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Outcomes of gait trainer use in home and school settings for children with motor impairments: A systematic review

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Abstract

Objective: To summarize and critically appraise evidence regarding use of gait trainers (walkers providing trunk and pelvic support) at home or school with children who are unable to walk independently or with hand-held walkers.

Data sources: Searches were performed in seven electronic databases including EBM Reviews, CINAHL, Medline and EMBASE for publications in English from database inception to November 2014.

Review methods: Included studies involved at least one child with a mobility limitation and measured an outcome related to gait trainer use. Articles were appraised using American Academy of Cerebral Palsy and Developmental Medicine criteria for group and single-subject designs and quality ratings completed for studies rated levels I-III. The PRISMA statement was followed with inclusion criteria set a priori. Two reviewers independently screened titles, abstracts and full-text articles.

Results: Seventeen studies involving 182 children were included. Evidence from one small randomized controlled trial suggests a non-significant trend toward increased walking distance while the other evidence level II study (concurrent multiple baseline design) reports increased number of steps. Two level III studies (non-randomized two-group studies) report statistically significant impact on mobility level with one finding significant impact on bowel function and an association between increased intervention time and bone mineral density. Remaining descriptive level evidence provides support for positive impact on a range of activity outcomes, with some studies reporting impact on affect, motivation and participation with others.

Conclusions: Evidence supporting outcomes for children using gait trainers is primarily descriptive and, while mainly positive, is insufficient to draw firm conclusions.

Keywords

Assistive devices, cerebral palsy, child rehabilitation, walking, mobility

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Introduction

The ability to move from one place to another independently appears to play a pivotal role in social development[1] and psychological function.[2] The transition from crawling to walking marks an important progression in overall development and social interaction in infants.[3] Children with cerebral palsy or complex developmental delays are often less mobile and interactive than their peers.[4]This lack of mobility and dependent positioning can have a negative impact on overall development, social interaction and social status.[5,6]

The Gross Motor Function Classification System[7] classifies children with cerebral palsy (and similar/related conditions) according to their gross motor abilities. Children in levels IV and V are unable to use typical hand-held walkers due to impaired trunk control, strength, balance and range of motion. Children with complex developmental delays also benefit from walkers that provide additional trunk and pelvic support.[8] Children with visual impairment or profound cognitive limitations may lack motivation to explore due to limited ability to engage in functional or stimulating activities.[9,10] Supportive walking devices or gait trainers may be used with these populations to influence different types of outcomes as defined by the International Classification of Functioning, Disability and Health (ICF).[11,12]

The term gait trainer is used to describe a supported walking device that provides trunk and pelvic support. These devices are also known as support walkers,[13] posture control walkers or suspension body-weight support systems. Commonly used examples include the Rifton Pacer, Mulholland Walkabout, Prime Engineering KidWalk, Ormesa Grillo, and R82/SnugSeat Pony and Mustang. There is some confusion about the term gait trainers as they are not always used to 'train gait' or develop independent, unsupported walking, but as a means to enhance activity and participation. In this paper, the term gait trainer will be used since it has been established by US coding, is familiar to clinicians, and appears to be longest standing in the literature.

Gait trainers commonly unweight the body through a solid or fabric 'seat', stabilize the trunk and support the pelvis. Survey data[13] suggests that therapists hope to influence body structure and function components such as hip structure, cardiorespiratory function and bone mineral density through gait trainer use. Despite the apparent widespread and long-term use of gait trainers, to date there are no systematic reviews or published evidence-based clinical guidelines. The aim of this systematic review is to evaluate the evidence for all outcomes potentially impacted by use of gait trainers with children in home and school environments. The specific question addressed is, "for children with motor impairments, which outcomes are positively influenced by a gait trainer intervention?' Secondary questions address "which populations benefit from gait trainer interventions" and "at what age should they be introduced?"

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was used to structure this review.[14] An electronic database search was undertaken from database inception to November 2014 and included: EBM Reviews: Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects (DARE), ACP Journal Club; CINAHL; Medline and EMBASE. As noted in online supplementary material Appendix A, search terms included 'gait trainer', 'support walker', 'walking device, 'ring walker, 'infant walker", 'baby walker', 'body weight support gait trainer', 'walker', 'supported ambulation', 'David Hart Walker', and 'supported walking'. Search terms were used in combination with the term 'equipment' or with diagnoses such as 'cerebral palsy', 'spina bifida' or 'muscular dystrophy'. No limits were placed on design methodology or publication status in the initial search.

Articles were included if they described primary source studies using quantitative or qualitative methods to explore outcome(s) resulting from use of a gait trainer and involved at least one child aged 18 years or younger with a movement disorder or motor impairment. A gait trainer was defined as a walker that is available with lateral and posterior components to stabilize or support the trunk and pelvis as well as a rigid or flexible seat to provide body-weight support. Studies that did not provide sufficient description of the walker to determine if it met criteria were included only if the population was described in sufficient detail to determine that they would typically use a gait trainer or where it was known that the intervention described involves a gait trainer (e.g. Movement Opportunities Via Education).[15] Studies using swivel walkers (e.g. Orlau walker), typical 'infant walkers', robotic devices (e.g. Locomat), exoskeletons or mechanical stepping devices with external power sources, stationary systems (confined to parallel bars or treadmill) or institutional-type gait trainers (e.g. Lite gait) too large to be used in a home or classroom environment were excluded as were non-English language and non-peer reviewed sources.

Bibliographies of electronically retrieved studies were manually searched to identify additional publications. Both authors independently read all titles and abstracts and agreed on the list of articles to be retrieved full-text. Following independent full-text review, both agreed to the list of studies meeting inclusion criteria. Differences of opinion were resolved at all stages through discussion and consensus without the need to involve a third reviewer.

Data were extracted independently by both authors using McMaster Critical Review forms for quantitative[16] and qualitative[17] designs. Consensus on content of tables and ratings was achieved through discussion. Outcomes and clinical information was divided into ICF[11,12] components of body structure and function, activity and participation. Level of evidence was rated using American Academy of Cerebral Palsy and Developmental Medicine Evidence Levels.[18] Quality assessment of Evidence Level 1-III studies was completed using American Academy of Cerebral Palsy and Developmental Medicine quality assessment.[18]

Results

The PRISMA flowchart outlining each step is shown in Figure 1.

Following full-text review, 17 articles met inclusion criteria[19–35] with 97% initial agreement between reviewers and 100% achieved through discussion. Nine of the included articles were identified through manual searching.[19-21,24-26,31,32] See online supplementary material Appendix B for details of excluded studies with reasons for exclusion.

Table 1 lists characteristics of included primary research articles. Evidence for effectiveness of gait trainers is limited as the majority of evidence is descriptive, with only two studies achieving level II evidence. One,[19] a single-subject concurrent multiple baseline design reports an increased ability to step following introduction of the gait trainer. The only randomized controlled trial, compared body weight-support treadmill training and overground walking and found a non-statistically significant trend towards increased walking distance in the overground group.[33] Two non-randomized group designs were also identified. One, comparing the effectiveness of the Hart walker to standing[22] found a statistically significant increase in mobility skills and significant improvement in bowel function in the walking group. The other study compared the Movement Opportunities Via Education[15] curriculum to traditional therapy and found statistically significant increase in independent mobility skills in the intervention group.[31]

One small randomized trial rated strong quality[33] and the other higher level studies rated as moderate quality.[19,22,31] Quality rating of these studies is summarized in online supplementary material Appendix C. Both authors independently rated evidence level and quality with 100% consensus achieved through discussion. Four studies explored outcomes from use of the Rifton Pacer,[19,23,31,32] and another four involved the David Hart Walking Orthosis,[22,30,34,35] a combination of a rear-support or hands-free gait trainer with lower limb reciprocal gait orthoses. One study[21] used a Mulholland Walkabout in combination with a leg guidance system and another used the Kaye suspension system.[20] The remaining studies did not identify the gait trainer used. Included studies reported use of gait trainers ranging from 5-minute sessions, many times each day[24-29] to 4 hours per day several times a week.[21] The most common use pattern appears to be 30 minutes daily (5 times a week).

The majority of studies included children with cerebral palsy and, while some[24–29,31] defined

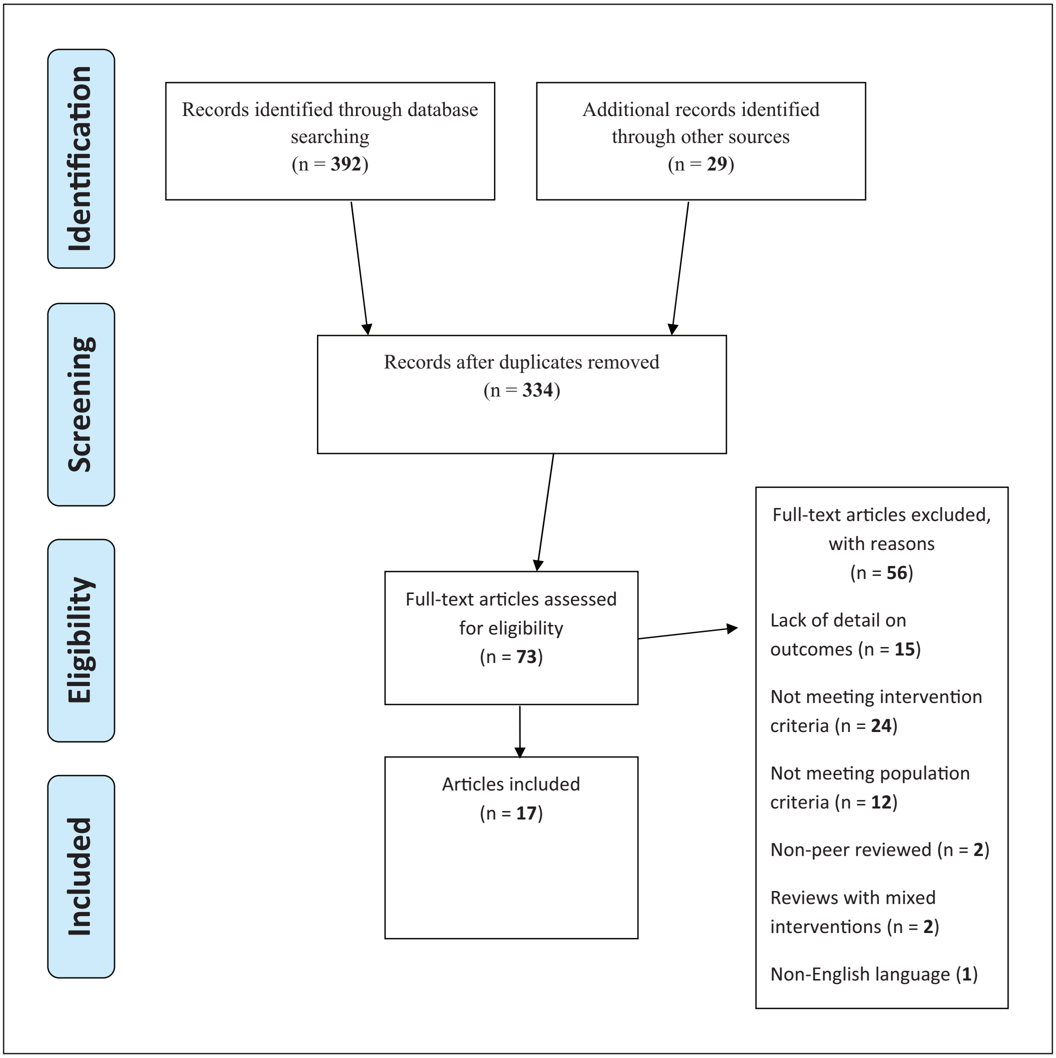

Figure 1. PRISMA flow diagram of the search results.

participants by level of intellectual disability, descriptions also suggest this diagnosis. Only one study[20] included a child with a spinal cord injury of traumatic origin. Age of gait trainer use ranged from two[31] or three years[19,22,27,32] to 18,[33] with the most prevalent age being 10 years.

Most studies relied on simple measurement tools such as step counters, counting steps from video-tape or measuring distance with tape measure and speed with a stopwatch. Four studies specifically reported carrying out inter-rater reliability checks of these measures.[19,25,26,29] Only six studies used standardized outcome measures[22,23,31,33-35] with the most common being the Gross Motor Function Measure[36] and the Pediatric Evaluation of Disability Inventory.[37] The single included randomized controlled trial[33] was the only one to use standardized measures for walking speed and distance. The10 Meter Walk Test[38] was used to measure speed and endurance and the travel subscale of the School Function Assessment[39] to measure walking function. These measures are reported to

Table 1. Characteristics of included primary studies.

Study	Design	AACPDM Level	*N*	Population	Intervention	Time	Results
Barnes and Whinnery, 2002[19]	SSRD MDB	Level II Single subject	5 total 3 used gait trainer	1. Hypotonic CP – 4 yrs 2. Hemiplegic and hypotonic CP – 3 yrs 3. Quadriplegic CP – 9 yrs	MOVE curriculum Rifton Pacer used with three students	Used daily in functional activities as per MOVE curriculum	1. Stable baseline 0 steps. Used gait trainer to increase walking to mean of 30.16 steps with assistance. Walking independently at 2 yr follow-up 2. Unable to step in baseline or intervention. Refused to use gait trainer in intervention but was able to walk 100 steps in gait trainer at 2 yr follow-up 3. 1.64 steps with adult assistance in baseline, 6.91 in gait trainer. Moved away and was not assessed at 2 yr follow-up
Behrman et al., 2008 [20]	Case report	Level V Group	1	4 1.2 yr old boy with severe incomplete SCI at C6/7	Treadmill and overground locomotor training including use of Kaye walker with suspension harness	20–30 mins treadmill and 10–20 mins overground training 5 x wk	Unable to make any independent movements with legs at start of locomotor training. Able to walk independently in rolling walker without body weight support at end of training period
Broadbent et al., 2000 [21]	Case reports	Level V Group	4	Quadriplegic CP– 9 yrs Diplegic CP – 14.5yrs Hypotonia – 8 yrs Quadriplegic CP – 8 yrs	Walkabout used in combination with LGS	3 x wk 30 mins/day 4 x wk 2 hrs/day 5 x wk 4 hrs/day 2–4 x wk 40 mins/day	Able to walk independently Walking distance and speed increased 3/4 able to walk outdoors as well as indoors
Eisenberg et al., 2009 [22]	Non-random 2 group study	Level III Group	22	CP GMFCS IV or V aged 3.5-10 yrs. 11 children in walking group mean 6.1 yrs. 11 age and sex matched controls mean 6.7 yrs	David Hart walker or static stander	4 x wk 30 mins day Walking group increased to 4.5 hrs wk ± 2.3 over 6 mos	Statistically significant: increase in PEDI mobility skills ($p=0.03$); and improvement in bowel function ($p=0.02$) in walking group. Moderate association between longer standing or walking times and BMD. Walking distance improved in intervention group but did not achieve functional speed
Farrell et al., 2010 [23]	Case report	Level V Group	1	CP – 10 yrs	Lite Gait Walkable, Up n Go and Rifton Pacer	3-5 x wk 30 mins/day for 4 wks	Able to walk 150 ft in Pacer with assistance to steer. Increased initiation of stepping and weight-bearing. Decreased hip flexion in stance. Improved transfers and bed mobility. Increased GMFM and PAM scores

(Continued)

Table 1. (Continued)

Study	Design	AACPDM Level	*N*	Population	Intervention	Time	Results
Lancioni et al., 2005 [24]	SSRD ABAB design	Level IV Single subject	1	Profound Intellectual disability and visual impairment. 13 yrs 1 month	Support walker with micro-switches. Stepping activated preferred stimulation during intervention phases.	5 mins, 2-4 x/day A – 20 sessions B – 43 sessions A – 18 sessions B – 116 sessions	Mean number of steps in first intervention phase – 45 steps with 3 indices of happiness. In first intervention phase this increased to 105 steps and 7 indices of happiness. There was a declining trend in second intervention phase and an increase again during second intervention phase. Change from baseline to intervention and second baseline to second intervention was significant for both number of steps and indices of happiness ($P<0.01$)
Lancioni et al., 2007a [25] Promoting foot-leg	SSRD ABAB design	Level IV Single subject	2	Profound Intellectual Disability – 10 yrs and 8 yrs	Support walker. Sensors placed on shoes. Touching foot to the floor activated preferred stimulation during intervention phases	5 mins, 3–5 x day Baseline sessions: 22 and 7; 12 and 15 Intervention sessions 96 and 48; 43 and 92	18 and 14 leg movements in first baseline phase First intervention phase – 52 and 82 leg/foot movements Second baseline - decline Second intervention phase – 58 and 129 leg/foot movements. Change in frequency between baseline and intervention phases significant ($P<0.01$)
Lancioni et al., 2007b [26] Automatically delivered	SSRD ABAB design	Level IV Single subject	2	Profound Intellectual Disability – 6.7 and 8.9 yrs	Support walker. Sensors on shoes. Stepping activated preferred stimulation during intervention phases	5 mins, 3–9 x day Baseline sessions: 16 and 11; 18 and 20 Intervention sessions: 77 and 112; 41 and 63	Baseline younger child – 35 steps increased to 75 in intervention. There was a decrease in second baseline and an increase to 100 in second intervention Older child had similar results but achieved higher step frequencies Step results were maintained at 1 month post intervention check Both children showed some increase in happiness indices during intervention and older child showed significant decline in aberrant behaviours during intervention phases and post-intervention check in comparison with baseline

Table 1. (Continued)

Study	Design	AACPDM Level	*N*	Population	Intervention	Time	Results
Lancioni et al., 2008 [27]	SSRD AB younger child ABAB older	Level IV Single subject	2	Profound Intellectual Disability – 3 and 12 years	Support walker with microswitches. Stepping activated preferred stimulation during intervention phases	5 mins, 2–5 x day 19 baseline and 72 intervention sessions - younger child. 17 and 16 baseline ; 81 and 262 intervention sessions - older child	Increased frequency of step responses with increasing trend during intervention phases. Decline with decreasing trend in second baseline phase for older child. Younger child: 6 in baseline – 56 steps in intervention phase. Older child: 18 and 79 steps during first and second baseline phases; 101 and 189 during first and second intervention phases. Difference between baseline and intervention (younger child) and combined baseline and intervention phases (older child) significant (*P*<0.01)
Lancioni et al., 2010 [28]	SSRD ABAB for 4 children AB for fifth child	Level IV Single subject	5	Profound Intellectual Disability Age 5.6, 6.5, 7.2, 11.4 and 10.1 yrs	Support walker modified with microswitches for two children and microswitches on shoes for others. Stepping activated preferred stimulation during intervention phases	5 mins, 2–7 x day 5-11 first baseline and 3–12 second baseline sessions 46–74 first intervention and 46-61 second intervention sessions	Increased frequency of step responses in intervention phases with decrease in level and slope during second baseline phases. Significant change (p<0.01) between combined baseline and intervention phases (and single baseline and intervention phases for child 5)
Lancioni et al., 2013 [29]	SSRD ABAB	Level IV Single subject	2	Profound Intellectual Disability Age 10.5 yrs and 12 yrs	Support walker modified with microswitches. Stepping or pushing walker activated preferred stimulation during intervention phases.	2–4 minutes, 4–19 x day for subject 1, 12–28 x day for subject 2 Baseline:15 and 16 sessions subject 1; 14 and 14 sessions subject 2. Intervention: 193 and 165 sessions subject 1; 112 and 346 sessions subject 2	Increased step/push responses in intervention phases with drastic decrease in level and slope during second baseline phases. Both were unable to achieve steps/pushes without adult guidance in baseline phase. During intervention phases subject 1 completed steps without guidance 85% of time and subject 2 independently pushed walker 80% of time

(continued)

Table 1. (Continued)

Study	Design	AACPDM Level	*N*	Population	Intervention	Time	Results
McKeever et al., 2013 [30]	Semi-structured interviews	Qualitative	19	Interviews with parents 3 years after their child began using walker. CP GMFCS III or IV aged 9-15.5 yrs at interview Mean 10.7 yrs	Hart walker	Not addressed	Parents value the physical benefits of being upright. They also reported psycho-social benefits such as improvements in communication and ability to participate with peers as well as enhanced freedom and independence
Van der Putten et al., 2005 [31]	Non-random pre-test post-test with control group design	Level III Group	44	Profound intellectual and multiple disabilities, 2-16 yrs 32 (mean 8.8 yrs) in intervention group and 12 (mean 10.6 yrs) controls. Two groups clinically comparable.	MOVE curriculum. Rifton Pacer gait trainer used as part of this program.	Daily in functional activities as per MOVE curriculum	Significantly increased independence in mobility skills in intervention group (P=0.001) moderate ES (0.69) Intervention: 20/32 increased, 4/32 decreased and 8/32 maintained level of independence. Controls: 4/12 increased, 3/12 decreased and 5/12 maintained level of independence
Whinnery and Barnes, 2002 [32]	Case study	Level V Group	1	CP – 3 yrs	MOVE curriculum. Rifton Pacer used as part of this program	In daily activities as per MOVE curriculum	Mean number of steps taken increased from 0 – 125 in gait trainer. Mean number of steps taken with adult assistance increased from 15–509
Willoughby et al., 2010 [33]	RCT	Level II Group	34	CP GMFCS III or IV 5–18 yrs Mean 10.35 yrs experimental group; 11.24 yrs control group	BWSTT vs overground walking. Children in GMFCS IV use gait trainers	30 mins, 2x wk for 9 weeks	No statistically significant difference between the groups. Trend towards increased distance walk in overground walking group
Wright et al., 1999 [34]	Pre-test post-test one group study	Level IV Group	20	CP GMFCS IV or V 4–12.8 yrs Mean 7.9 yrs	Hart walker	30 mins, 5 x wk	Significant improvement in: walking speed and distance (P<0.05); GMFM walk scores (P=0.006); and Directional Mobility Assessment scores (P=0.01) by 12 months. PEDI mobility scores significantly higher in walker (P<0.04) but did not change between 2 and 12 months. 6 children walked long distances indoors and out, 6 used in household and classroom, and 7 used for standing and exercise

Table 1. (Continued)

Study	Design	AACPDM Level	*N*	Population	Intervention	Time	Results
Wright et al., 2006 [35]	Pre-test post-test one group study. Assessed at 24 and 36 months follow-up	Level IV Group	19	CP GMFCS III or IV, aged 9–15.5 yrs at time of assessment after 3 years of use. Mean 10.7 yrs	Hart walker	13 children still used walker. Remainder too tall.	Walking speed unchanged from 12 mos. No significant change in GMFM scores from 12–36 mos. Significant gains on Directional Mobility Assessment (P=0.02). Increased self-care and social function scores at 24 mos on PEDI may be clinically but not statistically significant. Scores did not change from 24–36 mos

BMD: bone mineral density, BWSTT: body weight support treadmill training, CP: cerebral palsy, ft: feet, GMFCS: Gross Motor Function Classification System, GMFM: Gross Motor Function Measure, LGS: leg guidance system, MBD: multiple baseline design, MOVE: Mobility Opportunities Via Education, mins: minutes, PAM: Physical Abilities Measure, PEDI: Pediatric Evaluation of Disability Inventory, SCI: spinal cord injury, SSRD: single subject research design, wk: week, yrs: years.

have good test-retest reliability for children with disabilities. The only multiple baseline study[31] used the Top Down Motor Milestone Test, with modifications[40] and reports that it is a useful evaluative tool for measuring functional motor outcomes in children with severe and profound disabilities.

Outcomes were divided into ICF[11,12] components with details shown in Table 2. Body structure and function and participation outcomes were reported in only a few studies. The majority of included studies provided activity level outcomes with the largest group of studies measuring independence in mobility or walking.[20-23,31,34,35]

Discussion

Evidence supporting efficacy of gait trainers is primarily descriptive and, while impact is reported to be positive, no strong conclusions can be drawn. Use of a gait trainer to increase ability of children with cerebral palsy, Gross Motor Function Classification System level IV or V, to take steps and increase walking distance is supported by the highest levels of evidence identified in this review. However, the single small randomized trial[33] only suggests a trend towards increased distance in the overground walking group and cannot be considered high-quality evidence. The other level II study is a single-subject design[19] and includes only three participants using a gait trainer. Two non-randomized group studies[22,31] support impact on independence in walking and mobility level with one of these[22] reporting impact on bowel function and bone mineral density. Remaining lower-level evidence, case series and case-studies, provides support for positive impact on a range of activity outcomes including increased levels of overall independence, mobility, transfers, self-care abilities and posture. A group of single-subject designs[24-29] reports impact on affect, and motivation by adding sensory feedback to the gait trainer. One case series[35] and a qualitative study[30] support a positive impact on ability to participate with others and no evidence of harms or negative impact of gait trainer use was found.

From this review, the population that appears to benefit most from gait trainer interventions is children with cerebral palsy or related complex developmental delays. Two or three years-of-age appears to be the youngest age of introduction and is concerning as evidence around impact of upright positioning and mobility on motor and sensory,[41] visual[42,43] and social development[44] suggests that mobility assistive technologies should be introduced around nine to 12 months-of-age when children who are typically developing begin to explore their environment. While there appears to be little question that children with the more severe forms of cerebral palsy require the support of gait trainers, those children with mild to moderate forms (levels II and III) are unable to walk with hand-held walkers or independently below two years-of-age[45] and yet are typically not considered for gait trainer interventions that may facilitate weight bearing against gravity during this early critical period of sensory, motor, muscle and bone development. One case study involving a child with a spinal cord injury[20] provides support for the use of gait trainers as a transitional aid for children who have potential for more independent ambulation. Use of gait trainers with adolescents may be challenging due to difficulties with transfers and increasing physical limitations,[30,35] however, the motor growth curves suggest that adolescents with cerebral palsy tend to lose walking skills,[46] and gait trainers may assist in maintaining walking ability during this critical period.

The lack of experimental evidence identified in this review suggests that further research is needed to explore the broad range of outcomes that may be influenced by gait trainer interventions. Activity level outcomes should be explored with higher-level experimental designs while body structure and function and participation outcomes research should be expanded through a variety of research designs including qualitative and mixed-methods studies in order to establish a baseline of data prior to development of quasi-experimental or experimental studies. Psycho-social and quality-of-life impacts also merit further exploration as well as studies that compare different features and styles of gait trainers. There are significant difficulties inherent in carrying out more rigorous experimental designs and the lack of rigorous outcomes research for all assistive technology interventions may relate to a lack of sensitive or appropriate standardized outcome measurement tools.[47]

Table 2. Impacts on ICF domains.

Study	Body structure and function	Activity	Participation
Level II			
Willoughby et al., 2011 [33]		Increased distance	
Barnes and Whinnery, 2002 [19]		Increased # steps	
Level III			
Eisenberg et al., 2009 [22]	Improved bowel function Increased BMD	Increased mobility Increased distance	
Van der Putten, 2005 [31]		Increased independence Increased mobility	
Level IV			
Lancioni et al., 2005 [24]	Emotional function Motivation	Increased # steps	
Lancioni et al., 2007a [25]	Motivation	Increased # leg movements	
Lancioni et al., 2007b [26]	Emotional function Motivation	Increased # steps	
Lancioni et al., 2008 [27]	Motivation	Increased # steps	
Lancioni et al., 2010 [28]	Motivation	Increased # steps	
Lancioni et al., 2013 [29]	Motivation	Increased # steps	
Wright et al., 1999 [34]		Increased speed Increased distance Increased independent mobility	
Wright et al., 2006 [35]		Increased independent mobility Increased self-care	Increased social function
Level V			
Behrman et al., 2011 [20]		Independent walking	
Broadbent et al., 2000 [21]		Independent walking Increased speed Increased distance	
Farrell et al 2010., [23]		Improved transfers Improved bed mobility Increased mobility Increased distance Improved standing ability Improved standing posture	
Whinnery and Barnes, 2002 [32]		Increased # steps	
Qualitative			
McKeever et al., 2013 [30]		Increased independence Increased communication	Increased participation

BMD: bone mineral density, ICF: International Classification of Functioning, Disability & Health, #: number.

The Gross Motor Function Measure[36] is a criterion-referenced evaluative measure that has established reliability and validity for children with cerebral palsy.[48] While the 88 item version has been used to evaluate impact of walking aids on gross motor skills,[49] all standing and walking items cannot be completed by children who cannot walk unaided and therefore it may not be the most appropriate tool to measure outcomes of gait trainer interventions. Researchers in the Hart Walker studies[34,35] recognized this and developed other tools to measure change in independent mobility and quality of walking. The Supported Walker Ambulation Performance Scale (SWAPS) is designed to be sensitive to changes in gait of children who are unable to walk independently and preliminary inter-rater reliability and construct validity testing is encouraging.[50] It may be a more appropriate tool for future experimental designs. The Pediatric Evaluation of Disability Inventory[37] has established reliability and validity for children with cerebral palsy[48] and the mobility domain appears to discriminate between non-ambulatory children with or without a gait trainer.[34] However, in contrast to the social function and self-care domains, the mobility domain does not appear sensitive to change over time in older children with cerebral palsy.[35] In the case report by Farrell and colleagues,[23] the Physical Abilities Mobility Scale[51] was found to be more sensitive to changes in transfer and functional abilities in non-ambulatory children than the Functional Independence Measure for Children (WeeFIM).[52,53] These findings suggest that researchers need to consider carefully the age, population and outcomes being measured in order to select appropriate activity level outcome measures for future experimental research.

None of the included studies used standardized measures to explore satisfaction with the gait trainer or the 'fit' between the child, the technology and the various environmental factors. Standardized technology satisfaction measures[54,55] that have been used to explore impact of power mobility interventions on children with motor impairments[56,57] may be appropriate to consider for use with gait trainer outcomes research.

No research evaluating effectiveness of different types of gait trainers or evaluating their characteristics was found in this review and the following observations are based on clinical experience and background evidence. The Hart Walker, Mulholland Walkabout and newer models like the Prime Engineering KidWalk are all posterior hands-free walkers and parents may prefer this style with its more 'typical' appearance.[30] Using upper limbs for support when walking, may be detrimental to sensory development[41] suggesting that hands-free gait trainers may be more appropriate for younger children. Research with children using hand-held walkers[58,59] suggests that walkers with posterior configurations promote gait, posture and participation. However, older teens may have flexion contractures and an anterior gait trainer that offers upper extremity support may be preferred for this population. Some walkers (e.g. Rifton Pacer or Ormesa Grillo) can be used in either configuration. The Mulholland Walkabout and Prime Engineering KidWalk offer dynamic support and may allow for pelvic movement and weight shift. Research on dynamic seating[60] suggests that dynamic gait trainers may be beneficial for children with spasticity and dystonia.

There are a number of limitations to this study. Firstly, inclusion criteria were restricted to research studies published in English in peer-reviewed journals so grey literature and studies published in other languages may have been missed. The electronic search was challenging as many different terms have been used to describe gait trainers and more generic terms like walker or walking were difficult to narrow down. However, hand searching was effective in identifying more than half the studies that met inclusion criteria. The fact that no additional studies emerged in recent comprehensive reviews of interventions for children with cerebral palsy[61] and children and adults with intellectual disabilities[10] suggests that our search was relatively complete. Although, the search covered a long time period, early studies did not include outcomes information and so, all included studies took place in the last fifteen years and met similar reporting standards. One other limitation is that the quality rating used is only relevant to evidence level I-III studies and so excluded the majority of included studies.

Although the evidence supporting effectiveness is primarily descriptive rather than experimental, outcomes appear generally positive and no evidence of harm was found. No strong conclusions can be reached at this point and further research is needed. Clinicians should continue to measure outcomes for individual children to ensure that goals of intervention are being met for gait trainer interventions.

Clinical messages

- Gait trainers may assist development of independent stepping and walking distance for some children who are unable to walk without support.
- Observational evidence suggests that gait trainers may have a positive impact on body structure and function, activity and participation outcomes.

Conflict of interest

The first author has worked as an educational consultant for various manufacturers and suppliers of gait trainers. Funding from these sources did not influence or bias the content of this work. The second author reports no conflict of interest. The authors alone are responsible for the content and writing of the paper.

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