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| **Anterior vs. Posterior walkers for children with spastic cerebral palsy (CP)** | | | | |
| **Author/ Year** | **Purpose/Design/ Subjects** | **Protocol** | **Outcomes** | **Comments/ Important Background** |
| Low SA 2004  Comparison of Two support Walkers on the Gait and Mobility of a Child with Cerebral Palsy: a case report  *Poster abstract* | -The purpose of the study was to compare the use of a posterior and an anterior support walker on gait and mobility in a child with CP in the classroom and home.  -Case report, Subject: 12 yo male with CP | -The child switched to an anterior support walker from a posterior support walker secondary to growth  -GAITRite Walkway system was used to asses temporal and spatial parameters of gait  - Observational Gait Scale was used to determine gait quality  -Therapist and family preference was compared between walkers | -Ambulation with the anterior support walker resulted in improved trunk, hip, and knee flexion during gait.  -Ambulation with the anterior support walker resulted in improved heel/foot contact during phases of gait.  -Single and double limb stance time improved and foot progression angles improved when using the anterior support walker  -The therapist and family agreed in preference of the anterior support walker over the posterior support walker. | -It is unclear whether “improved flexion” means decreased or increased flexion at the hip, knee and trunk during gait.  -It is unclear whether stance times and foot angles decreased or increased using the anterior walker.  -These findings in one patient may not be generalizable |
| Lephart, et al 2014  Estimating Energy Expenditure for Different Assistive Devices in the School Setting | The purpose of the study was to compare the effect of ambulation with a posterior walker and with forearm crutches to determine effects on energy cost and academic performance in a child with spastic diplegia CP.  Case report: 9 year old both with spastic diplegia, level III on Gross Motor Function Classification Scale, left handed.  -At time of report- student used forearm crutches and bilateral AFOs in school and posterior walker during PE, recess and toileting | -8 sessions of 2 ambulation trials (forearm crutches and posterior walker, alternating order)  -Ambulate 55m, assess HR, point to exertion level and then complete academic tests  Measures:  -Energy Expenditure Index  - Pictorial Children’s Effort Rating Table  -Distal Finger control task for fine motor accuracy | -EEI was higher for posterior walker than crutches by 47%  -Fine motor accuracy was better after ambulating with posterior walker and the child took less time with the task  -The student was 4.4% slower when ambulating with forearm crutches compared to walker- may have been due to experience with the device  -Authors suggest since lower energy cost is more desirable- forearm crutches were recommended | -Children with CP spend 2-3x more energy ambulating that normal children  -Children with CP fatigue at low walking velocities- could affect academic performance.  -Goal of school based PT is to assist students in functional independence while conserving energy to allow for academic achievement  -Methods for determining energy expenditure: activity logs, questionnaires, HR, accelerometer  - EEI: calculated by subtracting the resting HR from the post walking HR and dividing the difference by walking speed  -Posterior walker may allow a child to use protective extension in falling forward |
| Park et al  2001  Comparison of Anterior and Posterior Walkers with respect to Gait parameters and Energy Expenditure of Children with Spastic Diplegic CP | -The aim of the study was to compare the effects of anterior and posterior walkers on gait parameters and O2 consumption rate in children with spastic diplegia CP. Authors wanted to determine if posterior walker use resulted in reduced energy expenditure for children with spastic diplegia CP.  -10 children average age 9.1 years (7-12). Each child was diagnosed with spastic diplegia CP an could ambulate with a walker independently  -Cross-sectional repeated measures observational study | -Used Pediatric Guardian walker and Kaye Posture Control two wheeled posterior walker with hinged AFOs and were given a month to practice with both walkers prior to the child  -Children ambulated for 5 minutes with each walker in a randomized order at a self-selected speed wearing hinged AFOs  -Vicon 370 gait analysis was used to examine gait parameters  -Energy expenditure was measured using KBI-C to determine O2 cost during the final 3 minutes of ambulation  -The data was analyzed using a Wilcoxon signed rank test. Statistical significance was set at p<0.05 | -Step length and single support time were significantly greater with posterior walker  - Double support time was significantly longer with Anterior walker  - Pelvic tilt was lower, hip flexion was smaller at initial contact and mid-stance and knee flexion angle at initial contact was significantly smaller with posterior walker (more upright position)  -Walking velocity and cadence were not significantly different  -O2 cost per min and average O2 consumption rate were significantly reduced with posterior walker use  -Authors concluded that reduced energy expenditure is desirable and a more upright position may require less effort so a posterior walker is more appropriate for children with spastic diplegia CP | -“Traditionally anterior walkers have been used however the child has a tendency to lean forward while pushing the walker. The posterior walker is advocated because it facilitates a more upright position and decreases double support time and increases walking speed.”  -“Extremely high heart rates and slow walking speeds have been recorded with children with CP during ambulation with walking aids”  -Small sample size |
| Gagnaire et al  2005  Growth Related Factors and Gait in Children with Cerebral Palsy  *Poster abstract* | -Hypothesis: age will be accompanied by BMI increases that are associated with decreased gait velocity and increased crouch in children with CP.  -32 children with CP who had orthopedic surgery and 398 children with baseline gait analysis  -Retrospective, longitudinal and cross-sectional Design | -Data about subject height, limb length, weight, gait velocity, assistive device use, mean knee flexion in stance and GMFCS score were used for analysis  -Data was analyzed using paired t-tests and backward step-wise regression | -32 children with surgical history:  -All had significantly increased BMI with age but no change in gait velocity.  -Significantly improved knee flexion in stance 5 years post-op when surgery was done at a young age.  -They had smaller changes in leg length and were more severely involved  -398 without surgical history:  - Increase in mean knee flexion predicted by slower velocity, longer leg length, increased level of severity and those who used an orthosis  - Factors of increased age, short stature, female, increased level of severity who used assistive devices and increased mean knee flexion in stance predicted decreased velocity  -BMI did not significantly impact crouch gait and velocity. Instead level of severity was most important. Age was significant only for velocity | -“The natural progression of children with CP is to walk more slowly with increasing crouch”  -“To maximize long-term outcomes of children with CP, PT should address determinants of crouch gait not associated with changes in BMI” |
| Kelly  2002  Oxygen Cost, Walking Speed, and perceived Exertion in Children with Cerebral Palsy when walking with anterior and posterior walkers | -The aim of the study was to determine differences in walking speed, energy cost, and perceived exertion when ambulating with anterior and posterior walkers in children with CP who were familiar with both devices  -n=10 mean age 11 (8-17 years) 7 with spastic diplegia and three with ataxic diplegia  -Subjects could walk with anterior or posterior walkers for 5 mins and had practiced with both in the previous 6 months.  -All children used assistive devices for ambulation- two children wore AFOs  -Cross-sectional repeated measures observational study | -Tests were conducted in schools.  -Subjects ambulated at self-selected speed on level ground in a 70m- circumference circle for four minutes with each walker in a randomly assigned order  - HR was measured  -O2 cost measured with argon diluted method using mixing box attached to a backpack carried by the child. Facemask captured the expired air and flexible tubing transported the air to the mixing box. Mass spectrometer analysis derived O2 cost.  -Subjects rated perceived exertion with words and face pictures labeled 1-5 | - One child ambulated at the same pace with both walkers, two walked slower and seven walked faster with posterior walker.  - No difference in HR increases with the two walking conditions  -No significant difference in O2 cost per minute or per meter between walker conditions.  -Seven children preferred the posterior walker. Three preferred the anterior walker.  -Authors suggest walking with an anterior walker or posterior walker had comparable physiological effects based on average heart rates, walking speeds, oxygen cost, and perceived exertion of the 10 children with CP.  -Results of this study indicate O2 cost is not different between walker conditions and so other factor such as alignment should be considered. For this population | -“The posterior walker fosters a more upright postural alignment than the anterior walker, which promotes forward flexion. Using any assistive device requires more oxygen per kilogram of body weight and per meter traveled compared with walking in healthy individuals”  -These subjects used a comparable amount of O2 to healthy children by walking at a slower pace. Implying if they attempted to keep pace with healthy children, they would increase O2 cost  -Small sample size |
| Levangie, Chimera, Johnston, Robinson, Wobeskya (1989)  The effects of posterior rolling walkers vs standard rolling walker on gait characteristics of children with spastic Cerebral Palsy | -The purposes of the study were 1) to examine the effects of an anterior walker with 2 wheels, a posterior rolling walker with 2 wheels, and a posterior rolling walker with 4 wheels and anti backward ratchets on ambulatory stability and mobility of children with CP and 2) to provide information to clinicians that might be useful in deciding on an assistive device for a young patient  -Subjects: 13 children ages 2-10 who had a diagnosis of predominately spastic CP and could use their assistive devices with minimal contact guarding.  -Cross-sectional repeated measures observational study | -Subjects were tested in schools in Boston, Eastern Massachusetts and Northern Rhode Island.  - Children ambulated along a 3x1.4m paper path with lines drawn 1/2m from each end with each walker type and inked moleskin on their feet, wearing AFOs if they typically wore them.  -Walkers were presented in randomized order and subjects completed one practice and one trial for each walker type.  --Footprint method of gait analysis was used to test velocity, cadence, stride and step length, BOS and angle of toe-out.  -Analyzed left and right stride length, step length, angle of toe-out, BOS, velocity and cadence of central 2m area between marked line. Velocity was recoded as the distance walked per second, cadence was steps per min  -One way ANOVA with repeated measures and Duncan Multiple Comparison Tests were used to analyze data for significance | - Velocity, left and right stride and left step length were significantly larger with PRW4 than PRW2 or SRW  -No other statistically significant differences were found between walker types and no differences were found between PRW2 or SRW (indicating position alone may not alter gait)  -Stride length increased but cadence was did not indicating stride length is more important for determining velocity in this population  -Minute conversion: PRW4 resulted in children covering 4.2 m/min greater than SRW and 3.6 m/min greater than PRW2 which could reduce daily energy expenditure and may allow a child to keep up with typically developing classmates better.  -The authors assume movement towards normal values is positive  -Footprint method documents changes but does not identify sources of change (trunk, pelvis, stance or swing changes) so combining with video data would be useful.  -It is unclear what long term changes would be seen with continued use of any particular walker type. | -“The anterior standard rolling walker frequently results in hip flexion and anterior trunk lean as the child leans forward to push the walker””  “The consequent anterior placement of the body’s line of gravity may lead to difficulty in forward progression”  “In comparison a more vertical postural alignment has been seen in children using a posterior rolling walker […] important to keep trunk over feet to facilitate forward motion” **SEE IMAGES**  -“Children with CP characteristically show decreased stride and step length, decreased angle of toe-out and decreased velocity and cadence compared to normal children”  -“Improving these values could be viewed as improved ambulatory mobility and a reflection of improvement in the ability to generate forward momentum.”  -“Since BOS reflects stability, a decrease in BOS with the use of a specific walker may indicate improved stability. It would also indicate less need for side-to-side displacement of the line of gravity as the child moves form one foot to the other and potentially, reduced energy expenditure.” |
| Logan, Byers-Hinkley and Ciccone (1990)  Anterior versus Posterior Walkers: a gait analysis study | -The aim of the study was to compare gait characteristics such as improved posture and gait pattern of children with developmental disabilities during ambulation with anterior and posterior walkers.  n=8 age 2.5-8 years. 7 with “moderate to severe CP” and one with Down syndrome  Each child typically ambulated with a walker.  -Cross-sectional repeated measures observational study | -Children ambulated along a 10-foot at a self-selected pace walkway typically 4-6 times with a two-wheeled Pediatric Guardian anterior walker and a two-wheeled Kaye Posture Control walker in a random order. Children wore their typical orthotics or walked barefoot if orthotics weren’t needed.  -Children were filmed in the sagittal plane and one representative pass was analyzed using Vanguard Motion Analyzer | - Film analyzed: stride length distance and time, gait velocity and percent of cycle spent in double limb support. Compared between walker conditions using a paired t-test  -Results indicated ambulation with a posterior walker significantly increased stride length by 41% and significantly decreased time spent in double limb support by 39%. Gait velocity differences were not statistically significant but children demonstrated increased velocity when using the posterior walker.  -One gait cycle analyzed for trunk hip and knee flexion at initial contact, mid-stance, pre-swing and mid-swing. Compared between walker conditions using a paired t-test.  -Results indicated children ambulated with decreased trunk flexion and decreased hip flexion throughout the cycle, reaching significance (p <0.05) for mid-stance, pre-swing and mid-swing. Knee flexion was also decreased with use of the posterior rolling walker but the value was not significant.  -Authors concluded ambulation with a posterior walker two-wheeled walker resulted in a more upright posture than ambulation with an anterior two-wheeled walker. | -The authors suggest decreased time in double support indicates increased stability  -Authors noted fewer instances of loss of balance or the child ambulating outside of the walker during posterior walker conditions  -It is possible ambulating with an anterior walker results in a more upright gait however it is unclear whether that gait is more energy efficient. |

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| **Anterior vs. Posterior walkers for children with lumbosacral level myelomeningocele (MMC)** | | | | |
| **Author/ Year** | **Purpose/Design/ Subjects** | **Protocol** | **Outcomes** | **Comments/ Important Background** |
| Williams 1999  Age-Related Walking in Children with Spina Bifida | -The purpose of the study was to determine the number of children who walked based on neurosegmental lesion level, the age walking began and the age walking ceased.  -n=173 Diagnoses: myelomeningocele (MMC), lipomeningocele, or intraspinal lipoma  - Retrospective, longitudinal and cross-sectional design | -Data from patients who visited the Royal Children’s Hospital in Melbourne Between 1978 and 1993 with three or more evaluations over three consecutive years was analyzed based on hospital records.  -Neurosegmental determined based on Broughton et al. (1993): Thoracic T10-T12, High lumbar, L1/2, Mid-lumbar L3, Low lumbar L4/5, Sacral as S1-S5 | -Average age of ambulation: T: 4yr 6 mo, (28/35 never walked), HL: 5yr 2 mo (5/10 never walked), ML: 5 yr (6/15 never walked), LL: 3yr 10 mo (7/45 never walked), S: 2 yr 2 mo (all walked)  -Some children ceased to walk, average age, T: N=3, 6yr 9 mo, HL: N=3 6 yr 11 mo, ML: N=3 7 yr, LL: N=5, 9 yr 1 mo  -Walking cessation may be due to rapid growth, which requires frequent brace changes, weight gain during puberty and spinal cord tethering increasing neurological deficit.  -Some delay in walking may happen regardless of the level of the lesion | -Community ambulator defined as complete ambulatory function with or without aids and braces and independent in brace donning  -Data analysis ended at age 9 so cessation data is likely incomplete |
| Ounpuu (2000)  An examination of the knee function during gait in children with myelomeningocele | -The purposes of the study were 1) to describe knee kinematic and kinetic characteristics to explore how trunk motion contributes to knee abnormalities in patients with L4, L5 and S1-2 MMC. 2) To examine the relationship between clinical visual recognition of knee valgus thrust and presence of knee adductor moment.  -37 pts aged 13 ± 9 years old and age matched controls  - Descriptive study using retrospective data and cross-sectional design | -Subjects were divided into groups based muscle function determined by 3/5 MMT and each side was analyzed independently:  -L4: functioning quadriceps, medial hamstrings and tibialis anterior  -L5: functioning quadriceps, medial hamstrings, tibialis anterior and hip abductors  -S1-2: functioning quadriceps, medial and lateral hamstrings, tibialis anterior, hip abductors, gluteus maximus and triceps surae  -Subjects ambulated at self-selected speed, barefoot, with reflective markers on a 10m walkway for multiple trials and were videotaped.  -Gait was examined visually and MMT was recoded along with tibial torsion measurements.  -VICON infrared cameras and Advanced Mechanical Technology Inc. force platforms were used to collect kinematic and kinetic data.  -Student’s *t* tests were used to assess the differences between means for within-group comparisons  -ANOVA one-factor design with Duncan’s post hoc testing was used to assess differences across groups for all significant findings  -Possible relationships between parameters were examined using Pearson correlations | -Mean flexion in stance was significantly greater and ROM was significantly decreased throughout the gait cycle for all groups with MMC.  - In L4 group, coronal trunk motion was 4x greater than motion of age mated controls L5 and S1 groups also demonstrated greater coronal trunk movement than controls  -Knee rotation was significantly greater than normal in all groups but greatest in L4  -Adductor moment was found in stance in 19/29 sides with L4 involvement and corresponded to a decrease in abductor strength  -Researchers were not successful in correctly identifying valgus visually in these patients  -Knee adductor moment may be linked to trunk motion- compensatory lateral trunk lean for hip abductor weakness  -Authors concluded forward progression during ambulation requires a dynamic set of compensatory movement throughout the trunk and lower extremities to overcome weakness. At higher levels of spinal involvement, the amount of compensatory motion in the trunk in the coronal, sagittal and transverse planes increases | Since higher levels of spinal involvement require compensatory motions to achieve forward progression, walker choice should allow for momentum. Reduced compensatory motion may achieve a less efficient gait  -Visual assessment of knee valgus should not be the only determination of KAFO prescription |
| Bare et al (2001)  Independent ambulators with high sacral myelomeningocele: the relation between walking kinematics and energy consumption | - The aim of the study was to quantify the gait kinematics in children with MMC with lumbosacral level involvement during independent ambulation and to analyze how those variables and varying walking velocities relate to energy expenditure compared to age-matched controls.  -n=14 average age 8 yrs 7mo (5-12) with high sacral MMC and 13 age-matched children without neuromuscular involvement  -Cross-sectional repeated measures observational study | -All subjects were tested for strength and range of motion of lower extremities using manual muscle testing.  -Subjects ambulated 6m at self-selected speed with thirteen retro-reflective markers in place. Children with MMC wore solid AFOs and all children ambulated without a device. Data was collected using a Vicon six-camera, three dimensional motion analysis system and analyzed using ANOVA  -Subjects with MMC ambulated on a treadmill and data were collected using the MedGraphics Pulmonary Diagnostic System with mouthpiece. Children ambulated at 75% age-matched self-selected speed, their own self-selected speed, 100% age-matched self-selected speed and 150% age-matched self-selected speed. Children were allowed to reach steady state and remain for 3 minutes at each interval.  -Data on O2 consumption and cost from 10 previously tested children without neuromuscular disorder were used for energy comparison.  -Energy expenditure data was analyzed using an ANOVA and paired t-tests  -Pearson product-moment correlation coefficients were used to analyze relationships between gait kinematic values and oxygen consumption and cost | - Subjects with MMC ambulated with significantly increased pelvic tilt range of motion, pelvic obliquity, pelvic rotation and hip ab/adduction compared to children without neuromuscular involvement.  - Subjects with MMC expended more energy than age matched controls when ambulating independently at a self-selected speed.  - When subjects with MMC ambulated at the pace of controls, they consumed more oxygen than at their self-selected pace.  -At a velocity greater than their self-selected speed, the children with high sacral-level MMC demonstrated more exaggerated gait kinematics than at their self-selected speed.  -Pelvic rotation and obliquity was significantly different for the subjects with MMC compared controls but the amount of excursion of whole-body center of mass was not significantly different between groups at self-selected speeds. Indicating portions of kinematics during gait may differ but the combined effect approximates a normal motion of COM. However O2 consumption is significantly greater. | - In order to successfully integrate children with high sacral level MMC into a community of children their age, it is important to address compensatory motions as a group to attempt to reduce energy expenditure. Changing just one compensatory motion without the others could in fact cause a greater change in their whole-body COM range of motion and further increase their energy expenditure. |
| Moen et al (2005)  Crouched gait in myelomeningocele: A comparison between degree of knee flexion contracture in the clinical examination and during gait | -The goal of the study was to quantify the amount of flexion during crouched gait in children with MMC and to compare that to clinical measures of contracture  - L4-L5 involvement (n=20 pts, 31 limbs, 17 amb with crutches, 3 with walkers mean age 11.0±3.7 yr) AFOs and device  - L5-S1 involvement (n=14 pts, 26 limbs age 11.2±4.3) AFOs, no device  -Cross-sectional repeated measures observational study | -Contracture was measured with clinical assessment used by Norkin and White (pt supine, neutral hip, max knee flexion  - Subject ambulated at self selected speed with reflective markers and Vicon 370 measured gait in hip, knee and ankle (checking knee flexion in initial contact, and min knee flexion in single limb stance)  -Calculated the difference between knee flexion contracture and knee flexion at IC and the difference between the contracture and knee flexion in single limb stance  -Percentage difference in knee flexion from knee flexion contracture was also calculated at IC and single limb stance | -Found significantly greater knee flexion during gait than knee flexion contracture on clinical examination  - Authors concluded computerized analysis may be important in analyzing these patients  -Authors also suggested functional status may be significantly different than static clinical exam suggests- typically worse  -Authors posit increased knee flex during gait increases O2 cost and is less efficient. | -Common problem for children with MMC is development of knee flexion contractures that results in a crouched gait which increases O2 consumption and O2 cost  -It may be important to chose a device that reduces knee flexion during gait to reduce O2 cost and consumption |
| Bartonek and Saraste (2001)  Factors Influencing Ambulation in Myelomeningocele: a cross-sectional study | -The aim of the study was to differentiate between the role of motor paresis and other possible causative factors influencing ambulatory function in children with MMC  -53 children in Sweden born between 1985 and 1992, mean age 7.6 (3.2-11.4)  -Cross-sectional design | -Assessed muscle function by MMT, spasticity, Joint contractures (in supine) and ROM, balance in standing or sitting, obesity, medical records  -Ambulatory function was assessed in relation to motor paresis of lower limbs.  -Orthoses were documented, physical effort during walking was assessed using the physical cost index (based on walking speed and heart rate) while children ambulated along 108m, and Functional mobility was determined using the PEDI and parent interviews  -Muscle function  -Level I and II (L5-S2) expected to community ambulate  -Level III and IV (L1-L4) household ambulation  -Level V (thoracic) non-functional ambulation.  (SEE CHART) | - All children had a higher PCI than that of non-disabled children, defined as .4 according to one source and 0.28 HB per meter walker  -In order to come up with a walking prognosis, the level of involvement has to be complemented with other data – spasticity in hips and knees significantly correlated to not achieving full walking potential, PCI was higher for all groups who did not ambulate than for those who did | -“Children with a similar level of motor paresis do not always develop similar ambulatory levels” |
| Darbee, Franks, and Palisano (1991)  The effect of walking with an assistive device and using a wheelchair on school performance in students with myelomeningocele | -The aim of the study was to examine the effect of walking with an assistive device and pushing a wheelchair (WC) on measures of school performance specifically reading fluency, visuomotor accuracy and manual dexterity in three students with MMC  -1 15 yo male, 1 10 yo female and 1 9 yo male from Wisconsin all with lumbar-level myelomeningocele able to walk with crutches or a walker and propel WC  - Subjects demonstrated a PCI>1.00 beats per meter while walking with crutches or a walker.  -PCI determined by subjects walking 200 m at maxi speed while HR was recorded every 25m using an Exersentry heart rate monitor and time was recorded using a stopwatch. | - Subjects used WC mobility at school for 1 week. Then switched to crutches or walker for one week. Then returned to WC mobility only for one week  -Data were collected daily for 3 weeks or until a total of 15 measurements for each dependent variable had been recorded.  -Students were accompanied from their classroom over a specific distance then academic tests were completed in random order  -A stopwatch was used to time the test activities.  -Three academic tasks:  -Reading fluency: measured using an audiocassette recording of the student reading a passage selected by the teacher. The oral reading was recorded.  -Visuomotor accuracy: Motor Accuracy Test- Revised. Trace a black line with dominant hand shaped like a butterfly with a red pen. Deviations are measured, recorded and multiplied by a constant based on the distance from the line. That value is subtracted from 200 for an accuracy score. Chosen to represent printing and writing skills.  -Manual dexterity: Purdue Pegboard Assembly subtest- one hand picks up peg and places it in the board, the other hand puts a washer on the peg then a cap and then another washer. Measures manual dexterity and speed-used to assess movements needed to perform industrial art and Home economics activities.  -Students were encouraged to follow directions and participate through a points system  -High interrater reliability was established as high for each activity  - Data were analyzed using the graphic presentation and visual analysis method described by Ottenbacher. | - Reading fluency was not significantly different between conditions  - Visuomotor accuracy was significantly lower with ambulation than with WC use in all three subjects.  - Subjects demonstrated significantly lower manual dexterity with ambulation compared to WC use  -Authors concluded ambulating with an assistive device, appeared to have an increased risk for poor school performance in activities requiring visuomotor coordination and the ability to comprehend printed detail.  -Limited because only used three subjects  -The authors suggest PTs and educators should be aware that increased energy consumption when ambulating with assistive devices may negatively affect educational performance. | -Children with lumbar level lesions are encouraged to use crutch walking but it has a high energy cost  -Fine motor skills, ability to concentrate, and visual perception have been found to be deficient in children with myelomeningocele  - Walking improves bowel and bladder function, prevent contractures and obesity, and increase bond density.  - To choose a mobility method at school, must take physical and academic factors into account. Academics must take precedence  -“Compared with normal walking, ambulation with assistive devices consumes more O2 per kilogram of body weight per meter traveled, independent of presence or absence of physical disability, type of disability, and age.”  -“Ambulation for the children with MMC was found to be 218% less energy efficient than that for nondisabled children. In contrast, WC propulsion was as fast and as energy efficient as normal walking.”  - Using WCs when transitioning in school may prevent excessive fatigue, thereby preserving energy for other activities.  -Walking for children with MMC may be equivalent to heavy exercise and may have compromise cognitive and fine motor performance, particularly in upper-elementary and middle school grades when walking speed and distance increase.  - A combination of assistive-device ambulation and WC may increase energy for school activities.  -PTs should help children with MMC participate in fitness programs to help maximize energy efficiency during ambulation with assistive devices. |
| Littlewood, Trocki, Shepherd, Shepherd and Davies (2003)  Resting Energy Expenditure and body position in children with myelomeningocele | -Aims of the study were to determine energy expenditure at rest and overall in children with spina bifida (SB), to determine body composition to determine if resting energy expenditure can be predicted using current predictive equations for this population.  -n=19 mean age=8.9 (3.3-16.8)  -Divided descriptively by neural level- Sacral-L5 were considered community ambulators, L4 functional ambulators and L3 and above non-functional ambulators | -Height (mm) determined using a stadiometer; weight (kg) measured by chair scales. H/W percentiles assessed using National Center for Health Statistics percentile growth charts  -Body composition: Total body potassium (found almost exclusively in muscle so a depletion indicates reduced muscle mass) was measured by a whole body counter. Measures were compared to values for normal children. Two measurements were taken. Significant muscle depletion was indicated as TBK for height <90% of expected for age and gender.  -Energy expenditure measured using indirect calorimetry with an open circuit ventilation canopy.  -Predicted REE were calculated using a Schofield Weight and age and WHO equations. TEE was calculated from a 3-day activity record of type and intensity of activities.  -Energy Intake was determined using 3-day food diaries kept by children and parents and then analyzed using the foodworks program | -Bland and Altman analysis were used to compare measured and predicted energy expenditure, P values,0.05 were considered significant. Two tailed paired t test was used to determine significant  -Subjects were average weight and height for age but using body composition measures, 14/19 were considered obese (<90% of expected TBK for height, weight or age for gender)  -Subjects had lower TBK than was expected. 11/19 had <90% of expected TBK for height. Measured TBK for height was 78.9± 24.1% of normal. All 19 children had <90% TBK for weight, mean 67.3±14.3%. 13/19 had <90% TBK for age mean value, 70.2±24.6%  - Mean REE was lower but not significant for all subjects compared to predicted values but there was a large variation in values 45.8%-125.7%  -7 participants returned activity and food logs, TEE was very low compared to normal children  -Energy intake was high compared to expenditure. Intake was equal to amount recommended for typical children but the expenditure was low.  -Authors suggest the results indicated the children were consuming more than was needed which may contribute to obesity.  -Children with MMC had increased percent body fat and decreased percent muscle mass compared to typical children of the same age.  -Authors posit the wide range of REE values suggest predictive equations may not be appropriate. | -The study used a small sample size and had low power  -Measures for energy expenditure and uptake were less invasive and more imprecise than other techniques  -The constancy of potassium in free fat mass in children with MMC is unknown so body composition results may be skewed.  -Caution should be used when altering caloric intake as food is needed to allow for growth.  -This study indicates predictive equations for energy expenditure are inappropriate and inaccurate for patients with MMC. Using them could lead to recommending food intake above energy needs. |
| Levangie et al. (1989)  The effects of the standard rolling walker and two posterior rolling walkers on gait variables of normal children | -The aim of the study was to describe gait variables in normal children ambulating without an assistive device, with a standard, two-wheeled, anteriorly placed rolling walker, with a two-wheel, posteriorly placed rolling walker and with a four-wheeled, posteriorly placed rolling walker at a self-selected speed to determine which assistive device most approximated normal gait and to quantify changes in gait with the assistive devices.  -Researchers hypothesized in normal children, gait characteristics would not differ between unassisted and assistive device ambulation conditions at self-selected speed. They also hypothesized that gait characteristics would not differ in normal children between assistive device conditions.  -n=20 age 6-8, no neuro involvement  -Descriptive, cross-sectional, repeated measures design with no control group. | -Subjects were tested in a school in Bedford, Massachusetts.  - Children ambulated along a 6m paper path without an assistive device and then with each walker type and inked moleskin on their feet  -Walkers were presented in randomized order and subjects completed one practice and one trial for each walker type. Each trial was timed  --Footprint method of gait analysis was used to test velocity, cadence, stride and step length, BOS and angle of toe-out.  -Analyzed left and right stride length, step length, angle of toe-out, BOS, velocity and cadence of central 2m area between marked line. Velocity was recoded as the distance walked per second, cadence was steps per min  -MANOVA with repeated measures and Duncan Multiple Comparison Tests were used to analyze data for significance | - Using any of the walkers changed the gait of normally developing children in all variables except toe angle  - The values of stride length and right step length in the PRW4 condition were closest to the values of the unassisted gate condition.  - Regardless of walker position, the frame results in a shortened stride length.  - Regardless of walker position, decreased base of support are consistent with the purpose of the walker in increasing medial-lateral support with the frame.  - Authors suggest clinicians should not expect a patient with involvement to ambulate similarly to normal peers without assistive devices when using a walker.  - The authors further suggest as PRW4 most approximated unassisted gait in this population and the SRW deviated most from unassisted gait, the PRW4 may be the better choice clinically.  - Even typically developing children without impairment will experience altered gait when ambulating for the first time with any of the three walkers. These differences between assisted gait and unassisted gait were statistically significant for each device indicating a “natural” gait is unlikely regardless of which device is chosen. Each device caused the children to take shorter steps, ambulate with less velocity, and to take fewer steps per minute. | -It is unclear how gait would have altered with continued walker use.  -It is unclear how the results would have changed if a four-wheeled anterior rolling walker had been tested |

Energy Testing

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| **Author/ Year** | **Information** |
| Lephart, et al (2014)  Estimating Energy Expenditure for Different Assistive Devices in the School Setting  \*Case report | - Can use EEI to measure energy  - Based on oxygen uptake and heart rate.  - Calculated by subtracting the resting heart rate from the post walking heart rate (after ambulating 55 m) and then dividing the difference by walking speed  -EEI has reliability coefficient: 0.81-0.94 at comfortable and fast walking speeds. Concurrent validity of EEI and O2 consumption of children with CP (r=0.61)  \*Use with posture and safety to determine appropriate device use and to compare devices  -“Physical therapists working in schools have the responsibility to understand the amount of energy a child with CP may expend when ambulating in school using and assistive device  PT thoughts:   1. Should an AD require less energy expenditure, that would be preferred to conserve energy for educational tasks 2. Should ambulation with an AD be faster than another, that would be appropriate for an IEP goal to keep pace with peers 3. Should use of an AD have a lesser effect on legibility or accuracy of fine motor tasks then that would be more appropriate |
| David and Sullivan (2005)  Expectations for Walking Speeds: Standards for Students in Elementary Schools | -School based PTs should consider environmental and task variables when making decisions about individual student accommodations or planning interventions  -The IEP team should consider 1) the student can move at the same speed as peers therefore, no accommodation is needed. 2) The student will not be able to independently move at a speed “good enough” to keep up with his or her peers in the halls; therefore another person will have to assist the student to move independently but too slowly to keep up with his or her peers. 3) The student may need an IEP goal related to mobility and PT intervention to improve his or her speed  -Collected direct observational data of walking speeds in elementary school hallways for 367 classes and collected data from 290 teachers on what a slower but ‘good enough’ speed would be if they had to slow to accommodate a student with a mobility limitation.  -Hypothesized speeds would change for different grades and PTs can aim for ‘good enough’ speed  -PTs measured the time it took for the first student in line to ambulate 50ft  - Mean walking speeds by grade: K=3.7ft/s, 1=3.8ft/s, 2=4.0ft/s, 3=4.1ft/s, 4=4.3ft/s, 5=4.6 ft/s, 6=4.7 ft/s  -For “good enough” the teacher walked as slowly as they would be willing to go and were timed over 50ft  -Mean walking speeds for teachers by grade: K=2.6ft/s 1= 2.3 ft/s 2=2.3 ft/s 3=2.1ft/s 4= 2.5ft/s 5= 2.9ft/s 6= 2.9ft/s- many teachers had a difficult time going this slowly  -Many teachers were at the front of the line demonstrating a high degree of influence on class speed  -‘Good enough’ times were highly variable and a teacher’s attitude could affect a child’s participation. The times were slow enough that a child with a disability might be able to participate  - When choosing an assistive device the goal should be the “good enough” time. IF students are unable to achieve that speed of walking, wheeled mobility should be considered.  -The authors posit participation may be more important than independence.  -Finally authors suggest PT goals should not be based on achieving a normal gait pattern but instead goals should be focused on achieving the highest level of participation. |
| Bartonek and Saraste (2001)  Factors Influencing Ambulation in Myelomeningocele: a cross-sectional study | Physical cost index based on walking speed and heart rate   * Children sit quietly for 5 minutes to obtain steady state resting heart rate. * Children walk as fast as possible along 108m hallway, recording HR at 6m intervals   PCI Calculated:  PCI (heart rate/m)=walking HR-resting HR (bpm)  Average walking speed m/min  -PCI calculation assumes HR reaches steady state during exercise but for children with more severe involvement, HR continues to rise |
| Low, McCoy, Beling, Adams (2011)  Pediatric Physical Therapists’ Use of Support Walkers for Children with Disabilities: A Nationwide Survey | -The purpose of this study was to document that SWs are being used by PPTs for children with disabilities through a national survey  - 8-page survey was developed and randomly mailed to 2500 members of the pediatric section members of the APTA. 513 surveys were returned  - Comments from open ended questions were coded and grouped  -“Support walker” was used to describe any mobility device used with children who need more support than a hand-held walker, including some manner of trunk, forearm and or pelvic support. Most have four wheels with a breaking system and are round or square to surround the child. Attachments can be added to improve positioning.  -Support walkers are used to create opportunities to practice functional movement in a safe, task-oriented manner  - Under the IDEA and DME under insurance plans, support walkers are considered assistive technology  -“Parents and educators promote the use of SWs in school and at home to assist in ambulation and exercise”  -PTs should assess posture, alignment and gait while using a support walker in various settings. PTs must also take family, classroom staff and student preferences into account.  - A group of researchers developed the Supported Walker Ambulation Performance Scale (SWAPS) an outcome measure to assess gait of children with CP before they become independent walkers: degree of support, posture, quality of steps, quantity of steps. (lacks evidence)  Results:  -9 most commonly used SWs in descending order: Rifton pacer Gait Trainer, Kaye PWB suspension, Litegait, Pony, Gator, Croc, Bronco, Mulholland Walkabout and Mae Walker (others: Up and Go walker, Hart Walker, and Bugsy Walker)  -Most commonly recommended with children with Spastic CP, Ataxic CP, Dyskinetic CP, Developmental Delay, Spina Bifida, spinal cord injury and pediatric orthopedic disorders   * -Order of importance of impairments considered in selection: weakness, motor control, poor balance, posture, hypertonia, gait pattern, hypotonia, cognitive status, and range of motion deficits.   -Physiologic factors ranked in order of importance for selecting SW: hip development, respiratory status, cardiovascular status, bone density, peripheral circulation, pressure relief, GI function and renal function  -When asked to rank the most important criteria for the selection of a particular SW, clinical assessment, then time a child could spend in a SW, current evidence, funding by agency, time to adjust SW, agency’s access to a particular type of SW and vendors supply of the SW  -Family’s concerns in selection of SW are also important: parent preference, family’s ability to adjust/maintain device, child’s preference, family’s financial resources.  -SWs were reported to be used posteriorly 65% of the time and anteriorly 53% of the time  -Accessories most used were trunk prompts, forearm supports, pelvic seat or sling and anti-scissoring systems  -Therapist reported needing time for trial: 1 month, 2 weeks, 1 week, 1 day with a minimum of 9 sessions needed to train, 6-8, 3-5, 1-2  -PTs reported SWs are use primarily for mobility and exercise. Activities that facilitated functional gains included interaction with pears, participation in school, performing activities of daily living at school, performing ADLs at school, participation in community, ADLs at home, participation in play.  -Most clinicians reassess the use of a SW every PT visit  - PTs reported few children use a SW for more than 2 yrs  -Reported factors for success: GMFCS level, motivation to walk, cognitive level, family support, positioning, unweighting, therapist training and practice.  -Considerations in Clinical Decision making: Clinical picture includes “examination of child’s impairments and physiologic functioning, an evaluation of the child’s cognitive status and motivation, age and diagnosis, unique needs, and ability of the family and child’s ability to participate in age-related activities.  -“Strength, motor control, balance and endurance are required for good postural control and independent gait.”  -Why anterior or posterior is chosen is unclear  -Tells why PTs think they are making choices but there may be “no direct evidence to guide them”  -“Studies are needed to investigate the effect of SWs on gait, mobility, ADLs, and participation using focused, reliable and valid assessment tools and outcomes” |
| Darbee, Franks, and Palisano (1991)  The effect of walking with an assistive device and using a wheelchair on school performance in students with myelomeningocele | -The physiological cost index (PCI) is a reliable measure of energy efficiency in walking that is based on the linear relationship of heart rate to [Vo.sub.2] and work. The PCI is calculated by dividing the increase in heart rate attributable to walking by the sped of walking and is expressed in beats per meter. Butler et al reported a mean PCI of 0.40 beats per meter for children without motor problems as compared with PCIs greater than 1.00 beats per meter for children with physical disabilities.  -In this study, the PCI was found to be a clinically feasible measure. The authors recommend including the PCI as part of a physical therapy assessment for children who walk with assistive devices, because it provides a measure of a child's energy cost while walking. The PCI may be useful in documenting the effectiveness of fitness programs. A high PCI can alert a therapist that the student is using excessive energy and that school performance may be at risk. |

Information for Background

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| **Author/ Year** | **Information** |
| O’Neal et al  2006  Physical Therapy Clinical Management Recommendations for Children with Cerebral palsy-Spastic Diplegia: Achieving Functional Mobility outcomes | -“CP is a neurodevelopmental condition that begins in infancy or early childhood and is present through the lifespan. CP is the most frequently reported diagnosis for children who receive physical therapy. Spastic CP is the most common type of CP and includes diplegia and hemiplegia. Spastic diplegia is characterized by increased stiffness in the lower extremities, minimal involvement in the upper extremities and trunk weakness.”  -These children may fall under Practice Pattern 5C: Impaired motor function and sensory integrity associated with non-progressive disorders of the central nervous system- congenital origin or acquired in infancy or childhood.  Examination Considerations for children age 5-12   * Where   + Consider family preference, child’s age, type of service delivery and any programs the child may be enrolled in. Settings could include school, hospital, outpatient or community location   + Under IDEA part B PT exams should take place outside the home unless home-based services are warranted (age 3-5 in preschool or community, 6-21 in school)   + Under IDEA Part B examinations in the school may be done every year but are required every 3 and written family permission is required (age 3-21) * What   + Examination must include Pt history, systems review and tests and measures * How   + Use a systematic child and family interview and chart review to determine mobility skills and health status. Important medical information includes past surgeries, spasticity management interventions, medications, review of any hip and spine x-rays and gait studies. Important social/developmental/educational information includes family and child’s experiences and expectations and a child’s placement and participation in the community or school settings.   Tests and Measures   * *Participation:* Involvement in life situations or ability to engage in community activities   + Considerations: observe daily mobility routines, coordinate with other providers to identify limitations, identify barriers. Birth-12 years, observe play and caregiver-child interactions in environments, observe teacher-child and peer interactions * *Activity*: task performance like floor mobility, wheelchair mobility and/or ambulation   + Considerations: identify how assistive devices and orthoses influence mobility and task performance and consider clinical gait analysis to identify temporal parameters * *Body Structure and Function*: refers to physiological functions of the body and anatomical structure   + Musculoskeletal System     - ROM: active and passive with goniometry and clinical observation, consider specific testing for joint motions and muscles (hip abduction with knees flexed and extended, hip extension with knee extended and flexed, knee extension with hip flexion, ankle dorsiflexion with knees flexed and extended     - Strength Testing: observe the child during age appropriate functional movements with gravity eliminated and against gravity (rolling, kicking, reaching, crawling, high kneeling, squatting, walking and climbing). Kids 3-5: consider MMT or assess functional muscle strength, conduct a full LE test and screen UEs, check trunk strength to determine flex and ext against gravity an isolated trunk movements. Kids 6-21: use MMT and observe functional context     - Alignment and Posture: Preschoolers: observe for postural symmetry, test for hip joint integrity, LE alignment, LLD. 6-21 yo: conduct scoliosis and LE alignment screening and test for LLD     - Growth: all ages are at risk for poor nutrition- conduct measures (head circumference, height, weight and calculation of BMI)   + Neuromuscular System     - Balance: clinical observation of static and dynamic balance, reactive and anticipatory control during functional activities (reaching, playing in sitting, moving from floor to stand, walking)     - Sensory: clinical observation of reactions to tactile, auditory, visual and vestibular stimuli     - Motor Function: clinical observation and/or video analysis of movement patterns during functional tasks     - Muscle Tone: determine hypertonicity, hypotonicity, or dystonia. Consider Modified Ashworth Scale.   + Cardiopulmonary System     - Endurance, pulmonary function, cardiac function: check fatigue, RR, color changes, HR, and blood pressure   + Integumentary System: document orthoses wearing schedule, any irritations, and characteristics.   + Medical Status: Physical environment; Communication/Behavior, Family/Culture systems: get PMH, and document all findings related to communication, safety, environment, and medical events   -Specific Considerations for POC and frequency/duration of services: 3-12 yo: PT is a related service in School setting and is provided in that setting to allow *access and participation in education setting*. Frequency/duration is decided by IEP team  -Outcomes: GMFCS has five levels, typically children with spastic diplegia are I, II or III.   * Level I will likely walk without restrictions * Level II: will walk without assistive devices and will have limitations outside and in the community * Level III: will walk with an AD and will have limitations outside and in the community * Level IV: power mobility * Level V: dependent for mobility   -Age 3-5 outcomes may include: Independent household mobility/ambulation, Independent age appropriate transitions and transfers, prevention of 2nd limitations  -Age 6-12 outcomes may include: Independent classroom ambulation w or w/o AD, Independent community amb., Independent bus entry and exit, Independent toileting, age appropriate transfer/transitions, Independent stair navigation, Independent playground use, prevention of deformity/pain, development of self-advocacy.  Intervention   * Coordination, communication and documentation should ensure high-quality coordinated care * Patient-related instruction   + Educate about home management, disease process, and transitions through various health care systems * Procedural Interventions   + Address limitations in body and or environmental systems to improve functional mobility, increase participation, adapt situations to meet child’s needs, and address systems that may limit functional mobility goals   + Musculoskeletal and Neuromuscular systems (include strength, ROM, alignment and posture, balance, motor function, tone and movement patterns)     - Consider motor learning principles like varying practice schedules, verbal, manual, visual and auditory cues     - Strengthening:       * 3-5 years: play therapy       * 6-21:play or direct resistive exercises- 2-3x per week 6-10 weeks at 65% of max isometric strength, should improve balance and gait     - Stretching       * 3-5: stretch through positioning, ROM and function- increases in hamstring length may improve temporal patterns during gait of semitendinosus and Vastus lateralis       * 6-21: teach self ROM     - Functional activities: floor mobility, posture, transitions, mobility on varied surfaces     - Treadmill walking, orthoses, EMG during gait for biofeedback and e-stim for coordination     - Can encourage kids to have a movement practice schedule * Cardiopulmonary System   + Children with CP are considerably less active than their peers   + Lower activity levels increase risk for weight gain and impairments that will lead to loss of functional mobility * Integumentary system   + Check for growth spurts of poor fitting of orthoses * Physical Environment   + Check family home environment (home visit), school and transportation issues, equipment considerations to improve alignment, ROM and functional mobility   + Teach device self-management, decide on modifications etc.   + “For children who need a walker, consider a posterior rolling walker which may have the advantage of facilitating upright positioning, increased gait velocity, and decreased double stance time compared to anterior walkers”   + Growth and environmental changes may warrant modification or a new device * Bone density: reduced ambulation can contribute to decreased bone density   Always Re-examine (also info on specific interventions) |