Manual wheeled mobility for children

Written by Roslyn Livingstone MSc(RS), OT, December 2012

Introduction

This document contains a brief overview of information regarding the use and introduction of manual wheeled mobility for children. It is intended to provide clinicians with relevant background information and to describe the current best level of evidence.

How was the literature review completed?

An electronic search was performed in October 2012 of the following databases: MEDLINE, CINAHL and Embase. Keywords used in the search included: 'wheelchair', 'child*', and 'mobility.' Studies published in English, involving at least one child with a disability, and an outcome related to the child's use of a wheelchair or manual mobility device were included. Mainly descriptive and qualitative evidence was identified regarding benefits of manual mobility and its use with children who have various diagnoses. Lower level intervention research was identified regarding factors influencing efficiency of manual wheelchair use (see Appendix 2) The American Academy for Cerebral Palsy and Developmental Medicine (AACPDM) Levels of Evidence[1] were assigned to relevant studies by two reviewers with consensus scores reported throughout the document (see Appendix 1). The International Classification for Functioning, Disability and Health (ICF) was used to describe study outcomes.[2]

What is manual wheeled mobility?

Mobility aids are assistive devices designed to compensate for or to enhance mobility and include walkers and wheeled devices, such as wheelchairs, wheeled carts and wheeled standers. Wheeled mobility devices may be manual (propelled by a person) or powered (powered by batteries). In a new taxonomy of assistive technology devices,[2] a manual wheelchair is defined as a 'seated device with two propelling wheels and two front casters'. Paediatric manual wheeled mobility devices have been defined as 'wheelchairs designed for children with options for growth' even though there are some paediatric manual wheelchairs with limited growth options.

Manual wheeled mobility is divided into four types:[2]

- ***Manual wheelchairs:*** Include lightweight and ultralight wheelchairs. Common examples of lightweight paediatric wheelchairs would include the Quickie 2 and Zippie GS. Common examples of ultralight paediatric wheelchairs would include the Tilite Twist and Zippie Zone.
- ***Specialty wheelchairs:*** Include sports wheelchairs and standing wheelchairs.
- ***Positioning wheelchairs:*** Include tilt-in-space and reclining wheelchairs.
- ***Transport wheelchairs:*** Include strollers and basic adult frame wheelchairs designed to be pushed by another person.

Manual wheeled mobility devices may be:

- ***Folding:*** The wheelchair folds in half by a cross brace in the frame.[2]
- ***Rigid:*** The welded frame does not have a folding cross brace.[2] Rigid wheelchairs are often available with folding backrests.

- ***Lightweight and ultralight:*** These manual wheelchairs are usually lighter than transport wheelchairs and are designed for self-propulsion. The actual weight of a lightweight or ultralight chair has not been consistently defined or used across wheelchair manufactures. Often, manufacturers report wheelchair weights without wheels, armrests or front riggings! Lightweight chairs may be folding or rigid whereas ultralight chairs have rigid frames[3].
- ***Recline:*** The angle between seat and back can be changed, while the angle between seat and ground remain the same.[4]
- ***Tilt-in-space:*** The seat angle orientation to the ground can be changed while the seat to back angle remains constant.[4]

Tilt and recline features are generally operated by an attendant. Recline and tilt-in-space wheelchairs can be ordered with large rear wheels, but are typically too heavy for efficient self-propulsion.

Some specialty wheelchairs provide change in position features such as seat elevation or stand-up that can be operated by the person in the wheelchair.

In the new taxonomy,[2] strollers are classed as transport wheelchairs, but strollers that are available with tilt and/or recline and supportive seating could also be considered as positioning wheelchairs.

Who needs manual wheeled mobility?

Independent manual wheelchair users may be able to travel as far each day as children using power wheelchairs, but boys tend to travel further than girls in either type of wheelchair.[5]

Children with Cerebral Palsy (CP)

Children with CP achieve most of their gross motor abilities before the age of five and peak in their motor performance before adolescence.[6] Children in Gross Motor Function Classification System (GMFCS)[7] level III walk with aids but often use wheeled mobility in the community. Children in levels IV and V use wheeled mobility in most settings. Only a small proportion of children with CP who use wheeled mobility are able to independently self-propel manual wheelchairs.[8]

Survey evidence suggests that use of manual wheelchairs assists with care but does not increase independent mobility for young children.[9] In a cross-sectional study, manual wheelchair users were less able to accomplish life skills in comparison with those who walked or used power mobility.[10] Adolescents who are able to walk may choose to use a wheelchair outdoors and in busy environments.[11]

Tips when prescribing manual wheelchairs for children with CP:

- For children with CP, manual wheelchairs are mainly pushed by another person and assist with care and mobility. Strollers are often used with younger children. Lightweight, folding or positioning wheelchairs are often used with older children.
- Efficient, independent manual self-propulsion occurs with a small number of children mainly in GMFCS level III. For these children, rigid ultralight wheelchairs may maximize their efficiency and independent self-propulsion.

Children with Spina Bifida (SB)

Children with lumbar and thoracic level SB often begin using wheeled mobility devices from a very young age. Caster carts are often introduced as an effective means of facilitating early exploration indoors and on smooth surfaces. Manual wheelchairs are available in small sizes for preschool and kindergarten environments and some are available with the large wheels in front. This is more effective for the child wheeling on smooth surfaces, but difficult for parents to push over obstacles outdoors.

As children with SB get older, they tend to increase their use of wheeled mobility depending on the environment or activity. In a historical review of 348 adolescents and young adults more than 50% used manual or power wheelchairs for at least one environment.[12] Shoulder pain in adults with SB is not as prevalent as in adults with spinal cord injury but it is more prevalent than in adolescence.[13]

Tips when prescribing manual wheelchair for children with SB:

- To maximize wheeling efficiency and avoid shoulder problems rigid, ultralight wheelchairs should be considered from an early age.
- Power-assist wheels for use on manual wheelchairs are also an option to consider for this population.
- Power mobility should also be considered to promote independence in early childhood and to promote participation for adolescents and young adults.

<u>Children with Neuromuscular Disease</u>

Most children with spinal muscular atrophy (and various types of muscular dystrophy) use power mobility for independence.[14] A manual wheelchair may be used for distance mobility while the child is still able to walk, and later as a back-up to a power wheelchair. There is no evidence that self-propulsion in a manual wheelchair is beneficial for children with Duchenne muscular dystrophy.[15]

Tips when prescribing manual wheelchairs for children with neuromuscular disease:

- For children who are able to self-propel, ultralight manual wheelchairs are recommended.[16]
- Positioning wheelchairs with tilt-in-space are commonly used as back-up manual wheelchairs for children who are primarily power wheelchair users.
- Manual or power wheelchairs should be prescribed for children who cannot walk. Prolonged use of strollers has a negative effect on children's independence.[14]

<u>Children with Spinal Cord Injury (SCI)</u>

Children with tetraplegia mainly use power mobility, but push-rim activated power-assist wheels are an option for those with lower-level tetraplegia.[17] Shoulder pain and injury is prevalent in adults with paraplegia who are manual wheelchair users but rates appear to be lower for those with childhood-onset disability.[18]

Tips when prescribing manual wheelchairs for children with SCI:

- For children with SCI using manual wheelchairs, rigid ultralight styles are recommended to improve efficiency and reduce the risk of shoulder problems.
- Positioning wheelchairs with tilt-in-space are commonly used as back-up manual wheelchairs for children with higher level tetraplegia.

What are the benefits of a manual wheeled mobility intervention?

- Parents of young children may perceive a stroller as having some benefits over a wheelchair such as increased ease of transport and maneuverability, and increased public perception of "normalcy" of their young child.[19] (Level V evidence)
- Decreased cost of energy for independent mobility. Walking with aids is associated with a high energy cost for children with SB and can negatively impact school performance in comparison to use of a wheelchair.[20] (Level IV evidence)
- Increased functional mobility and decreased need for caregiver assistance.[21](Level V evidence)
- Increased participation with peers at school.[22] (Qualitative evidence)

- Choice of the most appropriate means of mobility. Adolescents may choose between different mobility aids such as walkers or wheelchairs based on the safety and efficiency needs of a particular situation.[23] (Qualitative evidence)

Why is independent mobility so important?

In children who are typically developing, the ability to move independently has been shown to influence a wide range of early developmental skills. [24] Children who have restricted mobility tend to have passive, dependent behaviour and this can have long lasting consequences.[25] Children perform better on spatial memory tasks when actively moving than when passively pushed in a wheelchair.[26]

What factors make self-propulsion of a manual wheelchair more effective?

In their narrative literature review (level V evidence), Krey and Calhoun[17] describe the following as important considerations:

- ***Forward-back adjustment of the axle:*** For most efficient set up, children should be positioned so that the shoulders are just behind the axle. When wheels are positioned too far back (as is often the case with children in order to make the chair more stable) there is more weight over the casters, increased rolling resistance and the wheeling stroke is less efficient.
- ***Rear wheel height:*** When seated in the wheelchair, the child's finger tips should reach the axle with the elbow extended. When the hand is on the top centre of the wheel, elbow flexion should be between 100 and 120 degrees. If the wheel is too low, the child will use short, ineffective and effortful strokes. If the wheel is too high, the shoulders will hike during wheeling, increasing risk of shoulder damage.
- ***Rear wheel lateral position:*** When the wheel is too far away (e.g. chair is too wide, armrests are in the way or axle is too far out) the child's shoulders will abduct and hike. Adding camber or adjusting the axle closer may help improve upper limb position and allow more efficient wheeling.
- ***Wheel type:*** Spoked rims are lighter, have less rolling resistance, flex less and are more efficient. Mag wheels are maintenance free but are heavier, allow more flex, and provide more rolling resistance.
- ***Tire type:*** Solid tires are maintenance free and have less rolling resistance but have less shock absorption and may have poor traction outdoors. Pneumatic tires have increased tread and are better on uneven or slippery surfaces. They require maintenance but provide better shock absorption. Airless inserts are maintenance free but are heavier and have less shock absorption than pneumatic tires. High efficiency tires have a lower profile and higher pressure. They may be more efficient on smooth surfaces for playing sports but less effective outdoors.
- ***Caster size:*** Small casters have less rolling resistance on smooth surfaces and turn more easily. However, they are difficult to use outdoors or on uneven ground. Large casters are better on rough outdoor terrain, but have increased rolling resistance indoors and on smooth surfaces.
- ***Weight:*** Lighter weight chairs may reduce rolling resistance and increase efficiency.

Intervention studies have indicated:

- Use of an ultralight wheelchair may increase speed and decrease effort.[27] (Level IV evidence)
- Increasing wheelchair weight by 5-10lbs does not affect wheeling kinematics on level surfaces[28] (Level IV evidence)
- Decreasing tire pressure increases energy expenditure when wheeling.[29] (Level IV evidence)
- Progressive resistance exercise training may increase wheeling speed.[30] (Level IV evidence)
- Wheelchair skills training may increase skill level and efficiency.[31] (Level IV evidence)

What are some challenges for young children to effectively use manual wheelchairs?

- Size and proportion: Wheelchairs for children are often just scaled down versions of adult wheelchairs despite the fact that children's body proportions are quite different. Preschool children's arms are short relative to their trunk height and this makes it difficult to set up the wheel in an effective wheeling position.
- Growth and rear wheel position: Wheelchairs for young children need to be able to grow. Frames designed to accommodate growth tend to be heavier. Sometimes it is not possible to position the wheel in an effective position for self-propulsion. If the chair is longer and wider than required (to accommodate future growth), then it is imperative to have an adjustable axle so the wheel can be moved forward and cambered to the appropriate position.
- Weight: Even the lightest manual wheelchairs are a significant proportion of a young child's weight. A wheelchair weight of 25 or even 34lbs may be insignificant in comparison to the weight of an adult, but a 15lb ultralight wheelchair may be 30% of a four-year-old child's weight.

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Want to know more? Contact:
Roslyn Livingstone MSc(RS) OT
Occupational Therapist
Therapy Dept.
Sunny Hill Health Centre for Children
rlivingstone@cw.bc.ca
604 453 8308

A copy of this document is available at: www.childdevelopment.ca

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Appendix 1: American Academy of Cerebral Palsy & Developmental Medicine - Levels of Evidence (December 2008)

Level	Group Intervention Studies	Single Subject Research Designs (SSRD)
I	Systematic review of randomized controlled trials (RCTs) Large RCT (with narrow confidence intervals) (n>100)	Randomized controlled N-of-1 (RCT) Alternating treatment design (ATD) Concurrent or non-concurrent multiple baseline design (MBDs) (generalizability if the ATD is replicated across three or more subjects and the MBD consists of a minimum of three subjects, behaviours, or settings. These designs can provide causal inferences)
II	Smaller RCTs (with wider confidence intervals) (n<100) Systematic reviews of cohort studies “Outcomes research” (very large ecologic studies)	Non-randomized, controlled, concurrent MBD; (generalizability if design consists of a minimum of three subjects, behaviours, or settings. Limited causal inferences)
III	Cohort studies (must have concurrent control group) Systematic reviews of case control studies	Non-randomized, non-concurrent, controlled MBD; (generalizability if design consists of a minimum of three subjects, behaviours or settings. Limited causal inferences)
IV	Case series Cohort study without concurrent control group (e.g. with historical control group) Case-control study	Non-randomized, controlled SSRDs with at least three phases (ABA, ABAB, BAB, etc); (generalizability if replicated across three or more different subjects. Only hints at causal inferences)
V	Expert opinion Case study or report Bench research Expert opinion based on theory or physiologic research Common sense/anecdotes	Non-randomized controlled AB SSRD; (generalizability if replicated across three or more different subjects. Suggests causal inferences allowing for testing of ideas)

Appendix 2: Evidence Table of Intervention Studies

		Sampling	Outcomes			
Citation	**Study Design**	**Subjects & Size**	**Outcome of Interest**	**Measure Used to Assess**	**ICF Component**[2]	**Results/Findings**
Level IV						
Bednarczyk & Sanderson[28]	Cohort study without concurrent control group	10 adults with SCI and 10 children aged 8-17 yrs with SB matched for ASIA score and gender	Impact of 0kg, 5 kg and 10kg weights on wheeling kinematics	Video analysis	Body Structure & Function	Although there were significant differences between the wheeling kinematics of the two groups, additional weight did not change the kinematics of self-propulsion for adults or children wheeling on level ground at slow speeds.
Connell & Barnhart[30]	Cohort study without concurrent control group	6 children, 3 with CP and 3 with SB aged 4.8 years to 16.4 years	Impact of a progressive 8 week circuit muscular strength training program on wheelchair propulsion	6-Resistance Maximum strength, 50 metre dash and 12 minute distance wheelchair propulsion test	Body Structure & Function Activity	Significant improvement ($p \leq 0.031$) in 12 minute distance test and all 8 upper extremity 6-RM exercises ($p=0.018$-0.031)
Franks et al[20]	SSRD ABA	3 children with SB aged 9, 10 and 15 years	Impact of mobility method on school performance – reading fluency, visuomotor accuracy and manual dexterity.	Individualized reading fluency test. Motor accuracy test – revised (MAC-R) Purdue peg board	Activity	All subjects had decreased visuomotor accuracy scores during assisted ambulation phase in comparison to wheelchair phase. Manual dexterity scores were variable. Reading fluency was unaffected.
Meiser & McEwan[27]	SSRD ABA	2 girls with SB aged 4years 9 months and 5 years 9 months.	Impact of an ultralight versus a lightweight wheelchair on speed, distance, energy expenditure and perceived exertion.	Speed over 50 feet in a controlled environment. Speed over 50 feet in school with classmates. 2 minute propulsion test. Heart rate Self-report	Activity Body, Structure & Function	Visual inspection of data favoured the ultralight wheelchair for all variables except speed with classmates and perceived exertion for child one.
Sawatzky& Denison[29]	SSRD ABCD	10 children with SB or SCI aged 14.2 years ± 2.3 years.	Impact of tire pressure on energy expenditure	Heart rate and distance travelled during self-paced 5 minute trials.	Body, Structure & Function Activity	Energy expenditure increased with decreasing tire pressure; statistically significant between 25% and 100% inflation.

		Sampling	Outcomes			
Citation	**Study Design**	**Subjects & Size**	**Outcome of Interest**	**Measure Used to Assess**	**ICF Component[2]**	**Results/Findings**
Sawatzky et al[31]	Cohort study without concurrent control group	6 children – 5 with SB, 1 with SCI aged 6-19 yrs. 2 day wheelchair skills program	Wheelchair Skills and Participation	Wheelchair Skills Test (WST) Activity Skills for Kids (ASK)	Activity Participation	14% increased in wheelchair skills seen on the WST. No change in participation measured with ASK.
Level V						
Benedict et al[21]	Cross-sectional/ Survey	13 families surveyed - included 2 children using manual wheelchair	Use & effectiveness of assistive devices.(caregiver satisfaction and child/family function)	Survey. Modified QUEST. PEDI – scored retrospectively by parents of children using mobility devices	Activity and Environmental Factors	For one child using manual wheelchair as main mobility device: Increased functional mobility Decreased need for caregiver assistance
Shahid[19]	Survey	17 therapists and 28 parents of children with CP who used a stroller or wheelchair	Factors influencing use of a stroller or wheelchair with children	Questionnaire	Environmental factors	Major factors preventing transition from stroller to wheelchair: transportation difficulties, lack of space in the home, lack of manoeuvrability of wheelchair and lack of information about benefits of a wheelchair.
Qualitative research						
Huang et al.[22]	In person interviews – no specific approach identified.	15 children with CP aged 7-15 years, their parents and teachers	Users', parents' and teachers' perceptions of assistive devices and their use	Semi-structured interviews	Activity and Participation	Assistive devices helped increase participation with peers. Devices were used more at school than at home. Contextual factors were important considerations.
Palisano et al.[23]	Phenomenology	10 youth with CP aged 17-20 years	Adolescents' experiences of mobility in their daily lives	Semi-structured interviews	Activity and Participation	Mobility was important for self-sufficiency. Environmental and Personal factors including safety and efficiency influenced mobility choices.

CP = cerebral palsyPEDI = Pediatric Evaluation of Disability Inventory; SSRD = single subject research design; QUEST = Quebec User Evaluation of Assistive Technology