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| **CRITICALLY APPRAISED TOPIC** |

**FOCUSED CLINICAL QUESTION**

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| In a child with cerebral palsy, is an anterior walker more effective than a posterior walker in improving upright posture (measured by decreased hip and trunk flexion), gait parameters (such as cadence, walking velocity, stride and step length, single and double support/stance time) and energy efficiency (measured by oxygen consumption)? |

**AUTHOR**

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**CLINICAL SCENARIO**

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| A 16-year-old male with spastic diplegic cerebral palsy (CP) was in need of a new walker. His physical therapist had him practice over a period of two weeks with both an anterior walker and a posterior walker in various environments. After analyzing his gait with each walker and asking which type he preferred, a walker was chosen. Walkers are commonly prescribed in children with cerebral palsy because many have difficulty with ambulation due to abnormal muscle tone, impaired balance, equilibrium reactions, and postural stability.1,2 The type of walker chosen for a child, either anterior or posterior, is typically a subjective decision, based upon observation of the child by their physical therapist.2,3 Objective data regarding energy expenditure, postural alignment, and gait parameters could be beneficial for determining which walker type is more effective for a child, as all these factors can have significant impacts on the day-to-day life of a child with cerebral palsy. However, most therapy settings do not have the means by which to test these outcomes. Therefore, although it is not practical to assess these objective measures in daily practice, it is important for pediatric therapists to be aware of current research regarding this topic and incorporate that knowledge into clinical decisions. |

**SUMMARY OF SEARCH**

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| A total of 10 studies were selected that met the inclusion and exclusion criteria. All studies were observational studies with single-group, repeated measures design in which subjects are exposed to at least two conditions. Three of these studies were reviewed and discussed in detail.  Evidence from the three highest quality studies:   * For a child with spastic diplegic cerebral palsy, the posterior walker is more effective than the anterior walker in facilitating upright posture, reducing energy expenditure, increasing step length, and decreasing single and double support time during gait. There was a trend towards higher velocity and cadence while using the PW, but these values were not statistically significant. * The use of a posterior walker in children with spastic diplegic CP results in statistically and clinically significant increases in walking velocity, improved gait posture, and decreased double stance time, as compared to an anterior walker. Subjectively, both parents and children also preferred the posterior over the anterior walker. * For a child with cerebral palsy, anterior and posterior walkers are equivalent in terms of objective measurements of oxygen cost, walking speed, and perceived exertion. It is questionable whether there were any clinically relevant improvements. Even with no significant difference in objective data, 70% of subjects preferred using the PW. |

**CLINICAL BOTTOM LINE**

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| Current best evidence suggests that when compared to anterior walkers, posterior walkers can be more effective in facilitating upright posture, increasing walking velocity, and decreasing energy expenditure. This trend in objective data can be helpful for pediatric physical therapists trying to incorporate evidence into clinical decisions they must make regarding walker types for children with CP. Further research of high methodological quality that is more recent is needed to address key differences in samples, such as the use of an AFO, as well as larger sample sizes that will be able to detect differences in the observed effect sizes for all outcomes. |

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| ***This critically appraised topic has been individually prepared as part of a course requirement and has been peer-reviewed by one other independent course instructor*** |

**SEARCH STRATEGY**

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| **Terms used to guide the search strategy** | | | |
| **P**atient/Client Group | **I**ntervention (or Assessment) | **C**omparison | **O**utcome(s) |
| “cerebral palsy”  Hemipleg\*  Dipleg\*  Spastic\* | “Anterior walker”  “Anterior walkers” | “Posterior walker”  “Posterior walkers” | Posture  “postural control”  Gait  Walk\*  “gait characteristics”  Parameter  Parameters  “energy efficiency”  “energy expenditure”  “oxygen consumption” |

**Final search strategy:**

**Pubmed**:

1. Cerebral palsy[MeSH]
2. “anterior walker” OR “anterior walkers”
3. “posterior walker” OR “posterior walkers”
4. posture OR “postural control”
5. #1 AND #2 AND #3 AND #4
6. walker OR walkers
7. **#1 AND #4 AND #6**

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| **Databases and Sites Searched** | **Number of results** | **Limits applied, revised number of results (if applicable)** |
| Pubmed | 2  19 | The first search strategy (#5) yielded 2 results, so the search was broadened by not specifying anterior vs. posterior walker (see #7), which resulted in 19 articles. |
| CINAHL | 5  2 | The next search started with strategy #7 but ended up with fewer results than the Pubmed search. This search was revised by replacing (posture OR “postural control”) with “gait characteristics” in order to find articles with different outcomes that still addressed the PICO question. This search produced 2 results not found in the Pubmed search, of which 1 was relevant to the PICO question. |
| Web of Science | 8  7 | Search strategy #7 was again used and yielded 8 results. One article from this search was relevant and had not yet been found from previous searches in Pubmed and CINAHL. The search was refined by replacing (posture OR “postural control”) with “energy expenditure” and resulted in 7 articles, of which 6 were relevant to the PICO question. |

## INCLUSION and EXCLUSION CRITERIA

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| **Inclusion Criteria** |
| * Studied a population of children (up to 21 years old). * Published in English. * Published up to September 2016. * Include only subjects that were familiar with anterior walker, posterior walker, or both. |
| **Exclusion Criteria** |
| * Studies that include adults in the study sample. * Studies that focus on other assistive devices, such as canes or loftstrand crutches, instead of anterior or posterior walkers. |

**RESULTS OF SEARCH**

A total of 10 relevant studies were located and categorized as shown in the following table(based on Levels of Evidence, U.S. Department of Health and Human Services, 2006)4 using a modified Downs & Black checklist for assessment of methodological quality of randomized and non-randomized studies.5

**Summary of articles retrieved that met inclusion and exclusion criteria**

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| **Author (Year)** | **Study quality score: modified Downs & Black (reporting section only)** | **Level of Evidence** | **Study design** |
| Park ES, Park CI, Kim JY (2001)6 | 10/11 | Level 3 | Single group of patients tested with anterior and posterior walkers in random order |
| Mattsson E, Andersson C (1997)7 | 8/11 | Level 3 | Single group of patients tested with anterior and posterior walkers in random order |
| Logan L, Byers-hinkley K, Ciccone CD (1990)8 | 8/11 | Level 3 | Single group of patients tested with anterior and posterior walkers in random order |
| Strifling KM, Lu N, Wang M, et al. (2008)1 | 10/11 | Level 3 | Single group of patients tested with posterior then anterior walker after at least 1 month of acclimation |
| Bachschmidt R, Harris GF, Ackman J, Hassani S, Carter M, Caudill A, et al. (2000)2 | 7/11 | Level 3 | Single group of patients with multiple baseline, training/use period, then multiple post assessment |
| Konop KA, Strifling KM, Wang M, et al. (*Acta Orthop Traumatol Turc*, 2009)9 | 10/11 | Level 3 | Single-group design with initial gait analysis with usual walker, 30 days use of alternate walker, followed by gait analysis with alternate walker |
| Greiner BM, Czerniecki JM, Deitz JC (1993)10 | 10/11 | Level 3 | Single group of patients tested with unfamiliar walker after week of training, then tested with typically-used walker |
| Rose J, Medeiros JM, Parker R (1985)3 | 8/11 | Level 3 | Single group of patients tested with wheeled walker and quad cane in random order |
| Levangie PK, Brouwer J, McKeen S, Parker K, Shelby K (1989)11 | 10/11 | Level 3 | Single group of patients tested with anterior, two-wheeled posterior and four-wheeled posterior walkers in random order |
| Konop KA, Strifling KM, Wang M, et al. (*Gait Posture*,2009)12 | 10/11 | Level 3 | Single group of patients with initial gait analysis with usual walker, followed by gait analysis with alternate walker after at least 30 days of acclimation with alternate walker |

**BEST EVIDENCE**

The following 3 studies were identified as the ‘best’ evidence and selected for critical appraisal. Reasons for selecting these studies were:

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| * **Park ES, Park CI, Kim JY (2001)6:** This study was given a score of 10/11 on a modified Downs & Black checklist, which focused on the reporting section (items 1-10). The study clearly describes subject characteristics, interventions of interest, and all main findings.Another strength was that the subjects were randomly allocated to order of treatment. There was no loss of subjects, meaning outcome measures were taken from all subjects and results were analyzed as well as compared. Even though this study had a small sample size, it was chosen as one of the best for critical appraisal because it addresses all 3 outcomes of the PICO question: upright posture (trunk, hip and knee flexion angles), gait parameters (velocity, cadence, step length, single support time, double support time) and energy expenditure (oxygen cost and consumption). * **Greiner, BM, Czerniecki JM, Deitz JC (1993)10:** This study tied for the highest score on the modified Downs & Black checklist at 10/11. On paper this study represents some of the highest quality evidence. Its weaknesses were lack of randomization and blinding altogether, however it used valid and reliable outcome measures, as well as appropriate statistical tests to assess those outcomes, helping its internal validity. There was very good reporting, as the study described in detail all of the objectives, measurement outcomes, subjects, and results. This study was also very relevant to the PICO question, as the sample consisted of children with spastic diplegic CP, and tested trunk, hip and knee angles, step length, walking speed, and double stance time. This study may also help with clinical application of the question since parents and children filled out questionnaires regarding their thoughts on the anterior and posterior walkers. * **Mattsson E, Andersson C (1997)7:** This study received a score of 8/11 on the modified Downs & Black checklist, meaning it’s reporting was weaker than the first two studies. The study gave mean or median values and a range for all outcomes, but did not report standard deviations, confidence intervals or p-values. One limitation of this study was the variability in the sample regarding prognostic indicators. Three of the subjects had ataxic diplegia and seven had spastic diplegia. The child for whom the PICO question is geared towards has spastic diplegia, so it would be preferable for the sample to consist of all children with that diagnosis. However, spastic diplegic CP was not specified in the PICO question or in the inclusion criteria, and there were no other higher quality studies from the search whose sample consisted solely of children with spastic diplegic CP. This study was also chosen because it measured walking speed, spasticity, oxygen cost, heart rate, and perceived exertion, which made it very relevant to the PICO question.   *Rationale for why other studies were not chosen:*   * The article by Logan, Byers-hinkley and Ciccone “Anterior versus posterior walkers: a gait analysis study” was very relevant to the PICO question, providing outcomes for trunk, hip, and knee flexion angles during ambulation (indicating posture) and gait parameters (stride length, gait cycle spent in double support, and gait velocity). It also had a fairly good quality assessment score of 8/11 on the modified Downs & Black checklist like the Mattsson et al. study. The reason it wasn’t chosen as one of the 3 studies was because the subject sample included 7 children with CP and one with Down syndrome, and the PICO question specifies a child with CP. The results in this study are stated as averages, so there was no way to exclude the results of the child with Down syndrome in order to perform a separate analysis of the effect of anterior versus posterior walkers on only the subjects with CP. * A few of the other studies were not chosen due to their focus on upper extremity kinetics as a primary outcome. In each of these, at least one outcome of the study addressed part of the PICO question, however that was usually not the main purpose of the study. The three studies chosen all directly answered parts, if not all, of the clinical question. |

**SUMMARY OF BEST EVIDENCE**

**(1) Description and appraisal of “Comparison of Anterior and Posterior Walkers with Respect to Gait Parameters and Energy Expenditure of Children with Spastic Diplegic Cerebral Palsy” by Park ES, Park CI, & Kim JY (2001)6**

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| **Aim/Objective of the Study:** |
| The purpose of this study was to determine whether an anterior or posterior walker should be recommended for children with spastic diplegic cerebral palsy based on the comparison of energy consumption and gait pattern while using each walking aid, with a particular interest in determining if posterior walkers reduce energy expenditure. |
| **Study Design** |
| Single group of patients tested with both walkers in random order.  Subjects practiced with both anterior and posterior walkers under a PT for 1 month before testing to allow familiarization before the evaluation. Subjects were tested once with each walker in random order, with a 15 minute rest break after each trial to allow their heart rates to return to basal level; no follow-up. |
| **Setting** |
| The setting was not specified, but it appears to be conducted in an academic research lab at the Department of Rehabilitation Medicine at Yonsei University College of Medicine in Seoul, Korea. |
| **Participants** |
| N=10 (6 males, 4 females). No dropouts.  Mean age: 9.1 years old (range: 7-12 years). Mean height: 123cm (range: 111-140cm). Mean body weight: 24.9kg (range: 18-30kg).  Key characteristics at baseline: no subjects had undergone previous orthopedic or neurosurgical intervention before study enrolment; all subjects could walk independently without any walking aid for shorter distances, but used walkers for longer distances; all subjects had spastic diplegic cerebral palsy with a grade of less than 1+ on the modified Ashworth scale in their upper extremities, indicating a slight increase in muscle tone but good functional ability of UEs.  It is not clear how subjects were recruited. |
| **Intervention Investigated** |
| This was not an intervention study. All participants performed both conditions: walking with anterior walker, walking with posterior walker.  After 1 month of practicing under the guidance of a physical therapist, all 10 subjects underwent testing twice, once with each walker in random order. The anterior walker used was the Pediatric Guardian walker, which has two wheels. The posterior walker used was the Kaye Posture Control (two-wheeled) walker. During testing, subjects walked with ankle foot orthoses (AFOs) with a hinged joint. Subjects ambulated at a self-selected speed that was comfortable for them for 5 minutes, with the first 2 minutes considered as an adaptation period and the values taken during the last 3 minutes averaged to determine oxygen cost.  This study does not describe in detail either intervention. It does not specify who provided treatment, where and when treatment was provided, what kind of surface the subjects ambulated on during testing, and if the assessors gave any verbal cues or encouragement during testing. |
| **Outcome Measures** |
| The study does not specify where the measures were performed, or who administered them.  Gait parameters:  A Vicon 370 Motion Analysis system was used for gait analysis. Reflective markers were attached to these anatomic locations: sacral marker at midpoint of PSIS’s, bilateral markers at ASIS’s, midpoint between greater trochanter & center of knee bilaterally, markers at lateral knee joint bilaterally, midpoint between lateral knee joint & lateral malleolus bilaterally, markers at both lateral malleoli, and bilateral markers at the 2nd metatarsal head.  Motion analysis measured gait velocity (m/min), cadence (steps/min), step length (m), and percent of single support time and double support time of gait cycle (%). Flexion angles of the trunk, hip and knee (degrees) were measured at initial contact, mid-stance, pre-swing, and mid-swing of the gait cycle.  Energy expenditure:  A KBI-C was used to measure energy expenditure. The study does not explain what a KBI-C is or how it is used.  The study specifically used oxygen consumption rate (ml/kg/min) and oxygen cost (ml/kg/m) as measures of energy expenditure. |
| **Main Findings** |
| Gait parameters:  ***Velocity***: mean value for the anterior walker (AW) was 16.23 m/min (SD=10.51) and 20.37 m/min (SD=12.62) for the posterior walker (PW) (p-value=0.214). Effect size (ES) = 4.14 m/min in favor of PW.  ***Cadence***: mean value for the AW was 56.2 steps/min (SD=23.35) and 63.25 steps/min (SD=30.78) for the PW (p-value=0.297). ES = 7.05 steps/min in favor of PW.  ***Step length***: mean value for the AW was 0.27 m (SD=0.11) and 0.31 m (SD=0.09) for the PW (p-value=0.021). ES = 0.04 m in favor of PW.  ***Single support time***: mean value for the AW was 16.15% (SD=5.9) and 22.41% (SD=8.85) for the PW (p-value=0.028). ES = 6.26% in favor of PW.  ***Double support time***: mean value for the AW was 64.79% (SD=11.45) and 56.83% (SD=14.27) for the PW (p-value=0.028). ES = 7.96% in favor of AW.  Synopsis: The mean values for velocity, cadence, step length, and single support time were all greater for the posterior walker, however only step length and single support time were statistically significant. Double support time was significantly greater using the anterior walker (p<0.05), indicating the PW provided more stability than the AW.  *Flexion angles*: The angle of pelvic tilt was significantly smaller at each phase of the gait cycle for the posterior walker (mean difference between AW and PW was 4.6 degrees at initial contact, 8.48 degrees at mid-stance, 6.36 degrees at pre-swing, 5.09 degrees at mid-swing). Hip flexion angle was also significantly smaller at initial contact (mean difference=4.86 degrees) and midstance (mean difference=9.42 degrees) while using the PW. Finally, knee flexion angle was smaller at all phases of the gait cycle for the PW, but the only significant finding (p<0.05) was during initial contact (mean difference=3.08 degrees). Decreased flexion angles of the pelvis, hip and knee while using the PW indicate it is more helpful than the AW in achieving upright posture.  Energy expenditure:  Both the mean oxygen consumption rate and mean oxygen cost were lower for the posterior walker than the anterior walker. The mean difference for oxygen consumption rate was 0.1ml/kg/m and 1.14 ml/kg/min for oxygen cost in favor of the PW. The study reports these findings as significant (p<0.05), indicating the posterior walker is associated with less energy expenditure. |
| **Original Authors’ Conclusions** |
| The authors of this study concluded that the posterior walker is a better choice than the anterior walker for a child with spastic diplegic cerebral palsy due to its association with lower energy expenditure and ability to facilitate a more upright position during gait. The authors compared their results with previous studies, of which some had similar conclusions and some did not. However, the authors felt their study minimized bias by having strict inclusion criteria and a narrow range of ages in the sample. |
| **Critical Appraisal** |
| **Validity** |
| This study was given a score of 10/11 on the modified Downs & Black checklist indicating the quality of evidence is fair with some limitations. The study does not state how subjects were recruited, so there is no way to know if the sample is representative of the entire population. The repeated measures design allowed all 10 subjects to undergo both interventions, reducing the amount of error that could arise from natural variance between individuals, allowing for true comparison of effects of anterior versus posterior walkers on an individual. Every subject walked with AFOs with a hinged joint during the intervention, but this was not stated as part of the inclusion criteria, and may affect external validity. It is unclear whether or not AFO use was the norm for all 10 subjects, or if it was imposed as part of the intervention. An explanation of this would have been helpful seeing as orthoses can significantly affect gait and therefore significantly affect the relevance of the outcomes.  The subjects were also randomly allocated to order of treatment, minimizing any order effect. The most consistent source of bias was the lack of blinding of subjects and assessors, which compromises the study’s internal validity. Due to the type of intervention in this study, blinding subjects is not possible because the children know which walker they are using and outcome measures were assessed during ambulation, making it very difficult for the assessor to be blinded as well. However, outcomes were determined by the Vicon 370 Motion analysis system and KBI-C, which requires some human work to process this type of data, establishing a need for blinding of these assessors. Another issue was the small sample size (10 subjects). A small sample size can limit the generalizability of the findings. Because of the small sample size, there was no issue with retention and outcome measures were taken from all subjects and these results were analyzed as well as compared. This study did not complete a power analysis, but based on other similar studies, it seems as though this sample size is probably not large enough to detect differences in the observed effect sizes for some of the outcomes. This study allowed time between interventions, but it was only 15 minutes in order to allow heart rates to return to basal level, instead of weeks or days like similar studies I have seen. This may have been enough time to eliminate carryover effects when measuring energy expenditure, however those effects may have been significant for the gait parameter outcomes. The study provides the mean and standard deviation for all outcome measures, and the Wilcoxon signed rank test was used to allow for comparison of effects between interventions. |
| **Interpretation of Results** |
| The results of this study indicate that the posterior walker is more effective than the anterior walker for children with spastic diplegic cerebral palsy in terms of reducing energy expenditure, facilitating upright posture with walking, improving stability during gait, and increasing two gait parameters: step length and single support time. A statistically significant difference was found for all of these results. The study revealed no significant difference in velocity or cadence between the two walker types, however the average values were greater for both when using the posterior walker, meaning a clinical significance may still exist and the study may have been underpowered to detect these effects. The very small sample size is concerning in that it may be impossible to determine significant effects in all outcomes. Due to the little variability in the sample with all subjects exposed to both interventions, the results of this study may be very significant clinically for a child 7 to 12 years old with spastic diplegic cerebral palsy wearing AFOs and in need of a walker. |

**(2) Description and appraisal of “Gait parameters of children with spastic diplegia: a comparison of effects of posterior and anterior walkers” by Greiner, BM, Czerniecki JM, Deitz JC (1993)10**

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| **Aim/Objective of the Study:** |
| The purpose of this study was to determine the effects of posterior and anterior walkers on gait parameters in children with spastic diplegic cerebral palsy. The study also included parents’ perception of walker effects, as well as parent and child preferences for an anterior or posterior walker. |
| **Study Design** |
| Single group of patients tested with unfamiliar walker after week of training, then tested with typically-used walker.  Subjects practiced exclusively with unfamiliar walker for 1 week. Subjects then reported for testing with both walkers in the same session, with testing of gait with the unfamiliar walker occurring first. The study did not report any rest break between data collection of each walker type. After testing with both walkers, a questionnaire was then administered to the child’s parent. No blinding or follow-up. |
| **Setting** |
| The setting was not specified, it appears to be conducted in an academic research lab. |
| **Participants** |
| N=5 (2 males, 3 females). Two subjects typically used anterior walkers (both females) and three subjects typically used posterior walkers (1 female, 2 males). No dropouts. Convenience sample: subjects were recruited by a local physical and occupational therapists’ practice.  Mean age: 5.3 years old (range: 2-7 years). Data regarding height and weight were not provided.  Key characteristics at baseline: all subjects had a diagnosis of spastic diplegic cerebral palsy; all subjects had the ability to independently rise to stand with anterior and posterior walker; all subjects could complete right and left 90° turns, walk on a linoleum surface for 15 meters without falling and come to a controlled stop independently; all subjects typically wore AFO orthotics (1 subject had bilateral AFOs, the other 4 only required the use of 1 AFO). |
| **Intervention Investigated** |
| This was not an intervention study. All participants performed both conditions: walking with anterior walker, walking with posterior walker.  One week before data collection, each subject was fitted by one of the investigators with the walker that he or she did not typically use, which was either a two-wheeled anterior walker or four-wheeled posterior walker. Specific walker brands were not specified. A second occupational or physical therapist verified that the walkers were properly adjusted for each patient. After 1 week of using the unfamiliar walker at home and school, all 5 subjects underwent testing with each walker. Subjects walked back and forth twice on a 1.2 by 10 meter walkway, first with the unfamiliar walker and then with their typical walker. This allowed for collection of four strides of data, two left and two right, with each walker type. All subjects wore the same shoes and AFO orthotics throughout data collection, and no verbal cues regarding walking speed were given. The study does not specify who collected data, however it appears to be either an occupational or physical therapist based on information given regarding pre-intervention procedures.  After data collection, a questionnaire was administered to each parent. |
| **Outcome Measures** |
| Gait parameters:  A computer-interfaced video motion analysis system at 30H was used for gait analysis. An investigator was responsible for digitizing the joint marker coordinates. The one-inch markers were attached directly to the skin at these anatomic locations: lateral aspect of the 5th metatarsal head, postero-lateral corner of the heel, lateral malleolus, lateral femoral condyle, greater trochanter, and the lateral aspect of the mid cervical spine. The subjects were also filmed with a video camera mounted perpendicular to the walkway and at hip height. The digitized XY coordinates were then corrected for aspect ratio, scaled, and conditioned using a second order zero lag Butterworth digital filter at frequency of 7H.  After the data were digitized and filtered these variables were calculated: trunk angle during stance phase (degrees), hip and knee angles at foot-floor contact and midstance phase (degrees), step length (meters), walking velocity (m/sec), and double stance time (seconds).  Questionnaire:  A parent questionnaire was administered after each subject’s gait was tested with both walkers. The parents had the options of “no difference,” “not sure,” “anterior walker,” “posterior walker” or “not sure” when asked which walker was 1) less wobbly, 2) resulted in more normal walking, 3) easiest on gravel/grass, 4) easier to play with other children, as well as the 4) child’s preference and 5) parent’s preference. |
| **Main Findings** |
| Gait parameters:  ***Trunk angle***: mean value for the posterior walker (PW) was 14 degrees (SD=4) and 22 degrees (SD=5) for the anterior walker (AW) (p-value=0.03). ES = 8 degrees in favor of PW.  ***Hip angle at foot-floor contact***:  LEFT LEG: mean value for the PW was 45 degrees (SD=10) and 57 degrees (SD=12) for the AW (p-value=0.03). ES = 12 degrees in favor of PW.  RIGHT LEG: PW mean=37 degrees (SD=12) and AW mean=48 degrees (SD=11) (p-value=0.03). ES = 11 degrees in favor of PW.  ***Knee angle at foot-floor contact***:  LEFT LEG: mean value for the PW was 35 degrees (SD=19) and 55 degrees (SD=14) for the AW (p-value=0.03). ES = 20 degrees in favor of PW.  RIGHT LEG: PW mean=41 degrees (SD=16) and AW mean=46 degrees (SD=13) (p-value=0.22). ES = 5 degrees in favor of PW.  ***Hip angle at midstance***:  LEFT LEG: mean value for the PW was 15 degrees (SD=10) and 31 degrees (SD=13) for the AW (p-value=0.03). ES = 16 degrees in favor of PW.  RIGHT LEG: PW mean=15 degrees (SD=16) and AW mean=20 degrees (SD=13) (p-value=0.06). ES = 5 degrees in favor of PW.  ***Knee angle at midstance***:  LEFT LEG: mean value for the PW was 17 degrees (SD=20) and 22 degrees (SD=21) for the AW (p-value=0.16). ES = 5 degrees in favor of PW.  RIGHT LEG: PW mean=21 degrees (SD=24) and AW mean=18 degrees (SD=24) (p-value=0.41). ES = 3 degrees in favor of AW.  ***Step length***:  LEFT LEG: mean value for the PW was 0.37 meters (m) (SD=0.22) and 0.24 m (SD=0.04) for the AW (p-value=0.09). ES = 0.13 m in favor of PW.  RIGHT LEG: PW mean=0.36m (SD=0.12) and AW mean=0.26 m (SD=0.04) (p-value=0.06). ES = 0.1 m in favor of PW.  ***Walking velocity***: mean value for the PW was 0.34 m/sec (SD=0.12) and 0.25 m/sec (SD=0.08) for the AW (p-value=0.03). ES = 0.09 m/sec in favor of PW.  ***Double stance time***: mean value for the PW was 0.28 sec (SD=0.1) and 0.49 sec (SD=0.15) for the AW (p-value=0.03). ES = 0.21 sec in favor of PW.  Synopsis: The mean values for step length, walking velocity and double stance time all favored the posterior walker, however only walking velocity and double stance time were statistically significant (p<0.05). The mean values for trunk, hip, and knee flexion angles were lower when the posterior walker was used, with statistically significant findings for stance trunk angle, three of the four hip angle comparisons, and one of the four knee comparisons. Decreased trunk, hip and knee flexion angles indicate the posterior walker is more helpful than the AW in facilitating upright posture and decreasing crouch gait.  Questionnaire:  Four parents reported that the posterior walker was less wobbly, with the other parent reporting no difference. All five parents reported the posterior walker resulted in more normal walking and was easier for their children to use while playing with other children. Of the four parents who were able to observe their children using the walker on grass and gravel, three of them indicated the posterior walker was the easiest to use, with one parent noting no difference. All five parents indicated that their child preferred the posterior walker, and four of the parents reported that they preferred the posterior walker as well. The other parent indicated anterior walker preference for indoors and a preference for the posterior walker when outdoors. |
| **Original Authors’ Conclusions** |
| The authors concluded that all objective and subjective information obtained from their study pointed to use of the posterior walker over the anterior walker for a child with spastic diplegic cerebral palsy due to decreases in trunk and hip flexion angles and increased walking speed after only a week of practicing. The authors noted that not only did the results demonstrate a functional improvement shown by increased walking speed with the posterior walker, but 80% of the parents spontaneously commented that they observed an increased walking speed when their child used the PW. A significant reduction in double stance time was found when using the PW, but the authors were unable to determine if this was due to an increase in stability or just came as a result of increased walking velocity. All 5 parents noted the PW made it easier for their child to play with other children, which the authors concluded might be due to the lack of physical barrier between the child and their playmate. The authors pointed out their small sample size, stating that a larger sample may have substantiated the trend toward increased step length. The authors also compared their results with previous studies, of which most had similar conclusions regarding the PW. |
| **Critical Appraisal** |
| **Validity** |
| This study was given a score of 10/11 on the modified Downs & Black checklist. This score focused specifically on the reporting section, in which the study did very well. The study clearly described all objectives, subjects, interventions, outcome measures and results. A limitation of the study was that the subjects were not randomly allocated to order of treatment. The study also does not indicate there was any time in between testing, meaning there could have been order effects, such as decreased performance during the second condition due to fatigue. The study used a convenience sample, meaning the subjects that participated were most likely not representative of the entire population, which has implications for external validity. Similar to the first study, the repeated measures design in this study allowed all 5 subjects to complete testing with both the anterior and the posterior walkers, eliminating error that could come from natural variance between participants. With such a small sample size (5 subjects), it makes performing the testing easier, but can limit the generalizability of the results. In a table listing subject characteristics, information is given that all 5 subjects typically wear an AFO, with 1 subject wearing bilateral AFOs. The study also reports that footwear was controlled, with each subject wearing the same shoes and orthotics during testing. The results do not separate out the quantitative data for the subject wearing bilateral AFOs, except for the answers to the patient questionnaire. The study only gives the mean values for gait parameters so there is no way to differentiate the effect of the PW and AW between subjects wearing one AFO and those wearing bilateral AFOs. This information is important for external validity and being able to apply these study results in a clinical scenario.  There was a potential for bias due to lack of blinding of subjects and assessors, which could affect the study’s internal validity. Again, due to the design of the study, blinding during testing was very difficult since both children and investigators can see which walker is being used. However, there could have been blinding of the investigators who were calculating gait parameters from the data once it had been digitized and filtered. The authors explained that the frequency for the video motion analysis was chosen because it “appropriately exceeds the inherent frequency content of normal gait”10(pg. 382) indicating that the outcome assessment of gait parameters was appropriate. The statistical tests used to assess the main outcomes were also appropriate, as PW and AW data were compared using matched-pairs signed ranks tests with p-values based on exact tests due to the small sample size. There were no dropouts so all data were analyzed and compared. The study provides the mean, median, standard deviation, range, and p-value for all gait parameters. Like Park et al.’s study, this study did not complete a power analysis. However, the small sample size of this study is most likely not large enough to detect differences in the observed effect sizes for some of the outcomes. |
| **Interpretation of Results** |
| The results of this study indicate that use of the posterior walker in children with spastic diplegic CP resulted in a statistically significant increase in walking speed, improved gait posture, and decreased double stance time, as compared to the anterior walker. The effect size for walking velocity is 0.09 m/sec, which shows that this result is not only statistically significant, but also clinically significant, resulting in almost 18 more feet travelled per minute with the posterior walker. No significant difference was found in step length between the two walker types, however the mean values were greater when the PW was used. Even without statistical significance, the difference in step length could be clinically significant, and the study’s small sample size may have been underpowered to detect this effect. It may be impossible to determine significant effects for all outcomes with only 5 subjects. One limitation of this study is the limited amount of exposure the subjects have to the unfamiliar walker. The subjects only have one week of exclusively using the new walker in their home and school environments. Similar studies allocate one month of practice with the new walker, and most include gait training from a physical therapist, which this study does not. Years of use versus one week of self-guided practice may be enough of a difference to bias results towards the walker the child typically uses. There were also an uneven number of subjects in each group. Three out of the five typically used posterior walkers, meaning the majority of the subjects had years of experience using the posterior walker, which also may have led to a biased preference for the PW. However, there is something to be said for the two subjects who only had one week of practice with the posterior walker and still reported preference for the posterior walker, as well as demonstrated superior quantitative gait parameters for the PW. This may indicate that only a short amount of practice time with the posterior walker is needed to improve aspects of gait. The study also discussed specific results for left versus right for hip and knee flexion angles, but failed to include which leg the AFO was on for the four children that used the orthosis only on one leg. A significant strength of this study is the inclusion of a parent questionnaire. The subjective reports overwhelmingly point to a preference for the posterior walker, for both parents and children. Although no statistical significance can be gleaned from this questionnaire, it may be very significant clinically since subjective report is currently one of the main factors for choosing a walker type in the clinic. When compared to the AW, the parents reported that the PW resulted in increased stability, easier play with other children, more normal walking, and easier walking on uneven surfaces. These are all very relevant examples of how a walker can affect a child’s daily life and function, and are therefore very valuable when considering a walker type for a child. Because all 5 subjects were exposed to both walker types, the findings of this study may be very significant clinically for a child with spastic diplegic CP who is 2 to 7 years old, wears AFOs, and is in need of a walker. |

**(3) Description and appraisal of “Oxygen cost, walking speed, and perceived exertion in children with cerebral palsy when walking with anterior and posterior walkers” by Mattsson E, Andersson C (1997)7**

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| **Aim/Objective of the Study:** |
| The purpose of this study was to determine walking speed, energy cost, and perceived exertion while using posterior and anterior walkers and compare results in children with cerebral palsy who were familiar with both walker types. |
| **Study Design** |
| Single group of patients tested with anterior and posterior walkers in random order.  Subjects were tested once with each walker in random order, and given one trial in which data were not collected before each test. All subjects were familiar with both walkers before testing. The study did not report any time allotted between data collection of each walker type. No blinding or follow-up. |
| **Setting** |
| All subjects were tested at their own schools in Stockholm, Sweden. |
| **Participants** |
| N=10 (8 males, 2 females). Diagnosis: spastic diplegic cerebral palsy=7 subjects; ataxic diplegic cerebral palsy=3 subjects. Six subjects had previous lower extremity surgical intervention. Two subjects used an AFO. No subjects could walk independently at baseline. For the 6 months prior to the study, all children were able to walk with a posterior walker and an anterior walker for at least 5 consecutive minutes.  Mean age: 11 years old (range: 8-17 years). Mean height: 132cm (range: 113-150cm). Mean body weight: 34kg (range: 17 to 55kg).  Convenience sample: children who were registered in the Care Committee Stockholm County Council and met inclusion criteria were selected by their physical therapist. |
| **Intervention Investigated** |
| This was not an intervention study. All participants performed both conditions: walking with anterior walker, walking with posterior walker.  Since all subjects were familiar with both the anterior and posterior walkers, there was only one trial before each test in order for participants to familiarize themselves with the test method. Order of walker type was random. For testing, all subjects ambulated at a self-selected comfortable speed on a level floor. Subjects walked around a circle with a circumference of 70 meters for 4 minutes in order to achieve a steady state. The children’s own walkers were used. The study does not specify walker brands, however, pictures depict a four-wheeled posterior walker, and a standard rollator (anterior) walker. The study does not specify who collected data, and if any verbal cues were given during testing.  Immediately following testing, each subject was asked to grade his/her perceived exertion. |
| **Outcome Measures** |
| Measures were performed at the child’s school. The study does not specify who administered them. Assessors were not blinded.  Spasticity: Before being tested using both walker types, assessors used the modified Ashworth scale (MAS) to determine spasticity. The MAS has size degrees (0, 1, 1+, 2, 3, 4). Hip abduction/adduction, hip flexion/extension, hip rotation, knee flexion/extension, foot/ankle flexion/extension, and elbow flexion/extension were determined with each child in supine.  Walking speed: Walking speed was measured by a speedometer that logged distance, time and average speed. The speedometer was mounted on a small cart, which was pushed by an assessor close behind the child being tested.  Heart rate (HR): A telemetric device (Sport tester PE3000) was used to measure HR in beats per minute (bpm). The study defined steady state as a change of no more than 2 beats per minute, recorded twice for a period of at least one minute.  Oxygen cost: In order to measure oxygen cost, each child carried a lightweight backpack with a mixing box and wore a soft facemask with a flexible hose that carried the expired gas into the box. A mass spectrometer was used to analyze a sample of the gas from the box. From the gas analysis data, oxygen uptake (L/min), ventilation (L/min), BTPS (body temperature and pressure, saturated with water vapor), STPD (standard temperature and pressure, dry), carbon-dioxide elimination (L/min STPD), and respiratory exchange ratio were calculated. Oxygen cost was determined using oxygen uptake and presented in units mL/kg/min, as well as mL/kg/m to account for speed variations during testing.  Perceived exertion: Following each trial, subjects were asked to express their perceived exertion in their own words, as well as point to a 5-degree scale of faces, graded from 1 (least exertion) to 5 (greatest exertion). The faces were drawn specifically for this study.  Preferred walker: All 10 subjects were asked which walker type they preferred and then asked why they preferred that walker. The study did not specify when subjects were asked about their preferred walker. The study listed walker preferences for all 10 subjects, but only reported explanations for why subjects preferred a walker for 2 subjects. |
| **Main Findings** |
| No p-values were provided for any outcome measure regarding differences between the AW and PW.  Spasticity: MAS ranged from 1 to 2 in the upper extremities (seven subjects score 1+, two scored 2, and one scored 1) and 1+ to 2 in the lower extremities (seven scored 2 and three scored 1+).  Walking speed: mean speed while using the anterior walker: 27.2 m/min (range: 7-67m/min). Mean speed while using the posterior walker: 28.8 m/min (range: 12-68 m/min). ES = 1.6 m/min in favor of PW. One child walked the same speed with both walker types. Seven subjects walked faster with posterior walker, and two subjects walked faster with the anterior walker. Walking speed was not correlated with age, body weight, or spasticity. No significant difference in walking speed was found when the child walked with his/her preferred or non-preferred walker.  Heart rate (HR): mean HR at rest: 96 bpm (range: 76-112 bpm). Mean HR while walking with anterior walker: 147 bpm (range: 123-170 bpm). Mean HR while walking with posterior walker: 147 bpm (range: 128-197 bpm). ES = 0 bpm. No values for standard deviation were given. No statistically significant difference was found between the two walker types for HR.  Oxygen cost: mean oxygen cost per minute while using the anterior walker: 15.8 mL/kg/min (range: 8.8-21.2 mL/kg/min) and the posterior walker: 16.5 mL/kg/min (range: 11.5-20.8 mL/kg/min). ES = 0.7 mL/kg/min in favor of AW. Mean oxygen cost per meter while using the AW: 0.69 mL/kg/m (range: 0.24-1.41 mL/kg/m) and the PW: 0.68 mL/kg/m (range: 0.24-1.41 mL/kg/m). ES = 0.01 mL/kg/m in favor of PW. Oxygen cost was not correlated with spasticity or age. No statistically significant difference was found between the two walker types for oxygen cost.  Perceived exertion: mean perceived exertion after walking with the AW: 3.2 (range: 1-5). Mean perceived exertion after walking with the PW: 2.2 (range: 1-4). ES = 1 in favor of PW. Five subjects using the PW and three subjects using the AW assigned a score of 1 (very easy) to those walker types. Four subjects using the AW gave a score of 5 (very hard), whereas no subjects assigned a score of 5 to the PW.  Preferred walker: Seven subjects preferred the posterior walker, two subjects preferred the anterior walker, and one subject said he preferred the PW when playing with his friends, but liked the AW better when he was alone. The study does not mention ever asking which walker type the child primarily used previous to the study, but states that the child’s preferred walker was also the most used for every subject. |
| **Original Authors’ Conclusions** |
| The authors of this study concluded that anterior and posterior walkers are equivalent in terms of objective measurements of oxygen cost, walking speed, and perceived exertion, for a child with cerebral palsy. Although flexion angles of the trunk, hip, or knee were not measured, the authors suggest that the advantage of better posture could allow one to “feel free, in general, to prescribe the posterior walker rather than the anterior walker.”7(pg. 676) The authors compared their results with previous studies and explained that differences in results may have been due to age differences between samples, as well as the fact that their subjects were familiar with both walker types before initiating the study. The authors reported that their inclusion criteria was very limiting, which is why their sample size was so small. |
| **Critical Appraisal** |
| **Validity** |
| This study was given a score of 8/11 on the modified Downs & Black checklist, which makes it the lowest methodological quality of the 3 articles assessed. This study scored lower because it did not report standard deviations, confidence intervals, or p-values for any primary outcome measures. Another limitation of this study was the variability in the sample regarding prognostic indicators. Three of the children had a diagnosis of ataxic diplegic CP and seven of them had spastic diplegic CP. These classifications for CP are important because they indicate different impairments, which could have different implications for gait and the results of this study. However, like the other two studies, this study implemented a repeated measures design, allowing for true comparison of effects of anterior versus posterior walkers on each subject. Because results were given for all outcomes for each subject individually, separate means can be calculated for the 3 ataxic diplegic subjects and the 7 spastic diplegic subjects to see if there was a different trend than that which was calculated for the overall mean. The study also stated that 2 subjects wore AFOs, but did not specify which 2 these subjects were, which prevents comparison of results for those with and without AFOs and has implications for external validity. Another issue with the sample is the small size (10 subjects), which can limit the generalizability of the results. All subjects were randomly allocated to order of treatment, which is a strength of this study as this minimizes any order effect. This was shown to be true since the study states that no differences were detected between subjects who started with the PW and those who started with the AW. Similar to Greiner et al.’s study, testing for both the AW and PW was completed on the same day with no time between testing, which puts it at risk for order effects. The external validity of the study was weakened due to convenience sampling, and there was a potential for bias affecting internal validity due to lack of blinding of subjects and assessors.  There are strengths and limitations regarding outcome measures utilized in this study. Walking speed was recorded by a speedometer, which was mounted on a cart being pushed by the assessor, who was following the child. Although the speedometer itself may have been reliable and valid, it is likely that the assessor was not walking the exact same speed as the child for the entire 4 minutes of testing. It seems as though it could have been improved by mounting the speedometer directly on the child’s walker in order to get a more accurate assessment. There were also limitations with how spasticity and perceived exertion were measured. Spasticity was measured with the child lying in supine instead of walking, which would have been more appropriate since spasticity can differ between subjects, as well as for the same subject, when in different positions. The perceived exertion scale was created specifically for this study, meaning it had never been tested for validity or reliability. Another issue with this 5-degree scale of faces is that it is an ordinal scale, meaning there is no way to be sure that the distances between the consecutive faces are equal. However, similar faces scales, such as the Wong-Baker FACES Scale, have been shown in literature to be the preferred method of pain reporting for children.13 The method used to measure oxygen cost stood above the rest, as it has been tested for reliability and validity with good results. Even though the method for measuring oxygen cost has been validated, it requires the child to wear a backpack weighing 2.5 kg. An additional 2.5 kg of weight could naturally make ambulation more difficult for these children, and affect the other outcomes of walking speed and perceived exertion. It is important to note that the study accounted for speed variations between tests when calculating oxygen cost. This is important because children with CP do not use more oxygen than children without disabilities when oxygen cost is measured per minute (mL/kg/min), because the body requires the same amount of oxygen per kg of body weight for everyone. The difference between children with CP and typically developing children can be seen when speed is factored into the oxygen cost (mL/kg/m), because in order to consume oxygen at the same rate, children with CP have to slow down their walking speed.  The study provided only the mean or median and range for all outcome measures, with no estimates of the random variability in the data for the main outcomes. The study states that the student t-test or Wilcoxon’s signed rank test was used to identify differences between outcomes for the two measures, however, it does not provide any specific p-values but instead just states whether or not there was a significant difference. Similar to the other 2 studies being analyzed, this study did not complete a power analysis, and the small sample size would most likely limit the detection of differences in the observed effect sizes for some of the outcomes. |
| **Interpretation of Results** |
| Unlike the first two studies, this study did not find any significant differences between the posterior walker and anterior walker for any outcome measure. This would indicate that objectively in terms of oxygen cost, walking speed and perceived exertion, the AW and the PW have comparable effects on a child with CP. However, this study had many limitations, including valid and reliable outcome measures, minimal reporting on statistical analysis and of particular importance, a small sample size, which may have caused the study to be underpowered to detect effects for these outcomes. Seven subjects walked faster with the PW, but the effect size was 1.6 m/min. Depending on the patient, this can be significant or not. An extra 1.6 meters per minute may be clinically significant for a high schooler trying to make a 5-minute transition time between classes, but will likely not make a huge difference in a child worried about being able to ambulate longer distances. The small effect sizes for oxygen cost did not indicate a significant treatment effect for either walker type. Even with no statistically significant differences in outcomes, there is something to be said that 70% of the children preferred the posterior walker to the anterior walker, especially since in this study all participants were familiar with both walkers for at least 6 months before starting the study. This is very significant clinically, because it is important for physical therapists to involve patients in their own care, even if they are children, because the patients are the ones who will be affected daily by this decision. The results from this study indicate that for a child 8 to 17 years old with spastic or ataxic diplegic CP who is unable to walk independently at baseline, there is no objective difference in oxygen cost, walking speed, or perceived exertion between a PW and an AW and therefore the decision should be made using other information, such as observation of posture and gait mechanics and patient report. |

**EVIDENCE SYNTHESIS AND IMPLICATIONS**

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| These three studies utilized technology and expensive research equipment to assess gait parameters and measures of energy expenditure that cannot be performed efficiently by physical therapists in clinics with limited equipment. Although it is not practical for physical therapists to assess these objective outcomes on a daily basis, it is important for therapists to be aware of the current evidence regarding the differences between anterior and posterior walkers. Objective results are important to consider when the choice of an anterior versus a posterior walker for a child has historically been made based solely on the PT’s subjective findings. The current evidence for the effectiveness of a posterior walker versus an anterior walker for a child with cerebral palsy is not only weak but it is conflicting. There seems to be a trend towards the posterior walker’s ability to facilitate upright posture, reduce energy expenditure, and improve gait parameters such as step length, walking velocity and stance time, but studies with similar measures fail to find significant outcomes. Unless studies of higher methodological quality are published, it will be hard to base clinical decisions off of these results. One outcome that is consistent throughout various studies is the subjective preference for the posterior walker over the anterior walker by both the child and his/her parent. Reasons for this were improved posture, since the AW tends to naturally result in more of a crouched position while pushing the walker, as well as a lack of physical barrier, making it easier for the child to interact with other children. In directly applying this evidence to the patient presented in the clinical scenario, it is unclear whether or not a posterior or anterior walker would result in an objective improvement in his gait. If his age is the most important factor, the only study that would apply to his case is the one of lowest methodological quality by Mattsson et al.,7 which found no differences between walker types. If his ability to walk independently at baseline is the most important factor, the results from Park et al.6 would be pertinent, and one could expect an improvement in posture, energy expenditure, as well as other gait parameters. It’s important to consider the age of the subjects from these 3 studies. The subjects in Greiner et al.10 ranged from 2 to 7 years old, while the subjects in Park et al.6 ranged from 7 to 12 years old, and the study by Mattsson et al.7 had some overlap, with subjects 8 to 17 years old. Age is a significant factor that affects gait in children with CP, because these children have to learn to adapt as their bodies grow and experience changes in levels of spasticity of different muscles. Literature has also shown that in children, age is one of the key factors in changes in walking speed.14 This is why it is so difficult to compare results of gait studies when samples consist of subjects in differing age groups. It is also difficult to generalize the results from these studies to the patient from the clinical scenario because he did not wear AFOs, and at least two children from every study wore an AFO. Based on the mixed results of these lower quality studies, a physical therapist should be hesitant to implement them without also taking into account the specific impairments and functional needs of the patient. It is, however, helpful to know that walker types can make significant differences in certain patients, both statistically and clinically. Simply being more aware of these objective measures can help draw the therapists attention to specific parameters when observing their patient trial the two walker types.  Future research needs to include studies that have larger sample sizes that aren’t convenience samples. It is important that these studies have very strict inclusion criteria in order to decrease variability and promote similarity at baseline for the most important prognostic indicators. Studies should have samples with homogeneous diagnoses. In the study by Mattsson et al.7, none of the subjects walked independently at baseline, whereas all of the participants in the study by Park et al.6 were able to walk independently at baseline. Greiner et al.10 did not specifically state the subjects’ ability to walk independently at baseline. These differences in subjects’ gross motor function at baseline makes it difficult to compare the results of all three studies to one another. Future studies would benefit from classifying all participants into GMFCS (Gross Motor Function Classification System) levels, which have been shown to be a valid way to categorize children with cerebral palsy according to their gross motor function.15 It is possible that significant differences were found between walker types in the study by Park et al.6 and not the study by Mattsson et al.7 because the subjects in the Mattsson study had a greater level of disability, making it more difficult for them to make improvements that reached statistical significance. Studies should also specify details and provide rationale for all aspects of the study, especially for factors that can significantly affect outcomes, such as the use of AFOs. One significant issue with all of the current evidence on this topic is that it is quite old. There are very few recent studies looking at the influence of anterior and posterior walkers on gait parameters, posture and energy efficiency. Out of the 10 studies found in the search, articles go back as far as 1985. The 3 articles chosen for critical appraisal were of the highest methodological quality and relevance to the clinical question, and yet they were still very old, published in 1993, 1997, and 2001. The most recent study was published 7 years ago in 2009, but it focused on upper extremity kinetics as its primary outcome.12 There is no explanation for why researchers have stopped addressing this topic. It may be due to the fact that expensive equipment is needed, and it has been shown to be very difficult to recruit a large sample that is similar at baseline for prognostic indicators. |

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