinding not reported, outcome measures for all subjects. Between groups statistical comparisons reported.
De Groot et al (2009)[24]	IV	Case series	Determine if verbal training with visual feedback improved manual wc propulsion and examine the differences between those with paraplegia and tetraplegia	Manual wc users n=9	Verbal training can produce changes in push biomechanics of manual wc users. Longer training may be needed to sustain propulsion changes. Results confirm different propulsion techniques between those with paraplegia and those tetraplegia.	Pre- and post-test measures. Training on treadmill, with verbal and visual feedback to increase push length. Outcome measures for 75%.
Edwards & McCluskey (2010)[37]	IV	Cohort study	Investigate the characteristics of adults who use power wc and scooters, explore the process of power-mobility provision and examine the benefits and challenges of use	Convenience sample, surveys n=202	Power-mobility devices have many benefits for users, but can have negative outcomes like accidents, resulting in injuries. Further research is needed.	Cross-sectional survey. Approximately 650 surveys distributed through councils, personal contacts and disability organisations. No confounders identified. Comparisons made between wc and scooter users on outcome measures, group similarity n/a.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Hall et al (2005)[51]	IV	Case series	Describe 2 power mobility training protocols with a comparison of post-training driving performance	Subjects over 70, two sites for training n=5 site 1 n=7 site 2	Driving performance was associated with facility, gender, type of device used and training duration, all of which varied between facilities and training programs.	Eligibility reported, grouped according to training site. Post-test measures only. No statistical difference between groups. Blinding not reported for therapists and subjects, but in one site the assessor was blinded. Outcome measures for 92% of subjects, between group treatment comparisons with measures of variability reported.
Harrison et al (2002)[53]	IV	Case series	The application of two virtual environments to the assessment and training of inexperienced powered wc users, in terms of control of the chair and route finding	Novice wc users n=6	Virtual environments represent a potentially useful means of assessing and training novice powered wc users.	Eligibility criteria not provided, 2 different environments, no control group, no blinding or group similarity. Outcome data for 60% on environment 1 and 33% for environment 2, not all subjects completed all routes, no environment comparisons.
Hasdai et al (1998)[54]	III-2	Case control	Evaluate the ability of a basic driving simulator program to evaluate and train children with disabilities in their ability to operate a powered wc	Children with muscular dystrophy or cerebral palsy n=22	A simulator program can assist in the development and evaluation of the skills required to operate a powered wc.	Controls were experienced drivers. Eligibility criteria only partially reported. Grouped according to experienced versus novice wc user, groups different at baseline (sex and level of wc use) but similar for age and cognitive level, blinding not possible, outcome measures for all subjects, in both groups, between group comparison reported with statistics – SD, mean.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Jannink et al (2008)[61]	II	Randomised controlled trial	Investigate the possibility of using an electric scooter simulation program in addition to conventional electric scooter training to train future users driving skills	Stroke survivors n=5 control n=5 treatment	Patients with stroke were satisfied with the electric scooter simulation training, both groups improved (conventional and simulated).	PEDro 4/10. Eligibility criteria not reported, technique for randomisation not reported, no group similarity or blinding reported, outcome measure for all subjects. Limited intervention/ control group comparisons.
Kilkens et al (2005)[64]	III-3	Cross-sectional-retrospective cohort study	Test the hypothesis that wc skill performance is positively related to participation	SCI 1 year post-discharge from rehabilitation n=81 (56 paraplegia, 25 tetraplegia, 17 incomplete)	For persons with SCI who are manual wc users, wc skill performance is moderately associated to participation. Training of wc skills has to be an important goal of rehabilitation.	Not all participants obtained three wc circuit scores, with physical strain score lowest n=46, but all participants completed the sickness impact profile measure.
Kirby et al (2005)[65]	III-2	Comparative study with case control	Do able-bodied people simulating hemiplegia (one arm and one leg) have as much difficulty performing wc skills as people with hemiplegia	n=20 treatment group with hemiplegia (stroke) n=20 control group	Both groups experienced similar difficulties when performing wc skills, which suggests there are inherent difficulties with the task.	Controls were able-bodied. No randomisation, intent of project concealed from able-bodied, blinding of therapists not possible, groups similar at baseline, outcome measures available for all subjects, statistical reporting of between group comparisons.
Kirby et al (2008)[66]	II	Randomised controlled trial	Test whether a highly structured training method for wc curb-climbing requires less training time than conventional training, and whether this method increases success rate, reduces the need for spotter interventions and reduces participants perceptions of difficulty	Able-bodied subjects n=16 (7 treatment, 9 control)	In comparison with a conventional method for curb-climbing, a highly structured method seems to require less than 50% of the training time for able-bodied participants, which has implications for training.	PEDro score 7/10. Randomisation to intervention and control groups, method of allocation not clear, single trainer for both groups (no blinding), assessors blinded, outcome measures for 89%, outcome measures same for each group. Statistical reporting of between group comparisons.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Kirby et al (2008)[67]	II	Randomised controlled trial	Test whether wc training method that begins in a high-rolling resistance setting improves the success rate and reduces the training time, whether other factors (e.g. age, gender) affect training time	Able-bodied, no wc experience n=48	Neither success rate nor training time for wc skill acquisition by able-bodied learners are improved by a training method using high resistance rolling.	PEDro score 6/10. Randomised block manner to groups, not known if concealed allocation, no significant differences between groups, blinding not reported. Outcome measures for 96% subjects.
MacPhee (2004)[78]	II	Randomised controlled trial	Test whether a brief, formalised period of additional wc skills training is safe and results in significantly greater improvements in wc skills performance than a standard rehabilitation program	Mixed diagnoses n=35 (20 musculoskeletal disorders, 15 neurologic disorders)	The wc skills training program has a clinically significant effect on the independent wheeled mobility of new wc users.	PEDro score 7/10. Randomisation concealed after decision made for inclusion. Groups similarity reported with no significant differences, no blinding reported, although blinding of assessor inferred, outcome data for 79% of subjects, intention to treat analysis, between group comparisons, P values and SD provided.
McCluskey & Kay (2008)[81]	n/a	Opinion	Comment on the proposal for a competency driving test for new users of motorised scooters	n/a	Propose a more conservative practice and research recommendations than that published by Nitz (2008).[99]	
Nitz (2008)[99]	IV	Case series	Utilise the implementation of a new competency test in order to define skills required to safely drive a motorised scooter	Health subjects, test repeated 3 times to determine practice effect on proficiency n=10	Driving skills for motorised scooter need to be taught and learned with assessment for competency before unrestricted community driving is allowed.	Subjects never driven scooter before. No group allocation, confounders linked to risk of driver difficulty, no group comparisons reported, or blinding. Subjects completed test at least once, only 20% re-tested, assessment driver competency test (motor vehicle).

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Rodgers et al (2001)[107]	IV	Longitudinal, pre- and post-test	Compare pre- and post-training biomechanical and physiological characteristics of wc propulsion in manual wc users	Manual wc users n=19	Training effects for a range of factors (e.g. increased exercise loads for strengthening activities, decreased stroke frequency, increased maximum elbow extension angle, increased trunk and shoulder flexion/ extension).	Treatment group only, therefore no blinding, outcome measures for all subjects, pre- and post-test statistical comparisons.
Spaeth et al (2008)[115]	IV	Case series	Develop and test a wc virtual driving environment that can provide quantifiable measures of driving ability, offer driver training and measure the performance of alternative controls	TBI ambulatory and non-ambulatory n=8 (7 male)	Testing and instrumented real wc can validate virtual driving environment and assess whether virtual driving skills transfer to actual driving.	One group, random allocation to training order, allocation concealment not reported, no blinding of therapists, subjects or assessors reported. Outcome measures available for all subjects. For both conditions between group statistical comparisons, point measures and variability reported (P value and SD).
van Velzen et al (2009)[126]	II	Prospective cohort study	Describe the number of people with SCI who returned to work 1 year after discharge from inpatient rehabilitation and to investigate whether return to work can be predicted from wc capacity at discharge after correction for confounders	SCI subjects n=118	Return to work was successful in 33% of subjects, wc capacity was independently related to return to work, therefore it is recommended to train wc capacity in the context of return to work.	Main outcome measure return to work at least one week. No group allocation, only one group was followed up from the time of injury. Confounders identified as a marker of risk for return to work. Statistical group comparisons reported, outcome measures for 88% of subjects.

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Webster (2001)[133]	III-2	Case control study	Investigate whether a computer assisted training program for patients with left unilateral neglect would decrease symptoms of this disorder	n=20 treatment group, all from inpatient rehabilitation n=20 control group	Computer assisted training can reduce unilateral neglect symptoms on experimental tasks and some measures of accident risk.	Eligibility criteria reported in another article. Not clear whether the control is an historical control, no significant difference between groups at baseline, blinding not reported. Outcome measures for 95% of subjects, statistical reporting for between group comparisons – measures of variability.
Wielandt & Strong (2000)[137]	n/a	Literature review	Examine the post-discharge compliance of individuals with prescribed adaptive equipment	Databases CINAHL and Medline; 31 studies included	Five categories of factors that affect compliance: medical-related, client-related, equipment-related, assessment-related and training-related. Assessment-related factors included evaluation of client's environment and personal needs, not just diagnosis.	No study appraisal conducted, studies were surveys of compliance. Outcome of studies considered included nature of use, the time of follow-up and sample sizes.

Abbreviations: wc – wheelchair; TBI – traumatic brain injury; SCI – spinal cord injury; OT – occupational therapy; SD – standard deviation; ABA – (three phases: A=baseline conditions, B=intervention, A=return to baseline conditions)

5.6 Maintenance evidence table

Author and year	Level of evidence	Study description	Study objective or question	Population or study sample	Study results and findings	Comments
Fitzgerald et al (2005)[39]	IV	Cohort study	Assess wc durability and its effect on user satisfaction	Adult wc users n=130	Better understanding of wc maintenance and repair issues will guide improvements in wc design and enhance the community participation of individuals who use wc.	Convenience sample, no group allocation, outcome measure of questionnaire – no reliability and validity data. Confounders identified diagnosis and hours used per day, but not linked to risk or cause. Groups similar at baseline, outcome measures for 85%.
Hansen et al (2004)[52]	II	Randomised controlled trial	Investigate whether active intervention using a compiled checklist for wc check-ups increases user satisfaction and/or decreases accidents, near-accidents and pressure sores	Registered wc users n=216	Most wc users are unable to determine on their own when adjustments are needed. An active check-up on manually operated wc seems to reduce accidents.	PEDro 6/10. Randomisation by numbers, 2 groups: active intervention and standard intervention. No significant differences at baseline. Blinding not reported, analysed by intention to treat. Statistical between treatment group comparisons with measures of variability.
McClure et al (2009)[80]	II	Prospective cohort study	Investigate the frequency of repairs that occurred in a 6 month period, the consequences of breakdowns on wc users living with SCI, and whether there is an association with increased number of repairs and adverse consequences	Subjects obtained through Model spinal cord injury systems centres data base n=2213	Frequent repairs and breakdown can negatively impact on person's life by decreasing participation and threatening health and safety.	Convenience sample survey, eligibility criteria reported, confounders identified including power versus manual wc use linked to increased risk of repair, not allocated to groups, no blinding reported, outcomes for 100% subjects.

Abbreviations: wc – wheelchair; SCI – spinal cord injury

5.7 Existing guidelines evidence table

Author and year	Organisation	Overall objective of the guideline	Study outcome or findings	Appraisal by AGREE tool[119] across all domains
Consortium for Spinal Cord Medicine (2000)[12]	In conjunction with the Paralysed Veterans of America	Guidance on the prevention and management of pressure ulcers following spinal cord injury	Recommendations on the prevention, nutrition, assessment following the onset of a pressure ulcer, treatment, complications, support surfaces and positioning for managing tissue loads.	61%
Consortium for Spinal Cord Medicine (2005)[13]	In conjunction with the Paralysed Veterans of America	Guidance on the preservation of upper limb function following spinal cord injury	Recommendations on the assessment, ergonomics, equipment selection, training and environmental adaptations, exercise, management of acute and subacute upper limb injuries and pain, and chronic pain treatment to maintain function.	44.2%

6 Working party

Name	Position	Organisation
Jeanine Allaous	Senior Occupational Therapist Brain Injury	Royal Rehabilitation Centre
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Kate Hopman	Senior Occupational Therapist Traumatic Brain Injury	Liverpool Hospital Brain Injury Rehabilitation Unit
Greg Killeen	Consumer representative	
Suzanne Lulham	Director, Service Delivery	Lifetime Care & Support Authority
Jodie Nicholls	Senior Occupational Therapist Brain Injury	Westmead Brain Injury Rehabilitation Unit Representative of Occupational Therapy Australia – NSW Division
Thi Hong Nguyen	Consumer representative	
Sally Oates	Project Officer	EnableNSW Health Support Services NSW Health
Lesley Radbron	Senior Service Development and Review Officer	Lifetime Care & Support Authority
Lyndall Ross	Senior Occupational Therapist Brain Injury	Mid Western Brain Injury Rehabilitation Program
Charisse Turnball	Senior Occupational Therapist Project Officer and author of Spinal Seating education website	State Spinal Cord Injury Service Seating professional development program
Sue Lukersmith	Project Officer	Lifetime Care & Support Authority / EnableNSW

7 Consumer and public consultation

Consumer and public consultation was integral to the guideline development process. There were two consumer representatives on the working party. Their involvement assisted throughout the development in terms of the scope, key topics and priorities, and clinical questions, as well as providing feedback on terminology and sources of grey literature. Further consumer and public input was sought during the development phase. Key consumer and stakeholder organisations provided feedback.

The consumer information was reviewed by consumers and their feedback incorporated to improve the document. The consumer information sheet was also rigorously assessed for plain English.

The draft guidelines were widely circulated to over 50 stakeholder organisations, consumer groups and individuals for review and comment in March 2011. Four international peer reviewers provided feedback. All comments received were considered in the finalisation of the document.

The organisations and individuals who received the document for external review and comment include:

- Professional associations
  - » Occupational therapy
  - » Physiotherapy
  - » Suppliers
- Individual consumers
- Consumer representative organisations
  - » Brain injury
  - » Spinal cord injury
- Medical and therapy specialists (NSW and interstate)
- Seating clinics
- Specialist equipment resource organisation
- Academics and researchers
- Specialist statewide services
  - » Spinal cord injury
  - » Brain injury

8 Appendices

Appendix 1 Clinical questions

A. General

1. When is the optimal time for assessment of the individual and definitive prescription of a wheeled mobility device following a TBI or SCI?
2. Should the appropriate seating system be identified before the wheelchair?
3. At what stage should the discharge/home environment and potential modifications be considered in the prescription process?
4. When is the optimal time for review of the outcome of prescribed wheeled mobility?
5. What are common reasons for non-use of prescribed wheeled mobility? Should these be considered in the prescription process?

B. Assessment of the client's functional need for a mobility aid

6. What should the goals include for the prescription of wheeled mobility as an intervention?
7. What predictors (influences) should be used to determine if there is a long-term need for wheeled mobility?
8. How will the outcomes be assessed?
9. What training should be provided (manual/powered)?
10. What parameters are required to ensure OHS for clients and attendant care workers when using wheeled mobility?
11. What are the considerations for using public and private transport?

C. Assessment of the client's capacity to use a manual/powered wheeled mobility device

12. What is best practice assessment of the client's (carers) capacity to use a manual/powered wheeled mobility device? This should include efficient and safe use.
13. Where is the optimal place(s) for assessment (home assessment, community assessment, transport assessment)?
14. Is there a need for a power wheelchair at a specific level of function/mobility? Is there a need at a specific age?
15. What level of visual acuity and field of vision is needed to operate a wheeled mobility device safely? How should vision be assessed?
16. Are there any co-morbid conditions or risk factors (e.g. epilepsy or other conditions that may result in loss of consciousness) which preclude the use of a manual/power wheeled mobility device in the community?
17. How can it be confirmed that a person has sufficient compensation for any recent hearing loss to be able to safely use a wheeled mobility device?
18. Are there particular medications or drugs (prescribed or illegal) that preclude or restrict the use of a wheeled mobility device (manual/powered/scooter)?
19. What are the psycho-social considerations for a power/manual wheeled mobility device, e.g. acceptance of disability, including family/carer/client?
20. What activities place greater stress on the upper limb?

Manual

21. What are the cognitive requirements to operate a manual wheelchair?
22. What are the behavioural requirements to operate a manual wheelchair?
23. What are the perceptual requirements to operate a manual wheelchair?
24. What range of motion of the upper limb is required to operate a manual wheelchair?
25. What shoulder and upper limb strength is required to operate a manual wheelchair?
26. Is there evidence to indicate that a manual wheelchair enhances or maintains cardiovascular fitness? What is the frequency of use to achieve this?

Power

27. What are the cognitive requirements to operate a power wheelchair/scooter?
28. What are the behavioural requirements to operate a power wheelchair/scooter?
29. What are the perceptual requirements to operate a power wheelchair/scooter?
30. What upper limb strength and control is required to drive a power wheelchair/scooter?
31. What transfer, head control, balance and sitting abilities are required for power wheelchair/scooter use?

D. Parameters to be considered with respect to wheeled mobility features

32. What parameters should be considered with respect to potential client changes, e.g. width due to weight increase or growth?
33. What parameters should be used to determine whether a client requires tilt in space in their seating system?
34. Does a lightweight wheeled mobility device and seating system reduce the incidence of shoulder pain (or other symptoms) and/or over-use syndromes for users and/or attendant care workers?
35. Does a solid back rest (firm postural support) make pushing a manual wheeled mobility device more efficient?
36. Does power assist reduce the shoulder and wrist forces required when pushing?
37. What is the best alternative control system for people unable to use hand controls (e.g. chin controls)?
38. Are there benefits to titanium frames (e.g. 'better ride', less vibration, reduced incidence or intensity of user's pain/neuropathic pain)?
39. What is the fatigue life of a titanium wheelchair frame compared to the lightweight frame?
40. What are the indicators for variable seat elevation in powered wheelchairs?
41. What should be considered when assessing compatibility with transport options (e.g. self-drive, transfer options)?
42. What parameters/advantages are considerations for each drive position (rear/front/mid wheel drive) for indoor/outdoor use?
43. What are the parameters that determine the need for recline features?
44. What are the parameters that determine the need for leg elevation?
45. What are the parameters that determine the need for tilt?
46. What are the advantages of push rims and hand rims?

Two wheelchairs

47. What are the indicators for the prescription of two wheelchairs?

E. Re-assessment of the client in context (client, wheeled mobility device and environment interface

48. What are reliable outcome measures of wheeled mobility intervention? *(tools)*
49. When and where should the client be re-assessed? *(related to seating reviews and q. 12)*.

During guideline development, for a range of reasons, the working party decided it was not appropriate to include the following questions:

12. What is best practice assessment of the client's (carers) capacity to use a manual/powered wheeled mobility device? This should include efficient and safe use.
19. What are the psycho-social considerations for a power/manual wheeled mobility device, e.g. acceptance of disability, including family/carer/client?
46. What are the advantages of push rims and hand rims?
49. When and where should the client be re-assessed?

Appendix 2 Literature searches

Organisations and websites searched and the search terms used to identify other relevant publications

Table 3 Searches for existing guidelines

Organisation	Search terms
National Guideline Clearing House (US)	wheelchair all publications available on website
Scottish Intercollegiate Guidelines Network (SIGN)	all publications available on website
Royal College of Physicians	all publications available on website
Canadian Medical Association Infobase	wheelchair spinal cord injury mobility wheeled mobility brain injury scooter
Healthlinks, University of Washington	wheelchair
Institute for Clinical Systems Improvement	wheelchair wheeled mobility wheel mobility spinal cord injury brain injury traumatic brain injury closed head injury
National Health and Medical Research Council / National Institute of Clinical Studies	all guidelines available on website
New Zealand Guidelines Group	all guidelines available on website
National Institute for Health and Clinical Excellence	all publications available on website
Agency for Healthcare Research and Quality	all publications available on website
OpenClinical	all publications available on website

Centre for Health Evidence (Canada)	all publications available on website, user guides
Oxford Centre for Evidence-Based Medicine	resources
Clinical Information Access Portal, clinical guidelines	guidelines section
Physiotherapy Evidence Database (PEDro)	wheelchair spinal cord injury traumatic brain injury scooter wheel wheeled mobility
OTseeker	wheelchair wheel wheeled mobility spinal cord injury traumatic brain injury scooter
Psychological Database for Brain Impairment Treatment Efficacy (PsycBITE)	traumatic brain injury movement and motor problems independent/self-care/ADL
World Health Organization (WHO)	wheelchair spinal cord injury traumatic brain injury brain injury scooter wheeled mobility
Cochrane Database	wheelchair traumatic brain injury brain injury spinal cord injury
American Congress of Rehabilitation Medicine (ACRM)	wheelchair traumatic brain injury spinal cord injury
Centers for Disease Control and Prevention (CDC)	wheelchair spinal cord injury traumatic brain injury scooter
Implementation Science (BioMed Central)	wheelchair spinal cord injury traumatic brain injury scooter
European Federation of Neurological Societies (EFNS)	wheelchair spinal cord injury traumatic brain injury
Guidelines International Network (GIN)	wheelchair traumatic brain injury spinal cord injury

National Library of Guidelines (UK)	wheelchair traumatic brain injury spinal cord injury
Spinal Cord Injury Rehabilitation Evidence (SCIRE)	all publications available on website
Mount Sinai TBI Central	all publications available on website
Paralyzed Veterans of America (PVA)	all publications available on website
Queensland Health	all publications available on website
Brain Trauma Foundation	all publications available on website

When potentially relevant guidelines were identified, there was a keyword search within the document: *wheelchair, wheel, mobility, wheeled mobility, spinal cord injury, brain injury, traumatic brain injury, scooter*.

Organisation's websites and resources

Able data, assistive technology
http://www.abledata.com/abledata.cfm

Australian Rehabilitation and Assistive Technology (ARATA)
http://www.arata.org.au/

Brain Foundation
http://www.brainaustralia.org.au/

Brain Net Brain Research and Integrative Neuroscience Network
http://www.brainnet.net/

Centre for Neuroskills
http://www.neuroskills.com/index.shtml

USA TechGuide
http://www.usatechguide.org/

Consortium for children, youth disabilities and special care needs
http://gucchd.georgetown.edu/products/Consortium%20Brief%2012.pdf

Georgia Tech
http://www.pe.gatech.edu/conted/servlet/edu.gatech.conted.course.ViewCourseDetails?COURSE_ID=915

Institute of Rehabilitation Research and Development
http://www.irrd.ca/resource.asp

Institute of Electrical and Electronics Engineers, technical literature
http://ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/10755/33900/01616091.pdf?arnumber=1616091

International Seating Symposium
http://www.seatingandmobility.ca/IntSeatingSymposium.aspx

Monash University, Monash Epworth Research Centre – Brain Injury
http://www.med.monash.edu.au/spppm/research/merrc/ – Wheelchair Symposiums

National Pressure Advisory Panel
http://www.npuap.org/resources.htm

Rehabilitation Engineering and Assistive Technology Society of North America (RESNA)
http://www.rstce.pitt.edu/RSTCE_Resources/RSTCE_Resources.html

RAND research organisation
http://rand.org/about/glance.html

Seating, Mobility Outcomes and Evidence
http://www.permobil.nl/upload/holland/Seminar%202007/Schmeler%20Permobil%20Europe%202007%20Handout.pdf

Spinal Cord Injury Rehabilitation Evidence
http://www.scireproject.com/

Spinal Cord Injury Congress
http://www.ifkb.nl/news/SCIcongress/Rose.pdf

Ingenta connect, scholarly research
http://www.ingentaconnect.com/content/klu/586/2004/00000013/00000004/art00012?crawler=true

University of Washington, rehabilitation
http://sci.washington.edu/projects_and_research/published_articles.asp

Wheelchair outcome tools
http://www.mscare.org/cmsc/images/journal/pdf/journal_2006_v7_n3_Wheelchair_Outcome.pdf

Wheelchair net
http://www.wheelchairnet.org/WCN_ProdServ/Consumers/evaluation.html

Wheelchair skills program Dalhousie University
http://www.wheelchairskillsprogram.ca/

Appendix 3 Search terms for clinical questions

Due to the anticipated paucity of relevant research, a very broad search on Medline was initially performed using the search term wheelchair$. There were 970 citations, the abstracts for which were individually checked for relevance. However each clinical questions was searched again with key terms.

General

Optimal time or place for assessment or review

1. wheelchair$
2. optimal time$
3. 1 and 2
4. wheelchair fitting (MESH)
5. prescript$
6. time$ (MESH time factors, time perception, time or time management or time$)
7. 1 and 5
8. 1 and 5 and 6
9. 1 and 5 and 2
10. As above for optimal place

Discharge/home environment and potential modifications

1. home modification$ and when
2. wheelchair$
3. 1 and 2 (CINAHL)

Medline, Embase and PsychInfo

1. modifications
2. home
3. 1 and 2
4. modification
5. 2 and 4
6. environment
7. 2 and 6
8. environment and modifications

Non-use and abandonment, disuse, non-use assistive technology, wheelchairs

1. assistive technology
2. disuse$
3. 1 and 2
4. non-use$
5. 1 and 4
6. wheelchair$
7. 6 and 2, 6 and 4,
8. fail$
9. 1 and 8
10. 6 and 8
11. fatigue$
12. 1 and 11
13. 6 and 11
14. scooter$
15. 14 and 2, 14 and 4, 14 and 8, 14 and 11
16. abandon$
17. 1 and 16, 6 and 16, 14 and 16
18. breakdown
19. 6 and 18

Wheelchair and transport considerations

1. wheelchair$ or scooter or wheeled mobility
2. public and transport
3. 1 and 2
4. private and transport
5. 1 and 4

Outcomes

1. wheelchair$ or scooter or wheeled mobility
2. outcome$ and measure$
3. 1 and 2
4. effective$
5. 3 and 4
6. change$ and time$
7. 1 and 6

Better/best ride and sitting comfort/vibration

1. wheelchair and vibration
2. wheelchair$ and vibrat$
3. wheelchair$ and ride and comfort
4. wheelchair$ and best ride or comfort
5. wheelchair$ and better ride or comfort
6. spinal and cord and injur$ or parapleg$ or tetrapleg$ or quadrapleg$
7. 5 and 6
8. brain injur$
9. 5 and 8
10. wheelchair$ and discomfort
11. wheelchair$ and discomfort and brain injur$
12. wheelchair$ and discomfort and spinal and cord and injur$)
13. wheelchair$ and sit$ and comfort
14. 6 and 13
15. 8 and 13

Assessment, re-assessment and functional need

Goals

1. wheelchair$
2. goal$
3. 1 and 2
4. wheel$ mobility
5. 2 and 4
6. scooter$
7. 2 and 6
8. client goal$ (subject headings: ADL, patient care planning, brain injuries, health services accessibility, motivation, physician-patient relations, client goal$)
9. 1 and 8
10. patient goal$,(subject headings: goals, decision making, cognition disorders, patient care planning, quality of life, patient goal$)
11. 1 and 10
12. 4 and 10
13. 6 and 10
14. therapy goal$ (subject headings: goals, adult, middle aged, aged, occupational therapy, therapy goal$, students)
15. therapist goals (subject headings: locomotion, health personnel and physical therapy modalities)
16. 1 and 15

Predictors to determine long-term need

1. predictors, risk factors prognosis (exploded)
2. wheelchair$
3. 1 and 2
4. need$
5. 3 and 4
6. influence$
7. 4 and 2 and 6
8. wheel$ and mobility

9. 1 and 4 and 8
10. 6 and 4 and 8
11. prognosis or predictor$
12. 1 and 11
13. influence$
14. need$
15. 1 and 13 or 14

Hoffer system of classification of ambulatory capacity

1. gait (usual limits)
2. assessment
3. 1 and 2
4. spinal and cord and injury
5. 3 and 4
6. ambulat$ and capacity
7. 4 and 6

Training

1. training
2. wheelchair$ or wheeled mobility or scooter
3. 1 and 2
4. wheelchair$
5. skills and training
6. 4 and 5
7. mobility capacity
8. 4 and 7
9. wheeled and mobility
10. 9 and 1
11. skills$
12. develop$ and 11
13. 4 and 11
14. 4 and 12
15. as above but for scooter$

Occupational health and safety

1. wheelchair$
2. wheeled mobility
3. occupational and health
4. safety or ergonomic$
5. 1 or 2 and 3
6. 1 or 2 and 4

Assessment and capacity

User capacity

1. best practice
2. use
3. wheelchair$
4. wheeled and mobility
5. scooter$
6. 1 and 2 and 3
7. 1 and 2 and 4 or 5

Hearing loss and wheelchair

1. hearing loss
2. wheelchair$ or wheel$ mobility or scooter$
3. 1 and 2
4. hear$
5. audition$
6. 2 and 5

Hearing continued

1. hearing impairment or hearing loss
2. wheelchair$
3. 1 and 2
4. hearing capacity or hearing loss (subject headings: hearing loss, central, partial, hearing screening, rehabilitation of hearing impaired)
5. 2 and 4
6. recent hearing loss
7. recent hearing impairment
8. 2 and 6
9. 2 and 7
10. wheel$ mobility or scooter$
11. 4 and 10, 6 or 7 and 10

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1. hearing and loss
2. hearing
3. wheelchair$
4. 1 or 2 and 3
5. driving
6. 2 and 5
7. 2 and impairment and 3
8. 2 and impairment and 5
9. 1 and 5

Visual acuity and wheelchair

1. vision
2. wheelchair$ or wheel$ mobility or scooter$
3. 1 and 2
4. visual acuity
5. 2 and 4
6. field AND vision (subject headings: visual fields, vision disorders, adult, vision, ocular, space perception, contrast sensitivity, visual acuity, functional laterality)
7. 2 and 6
8. Field of vision (subject headings: visual acuity, vision disorders, ocular or visual fields, space perception)
9. driving
10. 2 and 9
11. 8 and 9 and 2

Co-morbid conditions or risk factors

1. wheelchair$
2. wheeled mobility
3. co-morbid
4. risk$
5. 1 or 2 and 3
6. 1 or 2 and 4

Medication or drug use that precludes wheeled mobility

1. wheelchair
2. drug$
3. 1 and 2
4. medication$
5. 1 and 4
6. driving and drug$
7. driving and medication$
8. 1 and 6
9. 1 and 7
10. driving
11. 10 and 4

Wheelchair and cognition, perception, behaviour

1. wheelchair$ or scooter$
2. cogniti$
3. mobility aids
4. 1 and 2 and 3
5. perception
6. 1 and 2 and 5
7. 6 and 3
8. behaviour or depression or aggressi$ or impulsiv$ or suicide
9. 1 and 8
10. accident$ or injur$ or self concept
11. 1 and 10
12. 1 and risk and tak$
13. 1 and depress$ or impulsive$ or aggress$

Manual wheelchairs and cardiovascular fitness

1. wheelchair$
2. cardiovascular or aerobic and fitness
3. 1 and 2

Upper limb and activities

Weight

1. wheelchair$
2. width or wide
3. 1 and 2
4. wheelchair$ and width
5. 1 and height$
6. 1 and lightweight
7. weight
8. 1 and 7

Overhead movements
1. overhead and activit$
2. wheelchair$
3. 1 and 2

Transfers
1. wheelchair$
2. transfer$
3. 1 and 2

Pushing
1. wheelchair$
2. push$
3. hill$
4. 1 and 2 or 3
5. 1 and 2 and 3

Upper limb and requirement for range of motion
1. wheelchair$ or scooter$
2. manual wheelchair$
3. wheelchair$ and propulsion
4. wheeled mobility
5. range of motion
6. 1 and upper and limb and 5
7. 1 and wrist$ and 5
8. 1 and shoulder$ and 5
9. arm and range of motion
10. wheelchair$ and propulsion
11. upper limb or arm
12. 1 and 11

Upper limb strength
1. upper limb
2. arm
3. power assist$
4. wheelchair$ or wheeled mobility
5. 3 and 4
6. manual and wheelchair$
7. wheelchair$ and propulsion
8. spinal cord injury or traumatic brain injury
9. strength
10. 1 and 9

Wheelchair and scooter features

Wheelchair and user changes
1. wheelchair$ or scooter or wheeled mobility
2. user and change$
3. client and change$
4. patient and change$
5. 1 and 2 or 3 or 4

Titanium

1. wheelchair$ or wheeled mobility
2. titanium
3. failure$
4. breakdown
5. 1 and 2 and 3
6. 1 and 2 and 4
7. aluminum
8. 1 and 7 and 3, 1 and 7 and 4
9. failure$
10. 1 and 2 and 9, 1 and 7 and 9
11. wheelchair$
12. pole and motor
13. 11 and 12
14. ultralight
15. ultralight and 11

Tilt and recline

1. wheelchair$ or wheeled mobility
2. 1 and tilt
3. 1 and angle$
4. 1 and recline$
5. seat and recline$
6. seat and back angle
7. chair$ and recline
8. chair$ and back angle
9. seat back and angle
10. seat back and tilt
11. tilt-in-space and 1
12. tilt-in-space and chair$

Leg elevation

1. wheelchair$ or wheeled mobility
2. 1 and leg elevation
3. 1 and elevation
4. 1 and calf support
5. 1 and foot plate
6. 1 and leg lift
7. 1 and foot and plate
8. sitting and knee and extension
9. seat and leg and elevation
10. chair$ and leg and elevation
11. sitting and leg and elevation

Back support

1. wheelchair$
2. back and support
3. 1 and 2
4. wheel$ mobil$
5. back support
6. 4 and 5
7. 1 and 5
8. 2 and 4
9. lumbar support (limited mesh terms to lumbar support, orthotics and furniture)
10. 1 and 9
11. 4 and 9
12. back rest
13. 4 or 1 and 12

Wheelchair and foot propulsion

1. wheelchair$ or scooter or wheeled mobility
2. 1 and foot and propulsion

Seat elevation

1. wheelchair$ or scooter or wheeled mobility
2. seat and elevat$
3. 1 and 2
4. seat and rais$
5. 1 and 4

Drive position (rear/front/mid wheel drive), also searched web of science

1. wheelchair$ or scooter or wheeled mobility
2. motor drive position
3. drive and position
4. 1 and 2
5. 1 and 3
6. axle position
7. 1 and 6
8. front and wheel and drive and 1
9. front wheel drive motor
10. rear wheel drive
11. 1 and 10
12. motor drive
13. motor
14. 1 and 13
15. 1 and 12
16. wheelchair$ and drive

Wheelchair maintenance

1. wheelchair$ or scooter or wheeled mobility
2. 1 and maintenance or repair
3. 1 and width
4. 1 and height
5. 1 and weight

Appendix 4 Abbreviations

ADL	Activities of daily living
AGREE	Appraisal of Guidelines for Research and Evaluation
AT	Assistive technology
CI	Confidence interval
CINAHL	Cumulative Index to Nursing and Allied Health Literature
CRPD	Convention on the Rights of Persons with Disabilities
DARE	Database of Abstracts of Reviews of Effects
EMG	Electromyogram
ICF	International Classification of Functioning
LTCSA	Lifetime Care & Support Authority
MRI	Magnetic resonance imaging
NHMRC	National Health and Medical Research Council
OHS	Occupational health and safety
OT	Occupational therapy
PCDA	Power-mobility Community Driving Assessment
PEDro	Physiotherapy Evidence Database
PICO	Participant Intervention Comparator Outcome
RCT	Randomised controlled trial
RESNA	Rehabilitation Engineering and Assistive Technology Society of North America
SCED	Single Case Experimental Design
SCI	Spinal cord injury
SCIRE	Spinal Cord Injury Rehabilitation Evidence
SD	Standard deviation
TBI	Traumatic brain injury
WC	Wheelchair
WHO	World Health Organization

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