Mobility and Function

Definition of mobility: the ability to move in one's environment with ease and without restriction.

Neurologic Level of Lesion and Anticipated Mobility

Walking at thoracic level is very rare-wheelchair T11-12 stable trunk allows for increased UE function L1/L2 level also has limited potential for long term ambulation mobility-wheelchair L3 has more ability to cont walking-mixed patterns L4/L5 fair/good walking-ambulation, wheelchair long distance Sacral all walk-wheelchair only for additional sports options


A practical classification of spina bifida, based on the neurological level of the lesion, is as follows: Group I Thoracic or high lumbar level lesion FMS 1,1,1 No quadriceps function Usually a household ambulator up to the age of 13 years, with the use of a hip-knee-ankle-foot-orthosis or reciprocating gait orthosis. 95%-99% are wheelchair users as adults, although exceptions are seen.

Group II Low lumbar level lesion FMS 3,3,1 Quadriceps and medial hamstring function No gluteus medius/maximus function Ambulation requires ankle-foot orthoses (AFO) and crutches 79% retain community ambulation as adults Most use wheelchairs for long-distance mobility Significant difference in ability to walk between children with L4 and L3 level lesions (Asher and Olson,1983) Medial hamstring function is needed for community ambulation

Group III Sacral Level Lesion FMS 6,6,6 High sacral-no gastrocsoleus strength; walks with and without support but uses AFO braces; has characteristic gluteus lurch with excessive pelvic obliquity and rotation during gait Low sacral-good gastrocnemius/soleus strength and normal gluteus medius and maximus function; walks without the need for AFO's; gait is close to normal

Benefits of mobility:

- contracture management
- exercise: cardiovascular-respiratory effects
- strength effects and endurance
- community engagement/household mobility
- bone density
- bowel and bladder evacuation
- pressure reduction/redistribution
Outcomes

1. Optimize functional and exercise/recreational mobility (speed, efficiency and highest walking ability) with appropriate devices.
2. Reduce threats/effects of pain, aging, neurologic deterioration and obesity on mobility
3. Avoid pressure ulcers.
4. Maximize safe functional mobility and acquisition of milestones for social and environmental exploration
5. Maximize safe and functional mobility for ADL, fitness, social/recreational and functional/pre-vocational goals.
6. Maximize functional and recreational/fitness mobility for social, recreational, ADL and pre-vocational goals
7. Optimize safe and effective mobility for ADLs, social, recreational, pre-voc and vocational, fitness goals.
8. Prevent or reduce threats to mobility.
9. Optimize safe and effective mobility for ADLs, social, recreational, pre-vocational and vocational, and fitness goals.
10. Prevent or reduce threats to mobility.

Infancy (through age 1 year): Goals/Outcomes:

Clinical Questions:

- What are expected milestones based on early neuro exam to help predict expected motor skills?
- What is the role of Vitamin D and bone health on bone and muscle function?
- If early mobility is delayed, does a device for mobility improve developmental outcomes (vision, later math and reading skills, social skills, less passivity?) ie: walker, caster cart, power w/c
- Do such devices help or aggravate development of pressure sores and contractures?

Guidelines:

- Assess neurologic level and strength (MMT chart) and changes over time.
- Assess progress in developmental skills with Bayley, AIMS or Denver Developmental.
- PT and OT programs to attain and maintain muscle length, strength, gross and fine motor skill development. Maximize motor development with good alignment to progress motor skills, with sitting alignment trunk control and a first key goal. (SATco or Segmental Assessment of Trunk Control to assess) not Ref: Adolph, KE
- Parent/caregiver coaching program as part of Early intervention to support motor skills learning in home environment
- Birth to three education program or Early Intervention based on how infants learn motor and social skills throughout the course of everyday life, at home and in the community.
Parents participate in motor development program and therapies. Coaching model Support primary caregivers to provide children with learning experiences and opportunities that strengthen and promote a child’s competence and development

Use casting, splinting, orthotics to support and maintain alignment and movement. (Also orthopedics involvement)

Monitor skin integrity with use of these devices. (registry to monitor skin breakdown episodes)


Build movement upon ideal sitting alignment. Maintain vertical neutral position of head and trunk. Outcome “Segmental Assessment of Trunk Control (SATco”) by Saavedra Sandra and Refinement, Reliability, and Validity of Segmental Assessment of Trunk Control Ped PT fall 2010

Optimum movement requires competent body center of mass management gained via massed practice. Multiples of thousands of weight shifts strengthen loaded muscles and off loads limbs to play and move. Adolph, KE


Toddler (1-3 Years) and Preschool (3-5 Years):

Clinical Questions:

- Does obesity impede development of walking?
- How long should a positioning program occur to prevent contractures?
- What is the usual trajectory of gait development by neurologic level, with gait speed and falls?
- What is the role of treadmill training on gait development and fitness?
- What is long term consequences of braced gait with shear/torque at the knee, hip, and spine and is there an “at risk” amount of force or step rate that adversely affects aging?

Guidelines:

- Assess neurologic level and strength (MMT chart) and changes over time. Monitor for gait changes, scoliosis, spasticity and bowel/bladder function change, FMS (what is earliest?)
- Monitor for sensory, motor and functional levels. Diagnose, identify cause and treat deterioration. Birth to three education program. Early Intervention; to support children learn in everyday life, at home and in the community.
- Parents participate in motor development program and therapies. Coaching model Support primary caregivers to provide children with learning experiences and opportunities that strengthen and promote a child’s competence and development.
- Stander/parapodium/RGOs to maintain Rom for walking if not pulling to stand, or for children with quadriceps weakness (Ref)
• **Monitor skin** after mobility/brace wear, (kids who crawl/combat crawl/sit scoot with absent sensation are also at risk of develop foot or knee or buttock sores)
• Maximize safe **home environment exploration** (and playground or yard) with caster cart, wheelchair or motorized devices (GoBabyGo) as cognition and vision allows, once sitting is attained and hands can be used.
• Continue to **monitor developmental milestones** (U of Mich Bev Ulrich used Bayley Scales & will share data for hundreds of kids with SB, age 1-42 months)
• For walking, consider **outcome measures for gait and balance** (falls frequency, FMS, TUGS)
• **Mass Practice**: Commence ambulation or other independent mobility about the child’s world. Typically developing early walkers engage in approximately 1,100 weight shifts per waking hour + approximately 3,000 weight shifts per standing hour. Adolph KE, Avolio AM et al TD age 12-19 months average 2,268 steps & 17 falls per hr of observation
• Use **appropriate bracing** to assist weak muscles and protect from torque, valgus and shear forces.
• For wheelchair users, consider **wheelchair mobility distance** (FMS) and skills (WST)

http://www.wheelchairskillsprogram.ca/eng/documents/version4.3.3/FORM_WST-M-WCU_4.3.3.pdf for potential wheelchair skills test, consider developing milestones

• Optimize **bone health**, vitamin D
• **Monitor BMI** or signs of excess adiposity

Standing programs 5 days per week positively affect bone mineral density (60-90min/d): hip stability (60 min/d in 30 -60 degrees of total bilateral hip abduction); range of motion of hip, knee, and ankle (45 to 60 min/d); and spasticity (30 to 45 min/d). Paleg, G. Systematic Review and Evidence-Based Clinical Recommendations for Dosing of Pediatric Supported Standing Programs Pediatr Phys Ther 2013;25:232-247

Effect of Core/Trunk Strength on Mobility Skills and Arm Function SATco & neuromuscular recovery scale Sandra Saavedra U of Hartford, tons of publications

Ped PT Jrnl spring 2011, Sensory Input and Treadmill Step Frequency in Myelomeningocele and Treadmill Trng for an Infant with SB

CDC lit search p 10 Muscle Activity of Infants With MMC While Treadmill Stepping Bev Ulrich U of Mich & Bone Mineral Content in Infants with SB with & without Treadmill Stepping 2016 Ped PTjrnl

CDC Lit search P 19 Power mobility for infants with SB, Cole Galloway (GoBabyGo), U of Delaware AACPDM 3/2014 Practical Considerations re Intro Power Mobility age 12 months, Ginny Paleg

Pediatric PT Jrnl April 2012 Motor Development Toward Ambulation in Preschool Children with Myelomeningocele-A Prospective Study, Sweden

**School age (6-11y):**
Clinical Questions:

- What is the usual trajectory of independence with wheelchair skills and gait speed and balance?
- What is the usual step frequency range for various neuro levels?
- What is the usual daily wheeling distances for children with MM who are primary wheelchair users?
- What is the role of gait analysis to monitor gait and improve it (assess joint torques and shear forces on joints)?
- Is there a benefit of early use of forearm crutches or KAFOs to protect the knee when valgus forces at knee may cause long term knee pain?
- In wheelchair users, are there signs of early shoulder or wrist wear and tear? Does early wheeling adversely or protectively affect upper extremity and trunk development?

Guidelines:

- Monitor neurologic level and strength (MMT chart) and changes over time. Monitor for gait changes, scoliosis, spasticity and bowel/bladder function change, FMS.
- Monitor walking or wheeling ability with outcome measures (6MWT, TUG, Obstacle and Curbs test, etc) ref.
- Continue flexibility/ROM and strengthening to maintain mobility goals.
- Teach independence in donning/doffing orthotics.
- Educate child about importance of physical activity for flexibility, strength and health maintenance especially during growth years.
- Continue to monitor skin health and teach child to do so after activity.
- Ensure appropriate adaptive physical education occurs or special recreation sports (exploration of fitness opportunities phase).
- Educate about signs of skin breakdown, fracture, neurologic change.
- Ensure proper wheelchair fit, posture and technique to reduce energy expenditure and promote long term function.


Computerized analysis and modelling of patients with deformities of lower limbs.


Preliminary study of novel, timed walking tests for children with spina bifida or cerebral palsy. June 2016. SAGE Open Medicine Volume 4:1-8

Teen Age (12-17):

Clinical Questions:

- What is the role of gait analysis to monitor gait and improve it (assess joint torques and shear forces on joints)
• Should forearm crutches or KAFOs be used to protect the knee when valgus forces at knee may cause long term knee pain? When should they be instituted? Early to prevent damage or later to accommodate?
• What is the impact of scoliosis surgery on gait, transfers and wheeled mobility?
• What is the impact of (height) growth on walking ability?
• What factors lead youth to prefer wheeving vs walking? (energy efficiency, balance, speed) How does this impact integration and maintenance of walking skills?
• What is the “survival curve” for community walking by neurologic level? What are the main causes for loss of mobility? Pain, progressive weakness, growth, obesity are candidates.
• Are there benefits to standing devices ie: to maintain walking ROM, bone health, general well being?

Guidelines:

• Monitor neurologic level and strength (MMT chart) and changes over time. Monitor for gait changes, scoliosis, spasticity and bowel/bladder function change, FMS
• Monitor walking or wheeling ability with outcome measures (6MWT, TUG, Obstacle and Curb test, etc)
• Consolidation or practice of sports or fitness of developing preference
• Continue flexibility/ROM and strengthening to maintain mobility goals
• Verify that the teen knows how to check insensate skin especially after activity and how to ameliorate friction/pressure.
• Optimize gait with supportive orthotics or devices for balance, monitor for torque forces at knee or excessive forces in upper body
• Optimize Vitamin D and bone health
• Monitor for excess weight gain/adiposity
• There are benefits to ambulation and wheelchair mobility, teens may choose the mobility method that is most functional or reflects their needs and values.
• Monitor for secondary injury (knee valgus; consider brace or crutches, shoulder strength program for wheelchair or crutch mobility) and pain with walking.

The long-term outcome of patients treated operatively and non-operatively for scoliosis deformity secondary to spina bifida.


Levels of mobility in children and adolescents with spina bifida-clinical parameters predicting mobility and maintenance of these skills.


PMID: 23093438 Study done by Williams 1999: Walking at thoracic level is very rare-wheelchair

• L1/L2 level also has limited potential for long term ambulation mobility-wheelchair
• L3 has more ability to cont walking-mixed patterns
• L4/L5 fair/good walking-ambulation, wheelchair long distance
• Sacral all walk-wheelchair only for additional sports options

**Adult (18+ years):**

**Clinical Questions:**

- What is the “survival curve” for ambulation, transfers and wheeled mobility and what are causes for loss of mobility function? (ie: Pain, obesity, neurologic progression, aging/fitness)
- What are typical wheeling and walking distances by neurologic level?
- Is there a role for gait analysis to monitor gait and improve it (assess joint torques and shear forces on joints)?
- What is the role of forearm crutches or KAFOs to protect the knee when valgus forces at knee may cause long term knee pain?
- Are there benefits to standing in devices (limited literature; consider to maintain walking ROM), in adulthood? Is it cost/effort effective?
- What is the role of physical therapy and fitness programs in maintaining mobility? What has long term impact? Ie: improve technique, shoulder strengthening, fitness programs, etc.

**Guidelines:**

- Monitor neurologic level and strength (MMT chart) and changes over time. Monitor for gait changes, scoliosis, spasticity and bowel/bladder function change, FMS
- Monitor walking or wheeling ability with outcome measures (6MWT, TUG, etc)
- Continue practice of sports or fitness activity of preference
- Continue flexibility/ROM and strengthening to maintain mobility goals
- Optimize gait with supportive orthotics or devices for balance, monitor for torque forces at knee or excessive forces in upper body,
- Optimize wheeling technique and transfers techniques to reduce impact on upper limbs.
- Lightweight w/c, appropriate fit and technique, or assistive pushrims may help maintain wheeling ability and reduce upper limb maladaptive forces.
- Optimize Vitamin D and bone health
- Monitor for symptoms of secondary injury (knee valgus; consider brace or crutches, shoulder strength program for wheelchair or crutch mobility) that may impede mobility
- Educate on how to assess and obtain help when fit or function of assistive devices (orthoses, crutches or wheelchair) needs attention in adult care
- Educate on the importance of preventing loss of mobility through good technique, maintaining healthy strength and healthy weight (Anticipatory guidance)

Age-related walking in children with spina bifida. Ambulation potential into adulthood: Roach 2011

Clin Orthop Relat Res. 2011 May; 469(5): 1246–1252 PMCID: PMC3069297
Thirty-one percent were at the thoracic neurologic level (all used wheelchairs), 12% were at L1–L3 (all used a wheelchair except one), 33% were at L4–L5 (78% used a wheelchair at least part-time), and 24% were at S1 and below (all walked).

**Adult Consequences of Spina Bifida: A Cohort Study**

James W. Roach, MD, 1,2
Barbara F. Short, RN,3 and Hanna M. Saltzman4,5


**Evidence-Based Strategies for Preserving Mobility for Elderly and Aging Manual Wheelchair Users.**

- guidelines for preserving mobility function for MWC users, including prescriptions for ergonomics, equipment selection, user–wheelchair interface (wheelchair seating), propulsion and transfer techniques, and exercise prescription [162, 163]. The Consortium for Spinal Cord Medicine organized by the Paralyzed Veteran's Association (PVA) developed a guideline “Preservation of Upper Limb Function Following Spinal Cord Injury: A Clinical Practice Guideline for Health-Care Professionals” including transfer techniques
- NB: first author (PhD) has a number of papers on wheelchair technique


Upper extremity kinetics during Lofstrand crutch-assisted gait.

Requejo PS1, Wahl DP, Bontrager EL, Newsam CJ, Gronley JK, Mulroy SJ, Perry J.

**RESEARCH GAPS**

- What is the frequency of joint pain at the knees, wrists, shoulders that may affect maintaining gait?
- Need tools such as “GMFM-like” curves to know the trajectory of motor skills development.
- What factors improve energy efficiency of gait?
- What exercise/assistive devices are effective in reducing obesity?

**REFERENCES**

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Adolph, KE

- developmental milestones (U of Mich Bev Ulrich used Bayley Scales & will share data for hundreds of kids with SB, age 1-42 months)

- Adolph KE,
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