Recommendations for Mobility in Children with Spinal Cord Injury

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Introduction

Mobility is an important aspect of the rehabilitation of children with spinal cord dysfunction, a necessary component of life, and it is critical in a child’s development. The concept of mobility should be viewed in a comprehensive manner that goes beyond ambulation to include effective mobility in all spheres of an individual’s life, including home, school, community and the world at large. Depending upon the individual’s age and degree of neurological impairment, the nature of mobility may vary. However, the broad categories of mobility ranging from bed mobility and transfers to movement at home, in school, and in the wider community apply to all ages and all degrees of neurological severity. Initially, mobility facilitates cognitive, social, and communication skills. As children age, mobility significantly impacts on activity and participation specific to each developmental stage that is critical to successful progression throughout childhood and adolescence. For a toddler, mobility accomplished through crawling and walking is critical in the child’s development allowing them to explore their environment; hence, impairment of mobility as a result of a spinal cord injury (SCI), may interfere with critical developmental milestones during early childhood. At the other age extreme of pediatric-onset SCI, adolescents with SCI may not have the opportunities to spontaneously access community activities because of mobility limitations that non-injured peers experience, such as “hanging out”.

As a result of a SCI, children are often unable to ambulate. If a child is unable to independently and safely ambulate, an alternate means of mobility is necessary. Most individuals who sustain a SCI will require a power or manual wheelchair as a means of mobility; the type is dependent upon the child’s level of injury and functional status. Many factors must be considered when
determining an appropriate form of wheeled mobility for a child with a SCI, including age, level and severity of injury, environment, and child and family preferences.

In addition to wheeled mobility, upright mobility using lower extremity orthotics is an option. There are three primary goals for the use of orthotics for children with SCI. The first is to protect and/or maintain bone and joint integrity, the second is to assist with function/mobility while substituting for muscle function, and lastly, to encourage normal orthopedic development in children\(^1\).

Because of growth and development, the goals and specific modes of mobility will change as a function of physical size, cognition, personal and family preferences, and functional and social needs. As a result, the individual must be re-evaluated periodically in order to evaluate the current mobility status and prescribe appropriate modifications or new modalities that are appropriate for the child’s current and future needs. Throughout development, the youth and their parents should be provided anticipatory guidance on potential future needs and alternatives. In addition, because of physical, physiologic and psychosocial growth, it is important to evaluate the appropriateness and fit of orthotics, standing frames, and wheelchairs over time. Finally, pressure reducing cushions are an integral component of mobility devices to promote optimal use as well as to prevent pressure ulcers.
Types of Mobility

Power Mobility

The aspects of power wheelchairs that should be considered include the base, drive control and seat functions

1. Power Wheelchair Base: The 3 options for placement of the drive wheels include front, rear, and center wheel drive.

   a. Front Wheel Drive: In this type of power base configuration, the main drive wheel is located in the front and the majority of the chair is behind the user. When driving this chair, there is more of a pulling motion since the front wheels are pulling both the chair and the user. This type of chair is good for uneven terrain and hills, but has a slower top speed when compared to the other two.

   b. Mid or Center Wheel Drive: In this type of power base configuration, the main drive wheel is located more centrally, typically under the individual operating the chair. This type of base has a smaller turning radius to maneuver in tight spaces. With a mid/center wheel drive chair there is less chair around the child, resulting in less chair that needs to be judged for maneuvering the chair.

   c. Rear Wheel Drive: In this type of power base configuration, the main drive wheel is located in the back and the majority of the chair is in front of the user. When driving this chair, there is more of a pushing motion than a pulling motion. It is a very stable chair for most circumstances and terrain and has a higher top overall speed compared to the other two chairs. Additionally, it is the most stable type of chair for power tilt, which is frequently necessary for individuals with SCI.
2. Power Drive Control: physical limitations should not rule out the use of a power wheelchair. Drive controls can be fabricated to access any body part. Drive controls require electronic programming to control speed, acceleration, deceleration, braking and torque. They should be adjusted based on the environment. Drive controls include but are not limited to:
   a. Switches
   b. Joystick
   c. Head array
   d. Mini proportional joystick
   e. Sip and puff
   f. Mouth piece

3. Power Seat Functions: can be used to optimize functioning and promote independence, assist with environmental access, and affect physiologic functioning
   a. Tilt: keeps the individual in the same seated position, but provides movement in space, allowing for
      - Positional changes and pressure relief
      - Increased sitting tolerance and decreased fatigue
      - Improved function
      - Comfort and pain relief
   b. Tilt/Recline: in addition to power tilt as described above, this function opens the seat to back angle allowing the individual to lie back, also allowing for:
      - Positioning for bladder management and hygiene
      - Positioning for respiratory care
      - Management of orthostatic hypotension
• Because of the shear potential inherent in a recline system, a mechanical shear reduction is available. With shear reduction the mechanical component of the backrest and the user interface of the backrest move relative to one another while reclining, therefore reducing shear on the user

c. Standing: can allow for
   • Weight bearing
   • Improved physiologic function

d. Seat elevation: can allow for
   • Environmental access
   • Assistance with transfers

e. Seat to Floor: can allow for
   • Peer interaction, which is important for toddlers, pre-school, and school age children
   • Access to lower surfaces
   • Allows a child to crawl into the chair

f. Power Elevating Leg Rest: allows for
   • Legs to be elevated but this function must be used in conjunction with tilt or recline for circulatory benefits
   • Edema control
   • Prolonged sitting tolerance
   • Ground clearance

4. Scooters: While a scooter is not traditionally recommended for children with SCI, it may be considered for an appropriate individual. Scooters may be used for individuals with mobility
or endurance impairments who do not require much postural support or pressure relief.

Although scooters cost less than power wheelchairs in general, they are not an appropriate choice for most children and adolescents with SCI.

5. Add on Power Joystick: This option, which includes a joystick and battery pack, can be added on to a manual wheelchair for users who will benefit from a power wheelchair but require the accessibility of a manual wheelchair.

**Manual Mobility**

1. Manual Wheelchair Frame: there are 2 options to consider regarding the selection of a manual wheelchair frame
   
   a. **Rigid:** This type of wheelchair frame does not fold, although some have the ability for the back to fold down on the seat. Rigid frames are usually lighter in weight than a similar folding chair due to less moveable parts and are also more durable than folding chairs.
   
   b. **Folding:** This type of wheelchair has the ability to fold in half via a cross brace underneath the seating system for stowing or transport. This type of frame contains more adjustable and moveable parts than a rigid frame and often does not meet a child’s sports and/or leisure needs.

2. Push rim activated power assist wheels: These wheels along with a battery pack can be added to a manual wheelchair frame to provide assistance to the user during propulsion. There are motors located inside the wheels which are activated via sensors in the push rims. The wheels give the user the ability to customize touch sensitivity, speed, and the amount of
assistance required. Additionally, these wheels can prevent backward rolling when ascending an incline.

The use of strollers should be limited to infants and toddlers, which are ages when strollers are commonly utilized for those without mobility limitations. Children as young as 1 year of age should be encouraged to utilize a power or manual wheelchair in order to facilitate independence.

**Walking and Upright Mobility:** the following are descriptions of lower extremity orthoses typically used with persons with SCI

1. Stander: commercially available and usually includes a seat that the user transfers into or a pelvic strap which allows the patient to stand directly from the wheelchair. A manual, hydraulic or electric lift is used to bring the individual to standing. Lower extremity, trunk, chest, and upper extremity supports are available as needed. Standers are available as both static standers, mobile standers and “active” standers which allow for upper extremity strengthening and lower extremity range of motion while standing.

2. Parapodium: This is an orthotic device often used for very young children, as long as they have sufficient head control. It is designed for standing and moving short distances without the use of an assistive device thus freeing up the patient’s arms and hands for functional use. The hip and knee joints of the parapodium flex and allow for sitting while in the device.

3. Ankle Foot Orthosis (AFO): when used for upright mobility, this type of lower extremity orthosis provides ankle and foot support for the user who has sufficient hip and knee strength to control the knee during stance and swing. Numerous types of AFOs are available based
on the type of support the user requires and can be adjustable or fixed for greater ease based on the types of functional activities the user is able to do. They may attach to a shoe or be used as an insert into a shoe. AFOs may be fabricated of all plastic or all metal components, or a combination of both. This orthosis may be used unilaterally or bilaterally.

4. **Knee Ankle Foot Orthosis (KAFO):** when used for upright mobility, this type of lower extremity orthosis provides knee, ankle, and foot stability. KAFOs may be fabricated of plastic or leather with metal uprights. They may attach to shoes, or be used as an insert into shoes. This type of orthosis may be used unilaterally or bilaterally.

5. **Hip Knee Ankle Foot Orthosis (HKAFO):** when used for upright mobility, this type of lower extremity orthosis stabilizes at the hip, knee, and ankle. This orthosis may be used unilaterally or bilaterally. When used bilaterally, this orthosis consists of a pair of KAFOs attached to one another by a pelvic band, or trunk orthosis. With the hip component locked, support is provided in the transverse and sagittal planes and a swing to/through gait pattern is used. With the hip component unlocked, the user may be able to ambulate with a reciprocal gait, however still receiving the stability in the transverse plane. HKAFOs may be fabricated of plastic or leather with metal uprights. They may be attached to shoes, or inserted into shoes and are more difficult to donn/doff than the options listed above, especially when they include the bilateral leg pelvic attachment.

6. **Reciprocating Gait Orthosis (RGO):** a pair of HKAFOs that are connected to one another by an isocentric bar and a cable system, allowing the user to ambulate with a dynamic reciprocal gait using body weight shifts to unload one side of the body and activate the opposite side. This orthosis may be attached to shoes or used as an insert into shoes, and may be difficult to donn/doff due to bilateral and pelvic attachments.
7. FES surface stimulation systems: these systems provide activation of muscle groups to allow for functional activities such as walking without foot drop, standing, or reciprocal walking patterns via stimulation of specific nerve/muscle groups. Pediatric and small models are available.

8. Locomotor Training (LT) a type of therapeutic modality involving use of the lower extremities with continuous repetition to complete a meaningful task (walking). Recently, the use of LT has been studied and used clinically to facilitate walking recovery in individuals with neuromuscular impairments. Prior to the use of LT in humans, LT was studied in the animal population with positive results. Therefore, studies involving LT as well as clinical use of LT were translated into humans. LT is often initiated with a body weight supported (BWS) system and a treadmill. This allows for decreased weight of the individual to make stepping easier. The BWS system includes an overhead support with harness attachment. LT may be conducted as either manual assist by a person, or by robotic generated mechanisms. Robotic gait orthoses can be programmed to train the individual specific to their needs. In addition to BWS LT on the treadmill, the therapy can also be conducted over ground. Progression of LT may occur via increased walking speed and/or distance, decreased body weight support, decrease manual assistance, and increased therapy and ambulation over ground. It is important that ambulation training progress to overground in order to have carryover into functional activities and tasks.

Community Mobility

Ready access to one's community is important at all ages, but becomes most critical in adolescence. Whether public or private, motorized transportation must be accessible and enhance
an adolescent's independence. Although individuals with lesions as high as C5 are capable of driving an appropriately-adapted motor vehicle it is imperative that they receive a proper driver evaluation and obtain appropriate prescriptions for motor vehicle adaptations. The age when adolescents can obtain a drivers permit and eventually a driving license varies between various countries as well as regions or states but generally is 16 to 18 years of age.

Adolescents with paraplegia should be able to transfer independently from an ultra-lightweight manual chair to the driver's seat of a motor vehicle and then transfer the wheelchair into the car. Most adolescents with tetraplegia, especially those who utilize power wheelchairs, will need an adapted van with a wheelchair lift and an automatic locking system for their wheelchair, either in the driver’s position or as a passenger. Using an adapted van with a wheelchair lift, adolescents with tetraplegia or paraplegia who utilize a manual wheelchair would generally transfer themselves into the driver’s seat. If the adolescent transfers onto the motor vehicle seat, their pressure-reducing seating system should be utilized.

Individuals of all ages with spinal cord dysfunction should be properly restrained in motor vehicles ranging from car seats for infants and toddlers, boosters for older children, specialized restraint systems for children with poor trunk or neck control, three point restraints for appropriately sized older children and adolescents, to approved restraint systems for those who remain in their wheel chairs that are properly locked down.
Medically Necessary and Medically Beneficial Mobility Recommendations for Children with SCI

The purpose of these guidelines for pediatric mobility is to provide information and make recommendations, but it is not intended to be prescriptive. When determining an appropriate form of mobility for a child, many factors must be considered. A comprehensive examination includes an understanding of functional abilities and limitations, neuromusculoskeletal status, knowledge of the child’s home and school environments, their financial coverage, as well as input from the child and parents/caregivers to consider all functional implications for the use of the wheelchair (i.e. transport, transfers, accessibility, etc.), and aesthetics. An evaluation for a permanent wheelchair and seating system is often completed during the initial inpatient rehabilitation. The child should be provided the opportunity to trial several types of appropriate wheelchairs and seating systems prior to a final decision. If there is anticipated significant neurological change, the definitive wheelchair evaluation should be postponed to allow for the most appropriate selection.

Prior to recommending any type of orthosis, the goal for their use should be determined. Upright mobility with lower extremity orthoses includes exercise or therapeutic ambulation, household ambulation, or community ambulation. Often an assistive device, such as crutches or a walker, are required. Orthotic considerations will be determined by the strength of key muscles assessed using the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI), as well as non-key muscles such as hip extensors, knee flexors, and gastrocnemius in traditional manual muscle testing positions.
The recommendations described below are written for those with complete SCI (AIS A) and sensory incomplete (AIS B). When considering the use of wheeled mobility, lower extremity orthoses and/or locomotor training for individuals with motor incomplete SCI (AIS C and AIS D) it is necessary to look at the strength and function of individual lower extremity muscle groups as well as biomechanical alignment, proprioception and range of motion as opposed to using the individual’s neurological level to make recommendations. Another important consideration surrounding the orthotic decision and ambulation potential are upper extremity strength and function.

**Definitions:**

A *Medically Necessary* piece of equipment has the capacity to prevent an injury, disease, or symptom from deteriorating, decrease pain or discomfort, and improve function.\(^2\) It should be clinically and medically appropriate for the person’s diagnosis, and be in accordance with accepted standards of practice. It includes the used of wheelchairs and orthoses to provide a means of safe, efficient, and functional mobility.

A *Medically Beneficial* piece of equipment is defined as equipment that may not be necessary to sustain life or safety, but may prevent degradation of impairment, augment an individual’s efficiency and ease of functional skills, decrease caregiver burden, and contribute to health and wellness of those individuals\(^2\). It includes the use of orthoses for stabilization, or therapeutic standing or ambulation, but not for those that provide assistance for functional walking/ambulation\(^2\).
SCI at the C1 to C4 levels, AIS A and B

Medically Necessary for Wheelchair Recommendations

- Power Wheelchair Base: may be front, mid or center, or rear wheel drive depending on user preference
  - Power mobility is necessary if an individual is unable to push a manual wheelchair or it is too laborious, inefficient, or painful
- Drive control: may be one of several types depending on user ability and preference
  - Sip and puff, mini proportional, head array control, joystick are some examples, but not inclusive
- Power tilt or power tilt/recline: necessary to allow a means of proper positioning, pressure relief and pressure distribution, to keep the individual stable and in a properly seated position, and comfort
- Seating: Solid back support and cushion:
  - Both need to provide postural support, pressure distribution, minimize moisture, and improve functional ability
- Seating accessories: Head support, pelvic belt, trunk support, lower and upper extremity supports, anti-tippers
- Ventilator Tray
- Back up Manual Wheelchair: vital should the user’s power wheelchair malfunction or for transportation purposes. Without a backup manual wheelchair, the individual is immobile and restricted to bed.
Considerations:

- Must consider ability to access/enter home and transportation with this equipment
- A headrest, seat belt, chest support, and approved lock or tie down system are recommended for any individual who will be transported in a motor vehicle

**SCI at the C1 to C4 levels, AIS A and B:**

**Medically Beneficial for Upright Mobility**

- Standing: Tilt table or Hydraulic standing frame
- Ambulation: not indicated

**SCI at the C5 to C6 levels, AIS A and B**

**Medically Necessary for Wheelchair Recommendations**

Option 1: depending on user’s functional abilities

- Power Wheelchair Base: may be front, mid or center, or rear wheel drive depending on user preference
  - Power mobility is necessary if an individual is unable to push a manual wheelchair or it is too laborious or inefficient or painful
  - Drive control: typically joystick, but based on user’s ability
- Power tilt or power tilt/recline: necessary to allow a means of proper positioning, pressure relief and pressure redistribution, to keep the individual stable and in a properly seated position, and comfort
- Seating: Promote an appropriate seated posture and stabilization relative to balance and stability needs
- Solid back support and cushion: both need to provide postural support, pressure distribution, minimized moisture, and ability to function
- Both should meet the users medical and functional needs
- Seating accessories as necessary: Head support, pelvic belt, trunk support, lower and upper extremity supports, anti-tippers
  - Provide seat elevation or possibly a standing position to individuals with upper extremity function\(^5\)
  - Back up Manual Wheelchair: vital should the user’s power wheelchair malfunction or for transportation purposes. Without a backup manual wheelchair, the individual is immobile and restricted to bed.

**Considerations:**
- Must consider ability to access/enter home and transportation with this equipment
- A headrest, chest support, and approved lock or tie down system are necessary for any individual who will be transported in a wheelchair

Option 2: depending on users functional abilities and possibly environmental considerations
- Manual Wheelchair Frame with push rim activated power assist wheels or add on joystick
  - Allows for manual wheelchair propulsion with decreased effort (lower oxygen consumption and heart rate) as compared to manual wheelchair propulsion\(^6\)
- Ideally provide manual wheelchair users with SCI a high strength, fully customizable manual wheelchair frame made of the lightest possible material:
  - Ultra-light (K0005) which weighs less than 30 pounds and is adjustable
  - Adjust the rear axle as far forward as possible without compromising the stability of the user
  - Position the rear axle so that when the hand is placed at the top center position of the push rim, the angle between the upper arm and forearm is 100 to 120 degrees
- Consider seat and back width and seat depth
- Anti-tippers are necessary as they prevent the wheelchair from tipping backwards
- Hill holders, which prevent the wheelchair from rolling backwards on inclines, may be necessary.
- Brake extension, which allow the brakes to be engaged or disengaged easier, may be necessary
- Promote an appropriate seated posture and stabilization relative to functional, balance, and stability needs:
  - Solid back and cushion: both need to provide postural support, pressure distribution, minimized moisture, and ability to function
  - Both should meet the users medical and functional needs
• Seating accessories as necessary: pelvic belt, trunk support, lower extremity supports

Considerations:

○ Ability to complete a pressure relief without power tilt is necessary

○ The ability to properly configure a wheelchair via custom modification has significant implications such as decreased incidence of upper extremity strain and injury, significant effects on mechanical efficiency, and oxygen cost/use.

SCI at the C5 to C6 levels, AIS A and B:

Medically Beneficial for Upright Mobility

○ Standing: Tilt table or Hydraulic standing frame

○ Ambulation: not indicated

SCI at the C7 and C8 levels, AIS A and B

Medically Necessary for Wheelchair

Option 1: depending on user’s functional abilities

○ Manual Wheelchair Frame with push rim activated power assist or add on joystick

  • Allows for manual wheelchair propulsion with decreased effort (lower oxygen consumption and heart rate) as compared to manual wheelchair propulsion

  • Provide manual wheelchair users with SCI a high strength, fully customizable manual wheelchair frame made of the lightest possible material.
• Ultralight (K0005) which weighs less than 30 pounds and is adjustable

• Adjust the rear axle as far forward as possible without compromising the stability of the user

• Position the rear axle so that when the hand is placed at the top center position of the push rim, the angle between the upper arm and forearm is 100 to 120 degrees

  ▪ Consider seat and back width and seat depth

  ▪ Anti-tippers are necessary as they prevent the wheelchair from tipping backwards

  ▪ Hill holders, which prevent the wheelchair from rolling backwards on inclines, may be necessary.

  ▪ Brake extensions, which allow the brakes to be engaged or disengaged easier, may be necessary

  o Promote an appropriate seated posture and stabilization relative to functional, balance and stability needs

    ▪ Solid back and cushion: both need to provide postural support, pressure distribution, minimized moisture, and ability to function

    ▪ Both should meet the user’s medical and functional needs

    ▪ Seating accessories as necessary: pelvic belt, trunk support, lower extremity supports

Option 2: depending on users functional abilities

  o Manual Wheelchair Frame
- Provide manual wheelchair users with SCI a high strength, fully customizable manual wheelchair made of the lightest possible material\(^5\)
  - Ultralight (K0005) which weighs less than 30 pounds and is adjustable\(^5\)
  - Adjust the rear axle as far forward as possible without compromising the stability of the user\(^5\)
  - Position the rear axle so that when the hand is placed at the top center position of the push rim, the angle between the upper arm and forearm is 100 to 120 degrees\(^5\)
- Consider seat and back width and seat depth\(^5\)
- May require rims with projections or that are modified
- Anti-tippers are necessary as they prevent the wheelchair from tipping backwards
- Hill holders, which prevent the wheelchair from rolling backwards on inclines, may be necessary.
- Brake extension, which allow the brakes to be engaged or disengaged easier, may be necessary
- Promote an appropriate seated posture and stabilization relative to functional, balance and stability needs\(^5\)
  - Solid back and cushion: both need to provide postural support, pressure distribution, minimized moisture, and ability to function
  - Both should meet the users medical and functional needs
- Seating accessories as necessary: pelvic belt, trunk support, lower extremity supports

**Considerations:**

- The ability to properly configure a wheelchair via custom modification has significant implications such as decreased incidence of upper extremity strain and injury, significant effects on mechanical efficiency, and oxygen cost/use.\(^7\)

**SCI at the C7 to C8 levels, AIS A and B:**

**Medically Beneficial for Upright Mobility**

- Standing: Hydraulic or standard standing frame\(^4\)
- Ambulation: not indicated\(^4\)

**SCI at the T1 to S5 levels, AIS A and B**

**Medically Necessary for Wheelchair**

- Manual Wheelchair Frame
  - Provide manual wheelchair users with SCI/D a high strength, fully customizable manual wheelchair made of the lightest possible material.\(^5\)
    - Ultralight (K0005) which weighs less than 30 pounds and is adjustable\(^5\)
    - Adjust the rear axle as far forward as possible without compromising the stability of the user\(^5\)
• Position the rear axle so that when the hand is placed at the top center position of the push rim, the angle between the upper arm and forearm is 100 to 120 degrees\(^5\)
  - Consider seat and back width and seat depth\(^5\)
  - Anti-tippers are necessary as they prevent the wheelchair from tipping backwards
  - Hill holders, which prevent the wheelchair from rolling backwards on inclines, may be necessary.
  - Promote an appropriate seated posture and stabilization relative to functional, balance and stability needs\(^5\)
    - Solid back and cushion: both need to provide postural support, pressure distribution, minimized moisture, and ability to function
    - Both should meet the users medical and functional needs
    - Seating accessories as necessary: pelvic belt, trunk support, upper and lower extremity supports, wheel locks

**Considerations:**

• The ability to properly configure a wheelchair via custom modification has significant implications such as decreased incidence of upper extremity strain and injury, significant effects on mechanical efficiency, and oxygen cost/use\(^7\).
• The height of the back rest and the seat to back angle must be considered based on the individual’s trunk strength and balance.
Manual wheelchair frames may be folding or solid. The type of transport, ability to independently transfer and bring wheelchair into a vehicle, and personal preference should be considered.

**SCI at the T1 to T9 levels, AIS A and B:**

**Medically Beneficial for Upright Mobility**

- Standing: standing frame

- Ambulation is not functional, typically therapeutic/exercise ambulation with significantly increased physiological demand.

- For therapeutic/exercise ambulation, depending on patient’s abilities with balance, RGOs, and/or HKAFOs may be used.

**SCI at the T10 to L1 levels, AIS A and B:**

**Medically Beneficial for Upright Mobility**

- Standing: standing frame

- Ambulation is not functional, typically therapeutic/exercise or household ambulation, with practice the user may become independent with the use of assistive device and lower extremity orthosis

- For therapeutic/exercise ambulation at these levels, and depending on patient’s abilities with balance, RGOs, HKAFOs or KAFOs may be used.
**SCI at the L2 to S5 levels, AIS A and B:**

**Medically Beneficial for Upright Mobility:**
- Standing: standing frame

**Medically Necessary for use of LE Orthotics and/or Locomotor Training:**
- The range of ambulation potential includes functional household to community ambulation. With practice the user may become independent with the use of assistive device and lower extremity orthosis
- With functional ambulation at these levels, and depending on the patient’s strength as discussed below, KAFOs or AFOs may be used.
- In addition to using the neurological level, it is important to consider the lower extremity total motor score obtained from the ISNCSCI. Individuals with a total lower extremity motor score less than or equal to 20 were found to be limited or household ambulators and those with scores greater than or equal to 30 were found to be community ambulators.
- Total motor score and lower extremity motor scores are also related to ambulatory ability; the greater the lower extremity motor score, especially in the knee and hip musculature, the greater one’s walking speed and endurance.
- One study found that individuals with SCI who retained or recovered quadriceps muscle strength 4/5 or 5/5 two months from the date of injury have an excellent prognosis for ambulation.
**Pediatric Considerations and Developmental Aspect**

**Mobility and Development**

Mobility enhances how we carry out our daily lives and affects everything we do. Mobility provides a means to learn, interact with others, attend school, earn a living, and participate in society. With an infant, the ability to move independently facilitates many aspects of development and early experiences influence all subsequent development. If there is a delay in mobility and motor development, all other development is delayed.

Locomotion induces or accelerates important developmental changes. Independent locomotion is linked to the growth of brain structures, coping, self-awareness, shifts in patterns of attachment and interaction with caregivers, the emergence of a sense of competence and initiative, and the development of cognition. With an infant and toddler, mobility provides a means of exploring the environment. Without independent mobility a child may have a decreased ability to learn, decreased socialization, and learned helplessness due to decreased ability to have an impact on their environments. It is critical that we do not wait to see if a child will eventually become an independent ambulator; mobility should be augmented to allow for independence.

**RESNA Position on the Application of Power Wheelchairs for Pediatric Users**

The Rehabilitation Engineering and Assistive Technology Society of North American (RESNA) published a paper in Assistive Technology in 2009. The position paper describes clinical applications and evidence based literature supporting the use of power mobility in young children. It is RESNA’s position that “age, limited vision or cognition, behavioral issues, and
the ability to walk or propel a manual wheelchair short distances should not, in and of themselves, be used as discriminatory factors against power mobility for children.” In addition, “RESNA recommends early utilization of power mobility for the appropriate candidates as medically necessary to promote psychosocial development, reduce learned helplessness, and facilitate social and educational integration and independence.”

When to Begin Power Mobility Training

There is no set age to initiate power mobility training for a child and it has been shown children 7-24 months can learn to use a powered mobility device safely over short periods of time.\textsuperscript{17,18} As opposed to chronological age, cognition and developmental age should be used to guide a clinician on the initiation of powered mobility training. For children without cognitive disabilities, studies have shown power mobility training can begin within the first year of life.\textsuperscript{18} Historically, therapists have considered the use of powered mobility as the ability to independently drive a chair in all situations.\textsuperscript{19} Just as a child learns to walk over time, a child should be able to learn to move in a power wheelchair over time. The same principles should be considered for power mobility training as ambulation.\textsuperscript{19}

Challenges to Pediatric Wheelchair Configuration

There are many challenges to prescribing a manual wheelchair for a growing child. Regardless of the type of wheelchair frame, the following are recommendations for the pediatric population:

1. Solid seating surface through a seat pan or cushion rigidizer to prevent hip internal rotation and adduction
2. Solid back to provide more postural support
3. Consider use of an abductor pommel for children with spasticity: the pommel must be large enough to keep the lower extremities abducted to maintain optimal hip positioning.

4. Although air filled cushions may provide adequate pressure relief, it may impair postural support.

5. The wheelchair frame must allow for growth potential, especially in frame length but also for width.

6. An adjustable axle is recommended to allow for adjustability in frame height and proper positioning for propulsion.

7. Reverse configuration (having the wheels in front) is an option for very small children allowing for better access to the wheels.

When prescribing a manual wheelchair the wheelchair weight to child weight ratio should be considered. The average ultra light wheelchair weight ranges from 12-30 pounds, without seating and accessories. The average adult weighs 150 pounds giving us a 5:1 ratio. The average child under 6 years weighs 30-40 pounds, bringing the ratio closer to 1:1 or 1:2. Therefore in addition to justifying the lightest wheelchair possible it is important to educate parents, aides, and children to avoid placing bags on the back of their wheelchair and therefore further increasing its weight.

**Orthopedic Considerations**

Orthoses for the lower extremities and the spine are often used to promote normal bone alignment during growth at the hips and spine. 80% to 98% of children who sustain a SCI prior
to skeletal maturity develop a scoliosis\textsuperscript{20,21} and one study\textsuperscript{22} found that 93\% of children with SCI injured prior to 11 years and 9\% of children older than 11 had at least one subluxed or dislocated hip. Some treatment methods to address orthopedic issues of the child with SCI may impact the child’s mobility. Early bracing of the spine, using an orthosis such as a thoracic lumbar sacral orthosis (TLSO) may delay the age that surgical intervention is required and in curves less than 20 degrees, an orthosis may reduce the possibility of a surgical fusion\textsuperscript{23}. In addition, to facilitate proper femoral head and acetabular positioning an abduction pillow can be used to maintain hip abduction in supine\textsuperscript{24} and a pommel can maintain hip abduction while sitting in a wheelchair.

**Pediatric Progression**

When a child sustains a SCI, it is important that ambulation training be supported as an essential component of rehabilitation and that the child’s developmental level is taken into consideration.

The “community” that the child will be involved in differs depending on the child’s age. For example, the “community” for infants and toddlers is primarily their home or day care environment. It expands to the playground, neighborhood and school as the child enters school age and further expands to the community at large for adolescents. Ambulation, therefore, must be part of a program that takes the child’s developmental needs into consideration and this program must be flexible, adjusting for the changing needs of the child.

Research\textsuperscript{25-27} has shown that children who are injured younger, especially those injured before 5 years of age, are more likely to ambulate in general and typically ambulate for a longer duration of time than those injured later in childhood. Additionally, children with paraplegia are more
likely to ambulate than those with tetraplegia. It is important that orthotics be as least cumbersome as possible while still supporting the appropriate muscles and joints for a child with a SCI to be successful in ambulating.

Mobility, and therefore ambulation, must be efficient and facilitate independence. It is a natural progression for children with SCI to progress to different orthotics, different assistive devices and ultimately a wheelchair in order for them to keep up with peers and be as independent as possible throughout the environment. As children get older, this progression to increased reliance on a wheelchair must be viewed as a natural progression and not as a failure.

**Pediatric access to therapy**

Physical therapy and occupational therapy are both integral components to the rehabilitation of individuals who sustain spinal cord injuries. Additionally, some children may require the services of speech therapy as well. Access to such therapies may be easier for children to obtain than for adults. This is especially true if the child is injured very early in life because of the creation of early intervention services. Early intervention is a statewide system that was mandated by the U.S. Congress in 1986. Each state receives funds from the federal government to run the programs in that particular state. Early Intervention is designed to help infants and toddlers from ages 0-3 and the caregivers who care for them. After the age of 3, children may be eligible to receive services from physical therapy, occupational and speech therapy through the schools that they attend.
Conclusion:

Mobility is critical for proper development to occur in the pediatric population and making recommendations for mobility is often very challenging. It is essential for clinicians providing care to children with SCI to address mobility in a comprehensive and longitudinal manner and across environments.
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