

Review

The Experience and Use of Power Mobility by Children with Complex Non-Ambulant Cerebral Palsy: A Scoping Review

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Abstract

Background/Objectives: To map the literature and describe the meaning, use, and experience of power mobility for children with complex non-ambulant cerebral palsy (Gross Motor Classification System (GMFCS) levels IV–V and Manual Abilities Classification System (MACS) levels III–V). **Methods:** Included searches in five electronic databases, grey literature, and hand searches with no restrictions on date, study type, or language, as well as independent duplicate screening and data extraction. Outcomes and experiences were mapped to the integrated F-words Interdependence Human Activity Assistive Technology (iHAAT) framework. **Results:** In total, 90 studies, from randomized trials to case reports and qualitative designs, included 916 children (10 months–18 years; 432 GMFCS IV; 262 GMFCS V; 222 GMFCS IV/V), with 351 parents, therapists, or educators. Only 32 studies reported MACS levels. Power wheelchairs were used by 724 children (68 used switches rather than joysticks). Other children used modified ride-on cars, specialty pediatric devices, or platform/smart training devices. Based on 22 studies where this information was provided, alternate access/control methods were primarily used by children classified at GMFCS/MACS V, but there was considerable variability. Introduction predominantly occurred in natural settings with limited training or support. Significant and meaningful improvements in power mobility use were reported for intensive play-based, child-led, and caregiver-supported approaches; for virtual training with joystick users; and for skills-training approaches with older children who already achieved functional power wheelchair use. **Conclusions:** Children classified at GMFCS IV and V may benefit from power mobility experience to promote fitness, functioning, friends, family, fun, and future outcomes. Their use and experience of power mobility may be interdependent with parents, therapists, and educators, changing attitudes and perceptions of child potential.

Keywords: adolescents; child; preschool; infants; power wheelchair; assistive technology; cerebral palsy; power mobility; mixed methods



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1. Introduction

Cerebral palsy is an umbrella description including all permanent or non-degenerative disorders of movement and posture due to disturbances in the developing brain, regardless of underlying cause [1]. It is the most common childhood-onset disability, with prevalence estimates ranging from 1.6 to 3.4 per 1000 live births worldwide [2]. The Gross Motor Function Classification System (GMFCS) classifies individuals with cerebral palsy according to their functional mobility and need for assistive devices. Those classified at levels IV and V are considered non-ambulant and primarily use wheeled mobility. Children classified at GMFCS IV require power wheelchairs (PWC), also known as motorized or electric wheelchairs, for efficient, autonomous mobility, but may wheel a manual wheelchair for short distances or walk indoors using a supported stepping device, also known as a body-support walker or gait trainer. Children functioning at GMFCS V are typically pushed by others in tilt-in-space manual wheelchairs, although some use PWCs with complex adaptations, including specialized seating and alternative access or control methods [3].

Manual Abilities Classification System (MACS) also ranges from I–V [4]. Children classified at level III can handle simple or adapted objects with occasional support; those at level IV can handle a limited selection of easily managed objects with continuous support, while those at level V usually require support to handle any objects, but may be able to target a single switch. MACS IV or V classifications are most common in children classified at GMFCS V [5,6] and those with spastic tetraplegia or dyskinetic cerebral palsy [7]. Children with non-ambulant cerebral palsy are also more likely to have other associated impairments, including visual, speech-language, communication, and intellectual impairments [8–11].

Although not standardized in the literature, the term *complex non-ambulant cerebral palsy* is used in this manuscript to describe individuals classified at GMFCS IV–V who have limited manual abilities (MACS III–V) and present with tetraplegia (also referred to as quadriplegia) rather than diplegia. These children typically use multiple assistive devices to increase their independence, engagement, and occupational participation [12]. Children with complex non-ambulant cerebral palsy are often interdependent with others, and positioning and mobility devices may be used to increase autonomy, agency, and engagement rather than with the goal of achieving complete independence [13].

Young children are typically moving and exploring actively by the end of the first year of life, and this exploratory behavior promotes a cascade of developmental changes [14]. Children with complex non-ambulant cerebral palsy, also have a right to “On-Time” (age-appropriate) mobility experiences [15]. Power mobility devices afford independent mobility, enabling age-appropriate exploratory behaviour, enhancing overall development, and promoting occupational participation [16]. Power mobility experience (playing in or using a power mobility device) may also promote changes in self-initiated behaviour and socialization in older children with complex non-ambulant cerebral palsy [17]. These experiences may be perceived as meaningful, increasing learning and exploration opportunities and promoting developmental and social gains even for those who may not develop competent PWC use [17,18]. Both negative and positive emotional responses have been reported in relation to children’s use of power mobility, and physical, social, and attitudinal barriers influence opportunities, experience, and use [18,19].

Power mobility devices include PWC as well as modified commercially available powered ride-on toys or cars (MROC), specialized developmentally appropriate devices for very young children (e.g., Explorer Mini (EM), Wizzybug, Bugzi, Baby Loco, Freeli, etc.), and powered platforms and/or smart wheelchairs or training devices [18–21]. These devices are propelled using battery power rather than manual (arm or leg) power and are operated using joysticks or alternative access or control options. These options include different access sites (hand, fingers, head, chin, mouth, arm, foot, etc.) and control devices

such as manual or electronic switches, head and eye tracking technology, and even brain-computer interfaces [22–26].

Selection and use of assistive devices, such as power mobility, are influenced by factors within the person (abilities, needs, and roles), the activity (including occupational participation), and the context (physical, social, and attitudinal). The Human Activity Assistive Technology (HAAT) model is the most long-standing assistive technology model [27] and has more recently been modified with an interdependence frame that emphasizes the relationships between all people interacting with the device, the interdependence HAAT or iHAAT model [28].

The F-words for child development [29,30] are a child and family-friendly adaptation of concepts from the International Classification of Functioning, Disability, and Health (ICF) [31]. Fitness relates to the ICF concept of body structure and functioning (BSF) and includes mental as well as physical well-being. Functioning relates to activity and participation. Friends or friendships, as well as fun, relate to both personal factors and participation. Family is the most important environmental factor for children; future, while not included in the ICF, is a vital focus for child development. The iHAAT model was previously integrated with the F-words in relation to use of supported standing and stepping devices with children with non-ambulant cerebral palsy and emphasizes the interdependence that is common for this population [13].

While reviews of power mobility outcomes for children with disabilities have previously been published, most include mixed populations [19,20,32,33] or focus on the use of specific devices such as MROC [34,35]. Only one review specific to children with cerebral palsy was previously published, a systematic review of the effectiveness of manual and power mobility for promoting mobility, activity, participation, and quality of life in children and adolescents with cerebral palsy aged 6–21 years [36].

A number of quantitative and qualitative research studies have been published since all previous reviews were completed. Despite the importance of power mobility for this population, no reviews to date have focused on the meaning, lived experience, perceived benefits, and outcomes of power mobility introduction and intervention for infants, children, and adolescents with complex non-ambulant cerebral palsy. A scoping methodology was selected to map the literature related to the meaning and experiences, usage, training characteristics, and outcomes of power mobility interventions for children and young people classified at GMFCS IV and V, with limited hand function (MACS III-V) and associated complex impairments and limitations. The adapted F-words iHAAT model [13] was modified to power mobility interventions and used as a framework to help illustrate the data in line with contemporary approaches to childhood-onset disability.

The review was guided by the following question:

- What is known about the meaning, experience, use, perceived benefits, and outcomes of power mobility in childhood for individuals with cerebral palsy, classified in GMFCS level IV and V who have limited manual abilities and/or other associated impairments?

Sub-questions articulate the scope of the inquiry:

- How do the experiences of relevant parties compare or differ, e.g., children, parents, caregivers, teachers, therapists, etc.?
- Are there data to indicate rates of power mobility use and associations between GMFCS and MACS levels, control methods (joystick, switch, or other), and devices?
- How do different methods of introduction or intervention compare or contrast, and do these differ for different age groups, GMFCS or MACS levels, control methods, or devices?

- Are different experiences or outcomes reported for different age groups, GMFCS or MACS levels, control methods, or devices?

2. Materials and Methods

The JBI methodology for scoping reviews [37] was followed, along with earlier guidance [38–40]. Reporting followed the PRISMA ScR statement [41] (See Supplementary Materials Table S1 for details). The protocol was registered a priori on the Open Science Framework on 18 October 2025 and may be retrieved at <https://osf.io/kme4r/overview>, (accessed on 22 May 2026).

An electronic database search was undertaken from database inception to October 2025 and included MEDLINE via PubMed; CINAHL via *Ebscohost*; and EMBASE and CENTRAL via OvidSP. Google Scholar searches included the first 50 results (number selected pragmatically based on prior exploratory searches) for each of the following search phrases: power mobility children; power wheelchair children; electric wheelchair children; ride-on toy children.

Reference lists of included studies were hand-searched along with clinical trial registers (<https://clinicaltrials.gov>; <https://www.isrctn.com/>). Conference proceedings from the previous 5 years (Rehabilitation Engineering Society of North America (RESNA), International Seating Symposium, and Oceania Seating Symposium) were checked to identify authors and studies in process. Trial registrations, theses, papers, or workshops associated with an included published study were considered secondary publications, and only unique reports not published elsewhere were included.

Search terms included key words for population (e.g., “cerebral palsy,” “spastic quadripleg*,” “tetraplegi*,” “disabil*,” “caregiver*,” “parent*,” “therapist*,” etc.) and intervention (e.g., “power* mobility,” “power* wheelchair,” “electric wheelchair,” “ride-on toy,” “ride-on car,” “explorer mini,” “Wizzybug,” “EPIOC,” etc.) with * indicating wildcard for word endings. Database-specific subject-headings were also included, e.g., Cerebral Palsy/, Child/, Adolescent/, Infant/, Preschool/, Parents/, Physical Therapists/, Wheelchair/power, etc. No limits were placed on design, age range, language, or publication status. Google Translate or DeepL were used to translate any references identified in languages other than English. See Supplementary Materials Table S2 for the detailed search strategy for each database.

2.1. Eligibility Criteria

Two authors (R.W.L. and G.S.P.) independently reviewed all titles, abstracts, and full-text articles in Covidence (www.covidence.com, accessed on 22 May 2026) and agreed for those to be included through discussion. Self-authored articles were independently reviewed by two other authors (e.g., studies by R.W.L. were reviewed by L.N. and P.G.; study by L.N. was reviewed by R.W.L. and G.S.P.). Primary source studies (qualitative or quantitative) including children (≤ 18 years) with cerebral palsy or “cerebral palsy-like” descriptions (e.g., congenital brain malformations, brain injury before age 2 years, periventricular leukomalacia, hypoxic ischemic encephalopathy, congenital Zika syndrome, etc.) and meeting criteria for complex non-ambulant cerebral palsy were included. Where GMFCS and MACS levels were not reported, they were confirmed through author contact. Where this was not possible, GMFCS level was estimated as level IV, level V, or IV/V, based on manuscript details and consensus of two reviewers (R.W.L. and G.S.P.). Where these two reviewers were unsure or disagreed, reported descriptions of child functioning were sent to at least two external experts for confirmation. Where insufficient information was available or agreement could not be reached, articles were excluded.

Survey and cross-sectional studies were included to extract population descriptors and/or power mobility usage data, as were articles focused on measurement properties of a tool or device development. Review articles and descriptive articles without data (e.g., letters, commentaries, and opinion pieces) were excluded. Outcome and lived-experience data were only extracted from studies that included at least 50% GMFCS IV/V, or data for these children could be extracted separately or were provided by the author. For studies including relevant parties (e.g., parents, family members, caregivers, therapists, assistants, teachers, etc.), at least 50% participants were identified as having relevant experience, or quotes/themes were clearly related (e.g., quotes from a parent of a child with cerebral palsy). Where outcome/findings data could not be separated, only descriptive population and intervention usage data were extracted. Where multiple publications were retrieved for the same study, these were reported together as one study with multiple outcomes.

2.2. Data Extraction and Mapping

For children meeting population criteria, data were extracted on age, GMFCS, MACS, and other associated impairments or co-morbidities, power mobility use, introduction, experience, control method, device, or training, and outcomes/findings were grouped according to the F-words and to the IHAAT concepts by two independent reviewers in Covidence. Guidance from a systematic review protocol regarding mapping of outcomes to the F-words was followed [42]. Other than self-authored articles, data were extracted from all studies by one reviewer (R.W.L.), with one of three authors (G.S.P., P.G., or L.N.) acting as second reviewer. Data extraction from self-authored articles was completed by two independent reviewers as detailed above. Agreement in all cases was reached through consensus and discussion.

For data and usage-mapping purposes, the following rules governed counts: (1) Population: participants were counted only once according to GMFCS or parties relevant to children classified as GMFCS IV/V (parents, therapists, educators, etc.) in (a) studies published over several manuscripts and (b) separate studies that included the same population or part of the same population at a later time period. (2) Publication Years: where a single study was published over several manuscripts in different years, the entire study was counted as being published in the year of the main publication. (3) Study design: since studies frequently used multiple study designs or approaches, the number of manuscripts was counted. Quality appraisal was not relevant to this scoping review's purpose of mapping the literature and describing use, meaning, and experience.

Based on duplicate data extraction, outcomes and lived-experience data from each study were grouped, mapped to F-words and iHAAT framework, summarized in tables and figures, and agreed with all authors. Lived-experience contributors (B.W.F. and D.C.) provided feedback on clarity, relevance, and interpretation of findings. They also contributed narratives illustrating their user perspectives. Microsoft Excel, PowerPoint, or Canva (www.canva.com, accessed on 22 May 2026) were used to create study figures and for descriptive statistics summarizing results.

3. Results

Database searches yielded 1208 references, and a further 12 references were identified through hand-searching and author contact. After duplicate removal, 599 references remained, and 155 articles were sought for full-text following title and abstract review. Three citations could not be retrieved: an article from 1992 and two clinical trial registrations where we could not identify author contact details or associated publications. Following full-text review, 35 citations were removed for various reasons: wrong population [43–49]; device description only [50]; secondary publication for an included study [51,52]; protocol

for a study not yet completed or analyzed [53,54]; or GMFCS not reported or unclear/ data for complex non-ambulant cerebral palsy not able to be separated [55–77]. See Figure 1 for the study flow diagram.

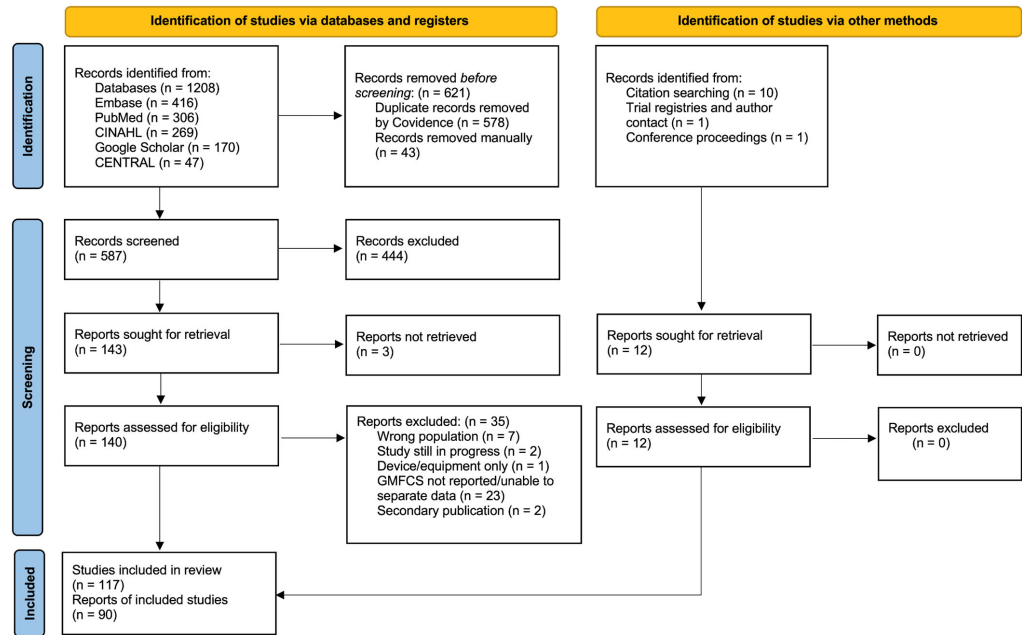


Figure 1. Study search flow diagram.

In total, 117 articles were included in the descriptive mapping portion of the review, representing 90 unique quantitative, qualitative, or mixed-methods studies. Figure 2 illustrates study locations, publications, and the increase in studies over time.

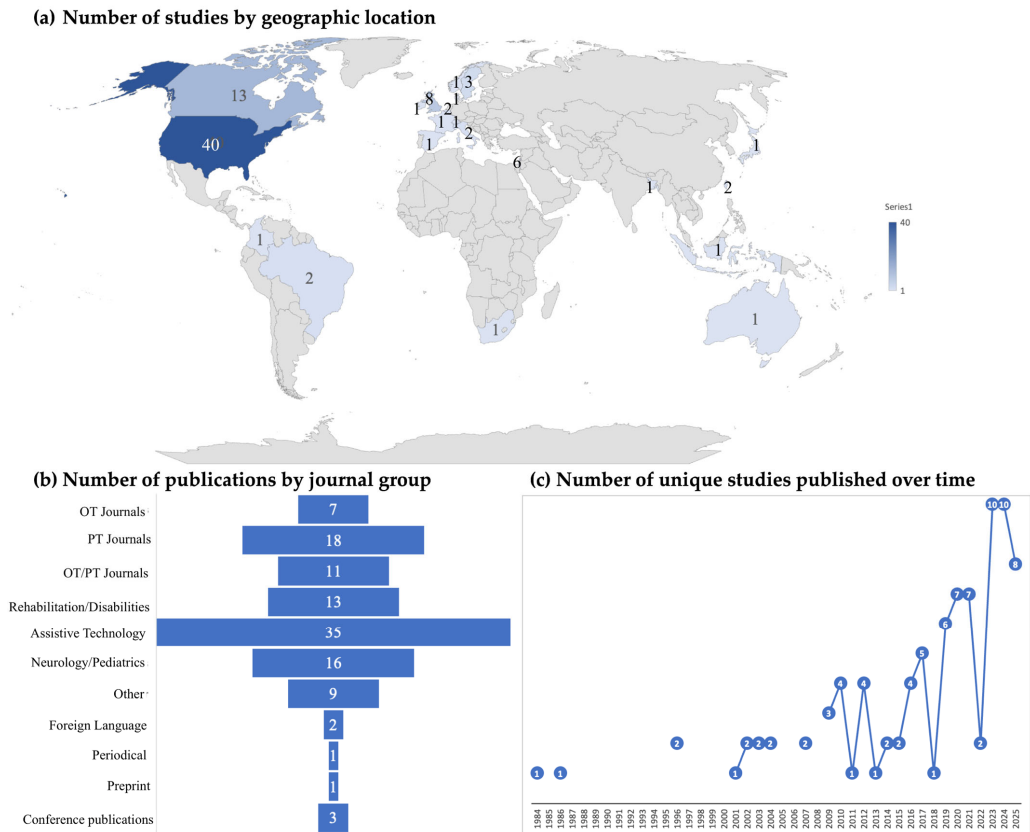


Figure 2. (a) Unique study locations, (b) manuscript sources, and (c) unique studies published over time.

3.1. Included Studies and Designs

Two randomized controlled trials (RCTs) compared PWC use to standard care on child development and functioning over 12 months [78,79]. Some results from the second RCT were published in a secondary analysis of factors influencing proficiency across both RCTs [80]. A qualitative study also explored parent experiences from the first RCT [81].

A pilot RCT focused on cause–effect with a single switch and included four children, with two using a platform trainer [82]. A randomized crossover trial compared outcomes from two different devices (EM and MROC) over 16 weeks and was reported over six manuscripts: two main publications [83,84], two qualitative analyses of parent interview data [85,86], a secondary quantitative language analysis of the interview data [87], and an examination of differences between usage reported via parent logs and built-in data loggers and/or global positioning systems (GPS) [88]. The only other quasi-randomized study compared virtual and physical PWC training [89]. Data from the same children were used to establish measures' psychometric properties [90].

Several single group studies took the form of interrupted time-series trials with a participant-controlled usual intervention baseline period followed by an intervention period with before and after measures. One described a 3-week intensive training as part of a school camp. Manuscripts described feasibility with the first five participants [91], examined outcomes for the entire group of 24 students [92], and explored the views of educational and therapy staff [17]. Two older studies included several months' baseline followed by PWC use for an equal number of months [93–95]. One study explored the impact of a power wheelchair standing device (PWSD) on participation [96]. A recent study examined the effects of 3-week training (based on the Wheelchair Skills Training Program [97]) in 12 adolescents and young adults [98]. This study was accompanied by a manuscript examining measurement properties of the Wheelchair Skills Test (WST) (<https://wheelchairskillsprogram.ca/en/skills-manual-forms/>, accessed on 22 May 2026) and the questionnaire version (WST-Q) [99] in the same population [100]. Another time-series MROC study included one child at GMFCS IV [101], with qualitative findings in an accompanying manuscript [102].

Remaining single-group studies included pre-post measurement [103,104]. A brain control interface (BCI) study [24] included earlier feasibility [105] and pilot studies [106]. One study [107] also included a PhotoVoice narrative project [108]. One two-phased study [109,110] had three associated manuscripts [111–113]. Two manuscripts described outcomes from the Indie-trainer clinical trial where use of a platform training device was combined with video gaming activities [114,115], and a recent post-test study examined impact on sleep following use of the EM [116].

Remaining quantitative designs included case series [117–129], single-subject designs [130–136], and case reports [137–147]. In total, 17 qualitative studies were not already cited as part of larger mixed-methods studies [148–163], including a PhotoVoice study [164], with four accompanying manuscripts [165–168]. Use and population data only were extracted from remaining cross-sectional studies [169,170], statistical analyses [171,172], population-based cross-sectional studies [173–178], measurement [25,179–184], technological training, and device development studies [185–193].

Figure 3a illustrates the relative proportions of research designs or study focus per included manuscript across the review. Randomized designs are at least represented ($n = 6$), while qualitative studies ($n = 25$) are most prevalent. Figure 3b illustrates the number of studies using various types of outcome measures. Individual studies frequently used more than one type of measure as well as more than one measure within each category. Online Supplementary Material Table S3 provides details of all included studies.

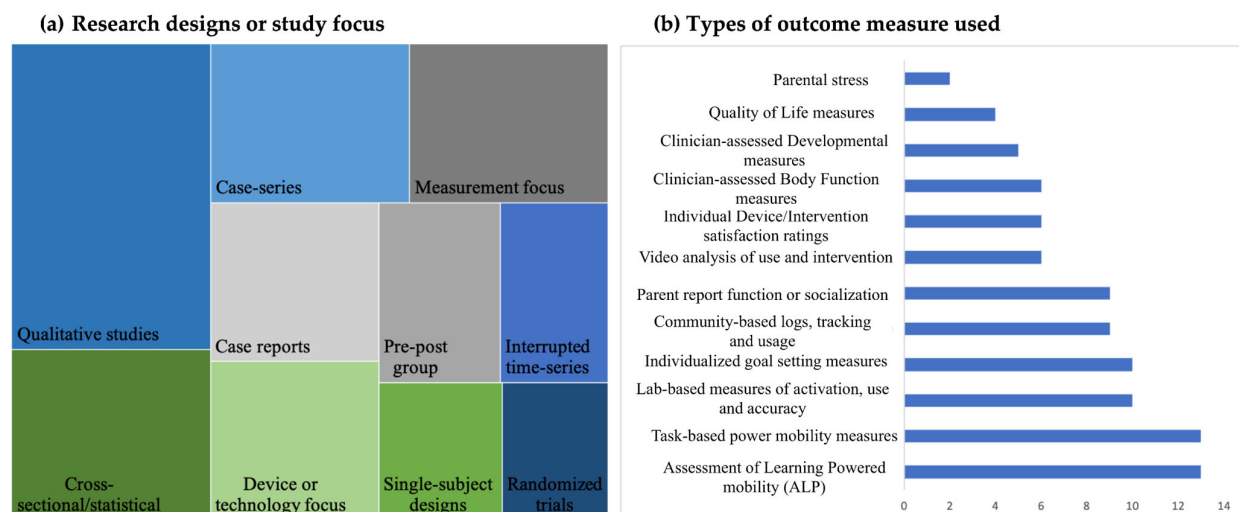


Figure 3. (a) Proportions of research designs or study focus and (b) numbers of studies measuring each type of outcome.

Progress in power mobility learning and use was most frequently measured. In total, 13 studies [24,89,92,107,110,114,119,132–134,136,139,146] used the Assessment of Learning Powered mobility use (ALP) instrument [194], a process-based measure. The same number [78,89,92,93,98,110,119,122,133,134,136,144,146] used validated task-based measures, with the Power Mobility Program (PMP) [195] or one of its many derivatives being most reported. In lab-based settings, counts of switch or joystick activations, distance travelled, and accuracy in completing obstacle courses were measured, while in community settings, use was tracked using parent logs, GPS, and/or device-specific tracking systems.

Individualized goal-setting measures such as the Canadian Occupational Performance Measure (COPM) [196] or Goal Attainment Scaling (GAS) [197] were also highly reported, while a few studies [92,96,109] reported the Wheelchair Outcome Measure for Young People (WhOM-YP) [182]. Parent report of child function or socialization was most commonly measured with the Pediatric Evaluation of Disability (PEDI) or PEDI-CAT [198,199]. Only five studies used norm-referenced developmental measures [78,79,83,84,103].

3.2. Population Characteristics

In total, 916 children and adolescents with non-ambulant cerebral palsy aged 10 months–18 years were included. GMFCS was estimated by review authors for 122 children. Of these, 106 were classified as GMFCS IV/V, as an individual level could not be confidently assigned. For a number of older studies, original study authors were also only able to confirm GMFCS as IV/V. MACS was reported in only 32 studies; 88 children were classified as MACS V, 99 as MACS IV, and 87 as MACS III. Associations between MACS levels and power mobility use could therefore only be meaningfully addressed for a small group of studies rather than across the entire review. Studies commonly described children as having spasticity ($n = 19$ studies), with accompanying cognitive ($n = 16$ studies) or visual impairments ($n = 17$ studies). Additional descriptors used were hypotonia or dystonia ($n = 7$ studies each), athetosis or dyskinesia ($n = 6$ studies), or ataxia ($n = 3$ studies).

A total of 351 other relevant parties were included: parents (or caregivers), therapists, and educational staff. Only two studies included feedback directly from siblings [146,159], although parents frequently referred to improved relationships with or increased interaction or participation with siblings. Significantly more mothers than fathers were directly included in studies. Figure 4 illustrates participants across all studies, as well as the GMFCS profile of individual children within different quantitative designs.

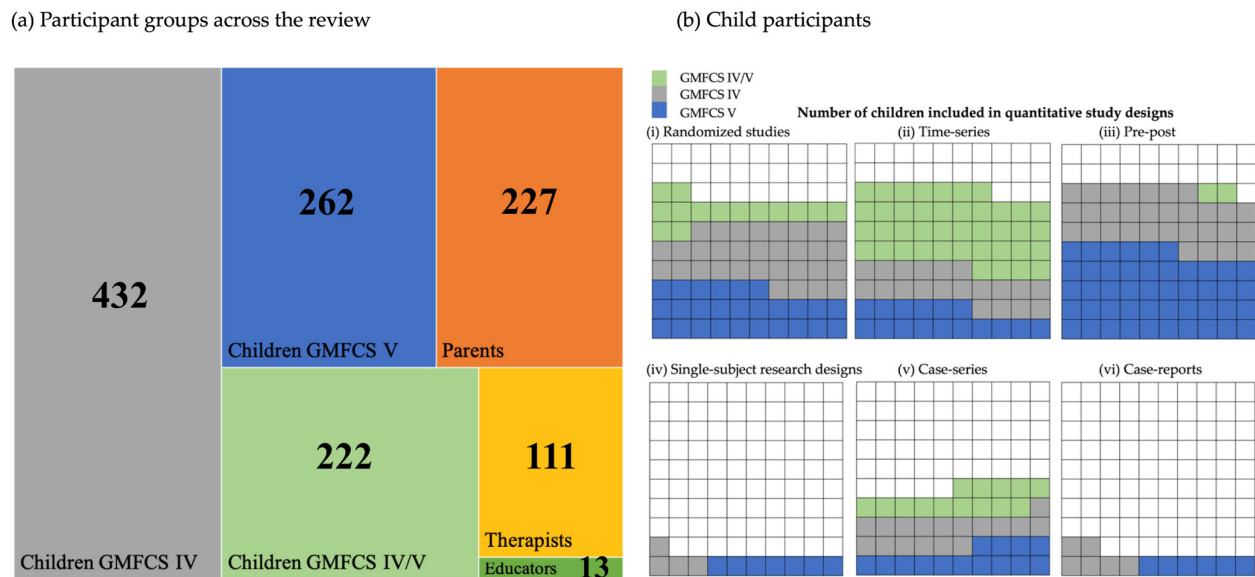


Figure 4. (a) Numbers of participants in each group noted on graphic illustrating relative proportions of participants across the review (b) distribution of child profile within quantitative study designs. Note: each completed square represents one participant. Each grid contains 100 squares, illustrating percentage of participants within each design.

Most qualitative or mixed-methods studies involved analysis of semi-structured interviews, and participants were primarily parents or therapists. Researchers conducting grounded theory or case study research observed 14 children aged 4–10 years [150,156,162]. One 5-year-old also participated with his mother in semi-structured interviews and in a photovoice project [162,163]. Two other photovoice studies included parents of children who were very young and/or had multiple and complex disabilities [108,164]. Seven children classified as GMFCS IV/V aged 7–12 years, using a combination of speech, symbols, signs, and other alternative communication methods participated in a focus group study [150]. The only other study accommodating alternative communication methods included 17 children, 7–18 years who answered close-ended questions regarding their experiences of a 3-week power mobility camp [92]. Additionally, 19 other children aged 11–18 years participated in semi-structured interview studies, but of these, only six children or adolescents participated without parent proxy report or parent assistance [151,152].

3.3. Device and Access Characteristics

A variety of devices were identified in this review. The largest number were PWCs, including standard PWCs (used in a sitting position) and PWCs with sit-to-stand capabilities (PWSDs). Younger children often used MROCs or specialty (commercially available, developmentally appropriate) power mobility devices. Remaining children used either platform training devices or smart wheelchairs.

Apart from the large population-based datasets ($n = 192$) [175–178], PWCs were used with 532 children from 12 months–18 years, average age 10 years. An additional eight children aged 5–18 years used PWSD [96,126,135]. Population-based data suggest that few children use PWCs as their usual means of mobility before school age [176–178]. Although use has increased over the last 10 years, it is still most limited at younger ages for children classified as GMFCS IV and V and MACS III–V [178].

MROCs were used with children aged 10 months–6 years, mean 31.12 months. Specialty devices were used with children aged 12–68 months, average 26 months. Some children used more than one device: in a randomized crossover study, children used both MROC and EM [83–88]; in a cross-sectional study, children compared MROC, a mini PWC,

Wizzybug, and Bugzi [112]; and in a case report, twins used GoBot, MROC, and a mini PWC sequentially [146]. Platform training devices and smart wheelchairs were used with more complex children from 3–18 years, average age of 9 years. Figure 5 illustrates the use of various devices by the number of children and by number of studies.

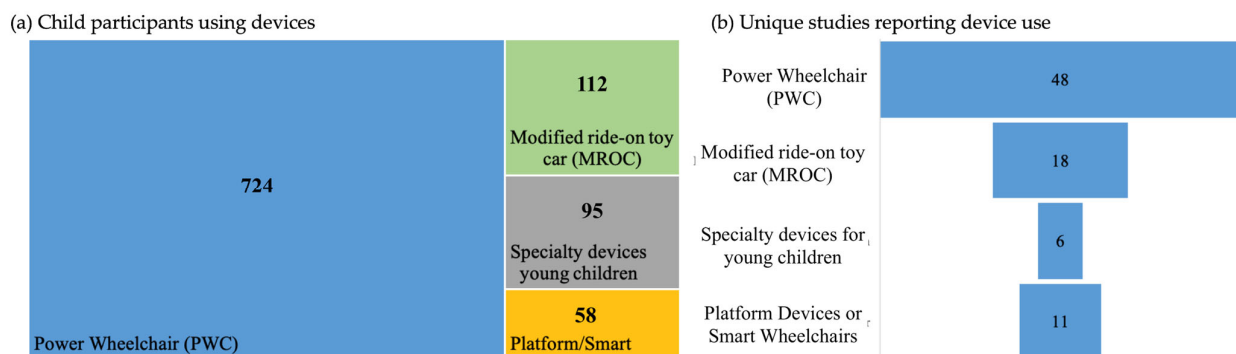


Figure 5. (a) Number of children using each device type and (b) number of unique studies reporting device use.

Other than one early study [130], the access site and control method were noted for all intervention studies. Hand-accessed joysticks were most commonly reported, although at least two children (both GMFCS V and MACS V) accessed the joystick using their foot [92], and another study included a chin joystick user [151]. From the 21 studies where control method and access site were clearly reported for PWC or PWSD, 241 children used joysticks, but less than half of these studies provided MACS levels. GMFCS for this analysis was estimated by review authors for 32/309 (10%) children. One study compared a bimanual control with side-mounted joystick and measured improved steering control and posture for six children, classified at GMFCS IV [185].

Switch control for PWC use was reported for 68 children, including one child using PWSD with a head array [96]. One case report described single-switch scanning using a knee switch [141], while another study reported 29 children using either switches or scanner, but access site and numbers using scanning were not differentiated. This same study reported that 24 children used head, chin, or foot to access either joystick or switch [172].

Four MROC studies included joystick use [104,131,139,191], while the rest were single-switch only. Although almost all children using MROC accessed the switch using a hand or fingers, MACS levels were rarely reported. Only one study described a child using head access for a single switch [123]. Also, 16 children at GMFCS V, 14 at GMFCS IV, and 10 estimated as GMFCS IV/V used the EM midline joystick [83,116,169].

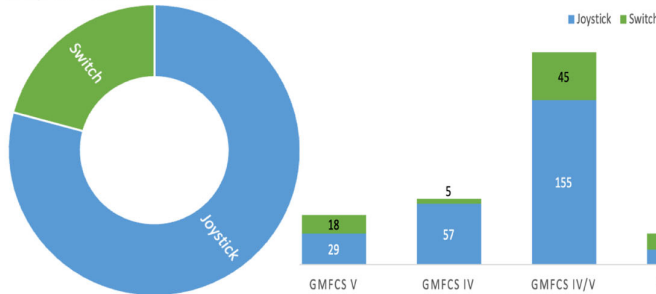
All children using platform training and smart wheelchair devices used switches or digital joysticks, although two transitioned to proportional joystick use [117]. Remaining children primarily used hand-accessed switches, although three used head access [117,134,145] and one child used his tongue to access three switches [119]. In total, 11 children classified at GMFCS V used brain control access within various phases of the BCI project using a platform trainer or modified switch-accessible PWC [24,105,106].

In total, 12 PWC/PWSD [17,89,91,96,98,132,135,141,144,179,181,182,193] and 10 platform trainer [24,119,120,133,134,136,145] or smart wheelchair [117,118,122] studies provided individual GMFCS and MACS profiles for children using various access sites and controls. All children, in these studies, who used foot joystick, head array, head and tray switches, and knee or tongue switch access were classified as both GMFCS V and MACS V, as most were using head and foot switch access or BCI. Several children, however, also classified at GMFCS and MACS V, used proportional joysticks. GMFCS and MACS classifications were estimated by review authors in 8/84 (9.5%) of these children. MACS

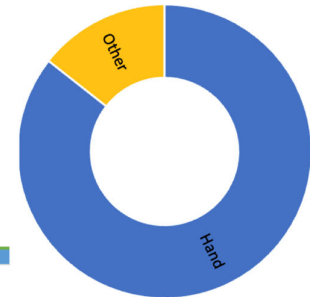
was rarely reported for MROC users, limiting our abilities to characterize the relationship between manual abilities and device use. Figure 6 illustrates access site and controls used for PWC or PWSD, MROC, and platform or smart training devices.

(a) PWC and PWSD access and control methods

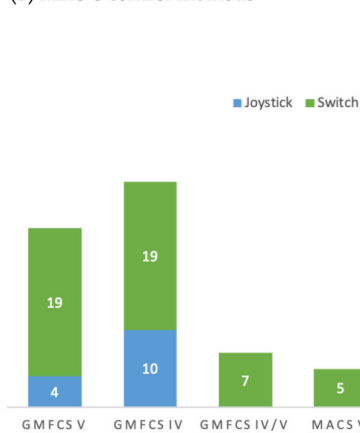
(i) Joystick versus switch control



(ii) Hand versus head or other access site



(b) MROC control methods



(c) Individual profiles for PWC, PWSD or Platform/Smart trainers

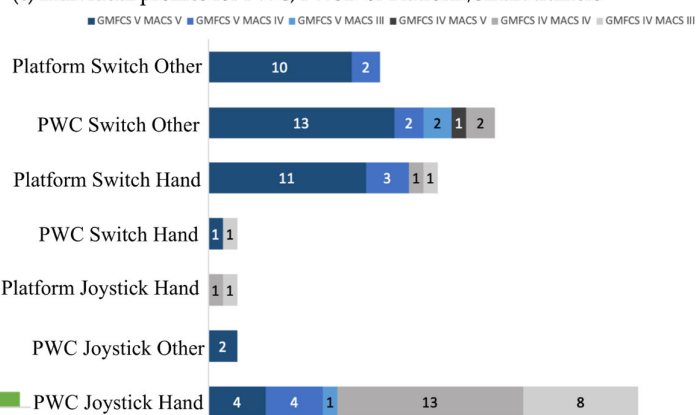


Figure 6. (a) (i) Proportions (left donut diagram) and numbers (bar chart) of children using joystick or switch for PWC or PWSD and (ii) proportions of hand versus other access methods for PWC or PWSD. (b) Numbers of children within each classification using joystick or switch for MROC. (c) GMFCS and MACS profiles for various access and control methods of 84 children using PWC, PWSD, platform trainers, or smart wheelchairs. Note: numbers of children within each profile grouping are illustrated on the bar charts.

3.4. Training and Intervention Characteristics

Introduction and training approaches varied widely. The majority of studies took place in natural settings such as home, school, or community, with no specific description of the training approach or support. Where formal training was provided, child-led and play-based approaches were commonly described. Five studies [92,114,116,124,132] used the ALP facilitating strategies [200], developed through Nilsson's work following her initial Driving to Learn study [156]. Two studies used motor-learning strategies [98,122], while most reported an individualized approach, dependent on child age and stage of learning. Level of therapist support provided to parents providing training in natural settings ranged from initial setup and safety training [44,104,162,163,171,172,191], intermittent therapist support [78,83,96,109,110], and structured weekly [116,127,138,140,143] every 2 weeks [103] or graduated timing (from several times weekly to less intense over time) [79,80].

Technology-assisted training tools ranged from virtual reality practice [89,187,193], smart wheelchair learning tools [117,118,122], video gaming to support practice [114,201], and robotic or biofeedback tools [186,190]. Structured training programs ranged in length and intensity. The two most intensive contrasted in approach, although both achieved statistically significant outcomes for their differing populations. One was adult-led structured training for adolescents who already had their own PWC [98], while the other was

play-based, used the ALP-facilitating strategies, and included children at the beginning phases of power mobility learning, with cognitive and sensory limitations [17,91,92].

Few studies directly reported the amount or intensity of use achieved during home and community-based training. Across studies, a minimum of 60 min weekly use (≥ 3 sessions of 20 min) emerged as a common recommendation for achieving developmental gains. Participants using virtual reality or PWC training in home settings achieved 20 min sessions, four times a week [89], and an MROC study made the same recommendation, although the child at GMFCS IV achieved 48 min per week [101].

The secondary analysis comparing developmental change with time spent using EM or MROC determined that children who achieved more than 60 min weekly use demonstrated developmental change regardless of device or GMFCS level [84]. Varying use was measured in MROC studies, from 27–87 min per week in one study [127], while another measured significantly different developmental gains and change in power mobility learning in children who spent almost identical total time but significantly different number of sessions [103]. Figure 7 illustrates training approaches reported across all studies and intensities of training reported in clinic or lab-based interventions.

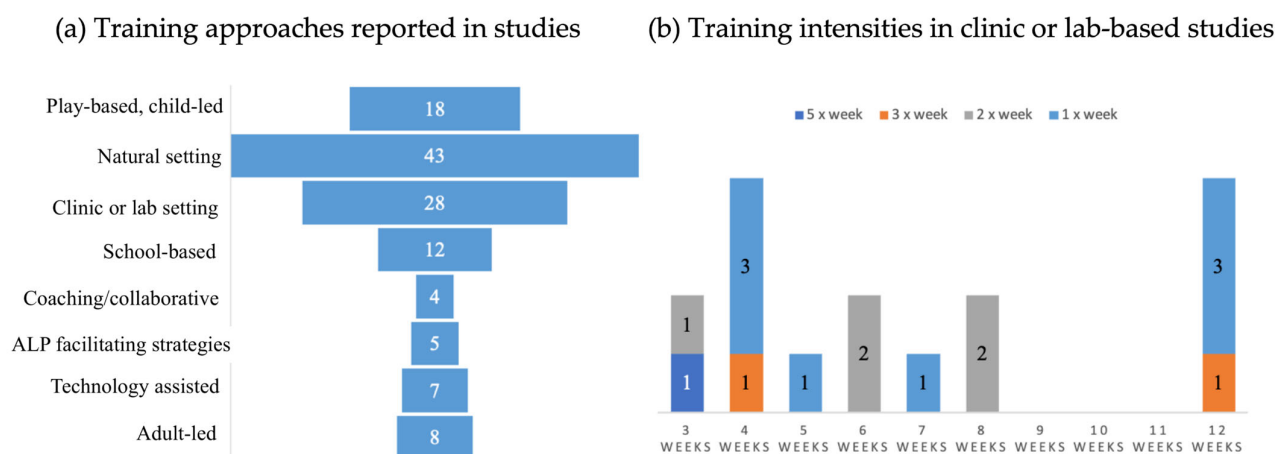


Figure 7. (a) Training approaches reported by number of studies, describing use of each approach. (b) Training intensities: number of studies by number of sessions per week over number of weeks. Note: More than one approach was reported in some studies.

3.5. Outcomes and Lived Experience

3.5.1. Quantitative Outcomes

Outcomes were grouped according to F-word [29,30] and iHAAT concepts [13,28] by two independent reviewers in Covidence and later agreed with all authors. In the area of functioning, although the focus varied, positive change in “Moving around using equipment” as defined in the ICF [31] was the most reported outcome. Increased general or functional mobility was measured with COPM or PEDI/PEDICAT mobility scale [78,93,107,120,133,143]. Self-initiated mobility or location change was measured using videotaped counts or parent report scales [95,123,128,130,131], while a number of other studies measured (GAS, COPM, lab, or device-based tracking) or described abilities to activate, sustain, and release switch or joystick [24,82,107,119,120,122,124,125,128,133,134,136,142,145,147].

Increased power mobility learning and use was measured in the greatest number of studies using the ALP [24,89,92,107,110,114,119,132–134,136,139,146]. It was also measured using task-based measures such as the PMP, with or without adaptations [89,92,93,103,110,122,144], and the Wheelchair Skills Checklist (WSC) [78,119,133,134,136]. Fewer studies used the Power Mobility Training Tool [202] (PMTT) [110,146] and Wheelchair Skills Test (WST) [98]. Others used country-specific tools [89,92,121] or study-specific measures or descriptions [117,118,137,141,187,190]. Positive change measured for remaining activity or func-

tioning outcomes included gross and/or fine motor change [83,101,103,138,147], self-care abilities [83,104,132], and increased vocalization or expressive communication [83,130,143].

Positive fitness outcomes included overall developmental change [78,103], cognitive development [83], receptive language development [78,83], social-emotional change [83], and positive changes in the sleep-wake cycle [95,116,118]. Occupational participation or friends/fun outcomes included positive change in individually selected participation goals that were measured using COPM, GAS, and/or WhOM-YP [24,92,96,98,109,135,136]. Functional social/cognitive change [104,120,132,143] and play/social development or increased toy interaction were also measured [94,95,130].

Family or contextual factors outcomes included device preference, device satisfaction, appropriateness, and feasibility of use [83,96,107,114,135,139] and were primarily rated by parents. Positive change in family views [93] and belief that the public accepts their child were also measured following PWC use [95]. Another study found that parent perceptions related to use of EM and MROC were influenced by the child's cognitive and motor abilities, as well as use of the device in an appropriate developmental order, i.e., progressing from single switch to a device that facilitated steering rather than the reverse [87].

It was not possible to determine rates of use or abandonment for this population, as this was not a focus in most studies. In randomized studies, dropouts ranged from as high as 19% [78] to none [79,82,83,89]. Several interrupted time-series studies had no dropouts [92,96,98,101], while in others, 3% [95] and 7% [93] discontinued use. In a pre-post group study [110], 6/46 parents (9%) discontinued power mobility use during the 6-month study, while 54% continued to use in the longer term. A mixed-methods study [148] reported that 9% of children had not achieved independent use and rarely used their PWC. An RCT, an interrupted time series, and two pre-post group studies specifically reported that no adverse events or effects had occurred [78,93,107,114]. It is possible, however, that evidence of unsuccessful intervention, harms, accidents, adverse events, or family burden is underreported due to publication or positivity bias.

Figure 8 illustrates quantitative outcomes: bar charts illustrate total number of children reported for each outcome, and counts are unweighted by study design. Table 1 details study designs (and related number of participants) contributing to each outcome.

Table 1. Evidence supporting quantitative outcomes.

Outcome	Numbers of Each Study Design and Included Participants
Power mobility use	2 RCT ($n = 52$); 3 time series ($n = 58$); 4 pre-post ($n = 55$); 15 SSRD/case series/reports ($n = 26$)
General mobility	1 RCT ($n = 8$); 1 time series ($n = 27$); 1 pre-post ($n = 3$); 3 SSRD/case series/reports ($n = 5$)
Joystick/switch use	1 RCT ($n = 2$); 2 pre-post ($n = 11$); 25 SSRD/case series/reports ($n = 25$)
Self-initiated mobility	1 time series ($n = 13$); 4 SSRD/case series ($n = 5$)
Self-care	1 RCT ($n = 15$); 2 SSRD/case series ($n = 9$)
Gross/Fine motor	1 RCT ($n = 15$); 1 time series ($n = 1$); 3 case series/reports ($n = 3$)
Communication	1 RCT ($n = 15$); 2 SSRD/case reports ($n = 2$)
Social play	1 time series ($n = 13$); 1 SSRD ($n = 1$)
Social-cognitive	1 SSRD ($n = 1$); 2 case series ($n = 11$); 1 case report ($n = 1$)
Self-identified participation	3 time series ($n = 35$); 2 pre-post ($n = 28$); 2 SSRD ($n = 2$)
Cognition	1 RCT ($n = 15$)
Language	2 RCTs ($n = 23$)
Overall development	1 RCT ($n = 8$); 1 pre-post ($n = 2$)
Socio-emotional	1 RCT ($n = 15$)
Sleep-wake cycle	1 time series ($n = 13$); 1 post ($n = 12$); 1 case series ($n = 1$)

Table 1. Cont.

Outcome	Numbers of Each Study Design and Included Participants
Family interactions	1 time series ($n = 13$); 1 case report ($n = 1$)
Parent beliefs/perceptions	1 RCT ($n = 15$); 2 time series ($n = 25$)
Parent stress	1 time series ($n = 13$)
Parent device satisfaction	1 RCT ($n = 15$); 1 time series ($n = 4$); 1 pre-post ($n = 2$); 2 SSRD/case series/reports ($n = 7$)

RCT: randomized controlled trial or crossover trial; Time series: interrupted time series.

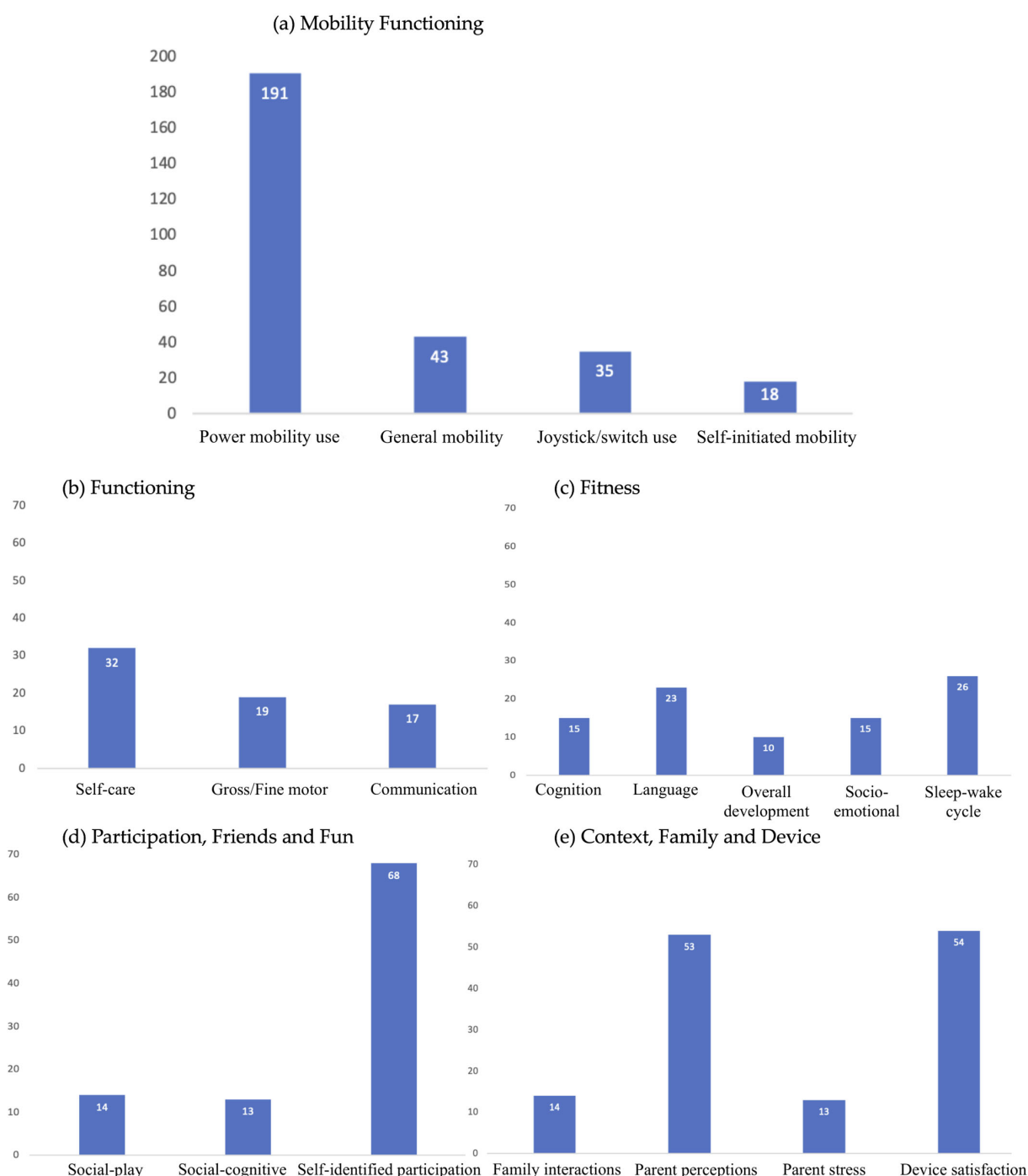


Figure 8. Significant and/or positive outcomes reported by numbers of children with non-ambulant cerebral palsy in relation to (a) mobility, (b) other functioning outcomes, (c) fitness outcomes, (d) friends and fun or participation outcomes, (e) outcomes related to parent, family, context, or the device. Note: Different Y axis for (a) compared to (b–e).

3.5.2. Qualitative and Lived-Experience Findings

Lived-experience data from qualitative studies and parent feedback within quantitative studies may be grouped into perceived benefits, as well as a number of reported barriers or difficulties. Experiences were influenced by hope, expectations, and the meaning of power mobility to other relevant parties. Although therapist or educator attitudes or lack of knowledge or support could be a barrier [96,148–150,158,162], many studies noted that children's use of power mobility helped to change the attitudes or perspectives of parents, siblings, other children, and adults as they recognized new or unexpected abilities or potential [17,89,93,111,122,153,158,162,164].

Two studies were primarily focused on power mobility learning. One emphasized the importance of the role of the adult as a “responsive partner” eliciting learning through play and following the child's lead and also described three stages of learning: exploratory, operational, and functional use [150]. The other explored the use of different learning approaches and strategies based on the child's stage of learning [154].

Fitness benefits experienced may be broadly described as positive changes in emotional function and include motivation, happiness, joy, excitement, confidence, self-esteem, and self-efficacy [17,102,104,108,111,117,119,122,135,152,159,162]. Activity or functioning included increased self-care abilities, use of arms and hands, or other physical abilities and switch access [17,83,89,104,118,122,132,156]. Attention and learning benefits perceived included increased alertness, cognition, attention, communication, or interaction [17,81,104,117,118,122,127,145,156]. Increased mobility and exploration included mobility play, enjoying speed, motion, and having fun [17,86,108,111,127,130,146,151,152,158,164]. Independence and freedom benefits included increased sense of control and choice [17,81,102,108,117,126,148,149,151,152,158,159].

Friends and fun or participation benefits experienced included increased family or sibling participation [85,86,89,104,108,153,159,162–164] and increased peer participation and socialization [17,85,86,102,104,117,149,151,152,158,159,161–163]. Two studies described children being able to engage in age-appropriate mischievous behavior, with one child telling his siblings “*I'm going to get you!*” [162], and parents describing their child as experiencing “*the joy of finally being able to disobey!*” [149]. More general participation benefits, such as increased autonomy and engagement, also included a sense of belonging, self-advocacy, and increased initiation [17,85,86,131,135,149,162–164].

Perceived barriers related to device features [85,86,127,148,149,151,152,164], lack of accessibility in home or community environments [148,152,158,164], transportation difficulties [148,151–153], and weather challenges [96,108,151,152]. One study also discussed barriers related to child health, tolerance, or abilities [85].

Figure 9 illustrates perceived benefits and barriers reported by numbers of participants included in reports, either with non-ambulant cerebral palsy or associated with children classified as non-ambulant cerebral palsy. It also illustrates the relative intensity of key themes or concepts across studies.

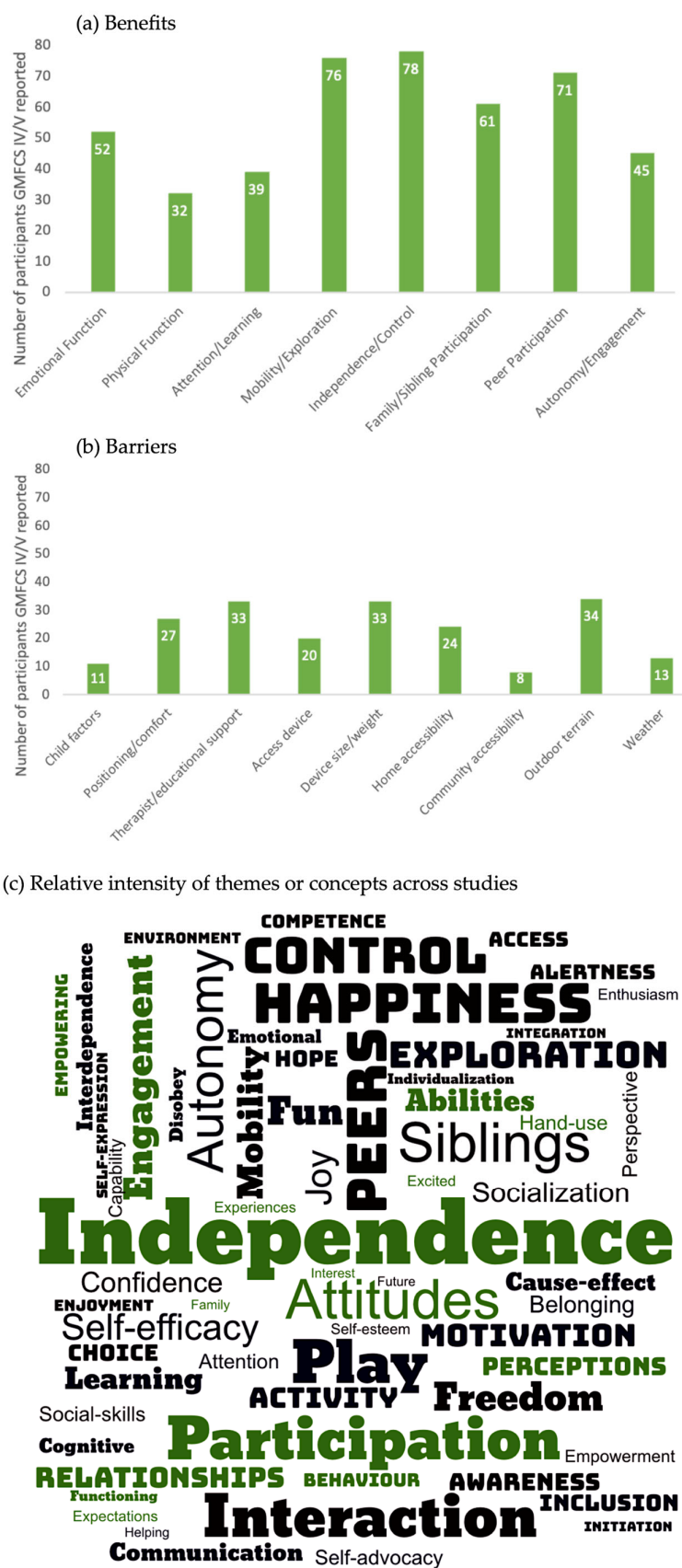


Figure 9. (a) Perceived benefits and (b) perceived barriers of power mobility interventions. (c) Relative intensity of themes or concepts across qualitative and mixed-methods studies.

3.6. IHAAT Framework Mapping: Figure 10

Findings and outcomes from the studies included in this review were mapped to a modified F-words iHAAT framework, as shown in Figure 10.

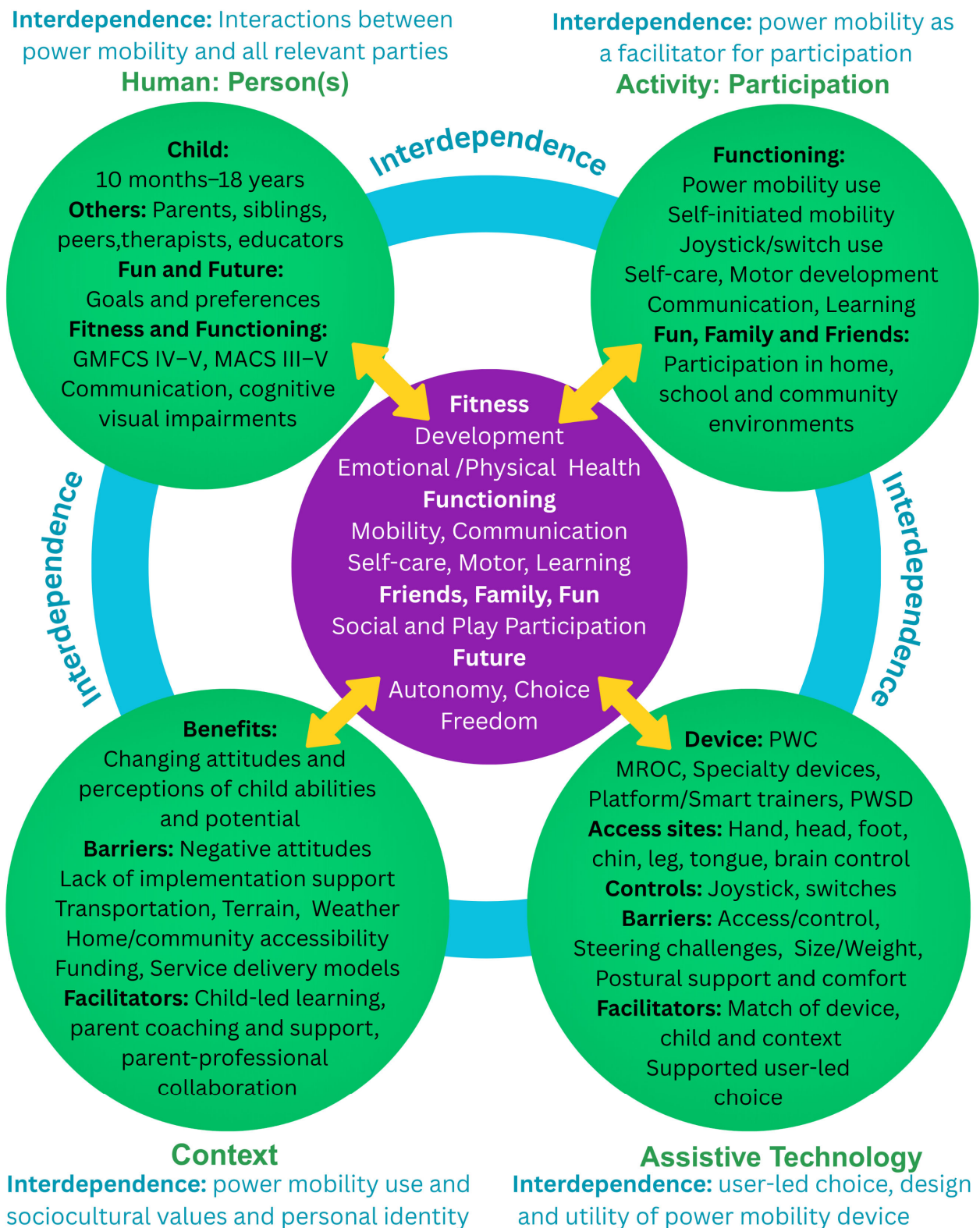


Figure 10. F-words iHAAT framework illustrating outcomes and lived-experience findings from the review. Adapted with permission from the iHAAT model, copyright 2021 Fani Lee [27].

4. Discussion

This scoping review expands on previous reviews by including data from additional quantitative and qualitative studies and focusing more specifically on the use and experience of power mobility for children classified at GMFCS IV–V and (where possible) MACS III–V. The 90 unique studies included 916 children aged 10 months–18 years and covered a wide range of geographical locations. Although 59% of studies were conducted in North America, these studies included only 39% of participating children, while 35% were in mainland Europe or the UK and 23% in Israel. Studies from low- and middle-income countries (LMIC) account for approximately 1% of the review population.

This review was guided by several sub-questions:

1. Experiences and meaning of power mobility for different relevant parties: In this review, we identified findings from children, siblings, parents, or caregivers, therapists, and educators. These experiences are compared and contrasted in Section 4.1, followed by a lived-experience narrative from our parent contributor (DC).
2. Rates of use: Our ability to determine associations with GMFCS and MACS levels was limited since few studies reported MACS levels, and for many older studies, GMFCS level was estimated by study or review authors as IV/V. Rates of switch versus joystick use could only be determined for 42% of children using PWCs, and associations between GMFCS, MACS, and access/control methods could only be determined for 11% of children using PWC, PWSD, and platform or smart training devices. These limited and preliminary observations are discussed in Section 4.2.
3. Methods of introduction and training: For most children, these were not defined or described. For those studies that did define training characteristics, a distinction between play-based, child-led, facilitating approaches and skills training was noted, based on age and/or developmental level, as discussed in Section 4.3.
4. Outcomes and findings: Other than developmental change, which was measured for young children, perceived benefits, and measured outcomes, as well as barriers and challenges, were surprisingly similar across all age groups, devices, and locations. Clarity of reporting was insufficient to identify subgroups based on functional classifications, access or control methods, or devices. This topic is further discussed in Section 4.4.

The remainder of the discussion addresses the relevance of the integrated F-words and iHAAT framework, illustrated by a lived-experience narrative from our full-time PWC user contributor (BWF); suggestions for future research; and review limitations.

4.1. Meaning and Experience of Power Mobility for Children and Other Relevant Parties

The meaning and experience of power mobility interventions were addressed not only in qualitative studies, but in a wide variety of study designs across the review. Accepting the child's disability and the need for a PWC is an emotional process and may trigger mixed feelings in relation to their child's newfound independence [81,153]. Parents may consider a PWC a "last resort," representing "giving up on hope" [158]. These feelings are likely influenced by dominant societal perceptions of disability, and parents may focus on the hope of walking, while their children see it as exercise rather than functional mobility [203]. Adolescents may become aware of these societal attitudes and the stigma of disability, describing unwanted attention when out in the community in their PWC [157]. Children may see a PWC as part of their self-identity, and they and some parents have described the PWC as the child's "legs" [117,148,152,158]. Adults with cerebral palsy describe PWCs and other supportive mobility devices as contributing to their freedom, participation, and independence [204].

MROC and specialty devices are more developmentally appropriate for young children and may help overcome attitudinal and environmental barriers [21]. Other children or adults in the community may be drawn to interact with children using these devices, helping to change attitudes [108,111,127,164]. Parents may be willing to provide their child with new mobility experiences in clinic [111,112,205] or community settings [127], even if not ready to consider a PWC as a long-term option.

While many studies reported parent attitudes changing from initial reluctance to mainly positive after their child began using the PWC, in contrast to their parents, children's attitudes may be positive from the start [93]. In one study, parental stress was measured at three time points: PWC prescription, PWC delivery, and after a few months of PWC use. Interestingly, stress decreased by the time of PWC delivery and remained stable at follow-up [95]. It is possible that the hope of future independence for their child contributed, as indicated by parents in qualitative studies [81,149].

Parents of children and adolescents using PWC, MROC, and specialty pediatric devices described difficulties with the joystick or switch not meeting individual child needs [85,86,149]. For an adolescent using a chin joystick, his mother reported that it was difficult to keep his head in place when travelling over rough terrain [151]. The only children who reported access/control issues were those using BCI, with some rating reduced workload in comparison to other options [24]. One child, who had only been allowed to use switches due to limited manual abilities, had more success when her PWC broke and she tried a joystick-operated PWC [150]. This speaks to the problem of adult preconceptions of child abilities, limiting or interfering with child opportunities. Parents of a child who successfully used single-switch scanning with knee access had not previously even considered a PWC because of his limited manual abilities [141].

Few studies directly included perceptions of teachers or educational assistants, although many children used the PWC primarily or initially in the school environment [117,118,144,148,150]. One study described educational staff being surprised by unexpected abilities and their eyes being opened to children's potential for learning [17]. These staff were working in a special education setting, but similar comments were made by a teacher of a child with complex disabilities integrated into a mainstream setting [118].

Studies across the review included both occupational and physical therapists, with the majority included either in qualitative studies [111,150,153–155] or in a cross-sectional study with follow-up pre-post study [109,113]. No statistically significant differences in device satisfaction [113] or goal achievement [109] were measured between parents and therapists. One qualitative study identified differing therapist attitudes and support of PWC provision for very young children or those with complex disabilities, between therapists working in UK national seating clinics and those working for charities [150]. This contrasts with a more recent survey of Canadian and American therapists, where the vast majority expressed positive views toward early introduction [206]; however, perceptions of the appropriate age and necessary cognitive skills varied widely [207]. Age and goals for use influenced device choice, with different expectations for MROC experience, compared with PWC prescription [207].

Parents and therapists both raised safety concerns when beginning to use a PWC, but while parents struggled with time delays in the prescription process, therapists described challenges with parent acceptance and readiness [153]. Therapist and technical support and knowledge are a major influence on PWC prescription [148,158,162]. Complex alternative access/control methods, such as customized head array access [144], single-switch scanning [141], or a custom bite switch [119], suggest access to specialized and experienced clinicians with technical or mobility industry support that may not be available in all settings, limiting opportunities for more complex children.

Size, weight, and transportation challenges included the need for a wheelchair van or a PWC suitable for public transport [148,151–153]. Financial barriers differed depending on the location and funding environment. Although most young children require manual and PWCs for different environments and activities, both may not be funded [164]. In LMIC, however, children may be unable even to experience MROC mobility without charitable assistance [160,192]. The importance of postural support and comfort, as well as weather and terrain challenges, were raised in studies related to all ages, locations, and devices. The meaning and experience of power mobility introduction are illustrated in the next section by our lived-experience contributor (DC) and mother of a child classified at GMFCS IV. Her narrative highlights common attitudinal and system barriers, as well as device, accessibility, and transportation considerations raised across studies in the review.

Débora's Lived Experience as a Parent

A couple of months after my daughter turned two, I began wondering if a power wheelchair was something she would benefit from. She was a very curious toddler, but her physical disability was getting in the way of her exploring the environment at our home. I had this intuition that if she got the opportunity to drive around, she would benefit from the freedom and the autonomy she would get. Especially around meals, we could get in a situation where Mom and Dad had to leave the table to help the older siblings somewhere else in the house or to find something in the kitchen, and our daughter could get frustrated that she was left behind.

When I mentioned to my husband that I was thinking of a power wheelchair for her, his first comment and concern was that she would lose interest in moving with her stepping device. At that time, I had just gotten some funds to visit the European Academy of Childhood-onset Disability (EACD) conference in Bruges, and I told my husband that I would ask someone at the conference for advice. At the conference, I realized that this was an area of research. I didn't even know that there were power chairs for toddlers, and I came soon to find out that research shows that children can be motivated even more to use stepping devices and move around, when presented with the opportunity to use power mobility.

When I came home from the conference, I contacted my daughter's OT (occupational therapist), telling her that I wanted to apply for a power wheelchair, and her answer right away was that I could apply, but I should know that the answer would be no. She told me that they never gave power chairs to toddlers and they first got to use them at school age, if they could prove to be able to navigate the chair without risk. I told her that I could understand the rules, but that she, as an OT, probably understood that a PWC would be beneficial for my toddler. Her answer was no, and as surprised as I was, I replied that then this would be a battle, scientific data was my weapon, and I knew I would win at the end.

A couple of months before my daughter's 3-year birthday, we got the chair. Not the best one, the torque was too high, the responding time of the joystick was delayed, but the chair was small, it could be driven in our home, wasn't heavy, and could not harm the older brothers, and we could take it into our car. The boys loved that their sister got the chair. It is one of their favorite toys, and their friends are also allowed to play in it. The kids that visit us love to play in the chair, and my husband and I used it as a strategy: before asking our community to integrate our daughter, we integrate the kids from the community in our life. Our daughter's assistive devices are toys for the other children, and one of our boys once said: that is not fair! I want to have a disability so I also can get a power chair that fits me!

Our daughter has learned to navigate around our home with her chair, and she learned it faster than we ever could expect. I wanted to give her an opportunity to explore, not

knowing if it would work or not, but either way, she would be experimenting with cause and effect, and that was good enough for me. I wish other parents could see the power chairs as something expanding the possibilities for their children, other than something to fear. I love that I followed my intuition and that there was data to back me up, when our own OT was against trying.

4.2. Power Mobility Device and Control Use

4.2.1. Device Use According to Age

For mobility opportunities to be “On-Time” or equitable, they should be introduced by age 12 months [15]. For children with cerebral palsy, PWCs appear to be introduced later than for children with other conditions. While included studies reported children with other disabilities using PWCs from 14 months [78], 18 months (mean 30) [94,95], and 21 months (mean 27) [183], children with cerebral palsy in these same studies used PWCs from 26 months [78], 18 months (mean 47) [94,95], and a mean of 52 months [183]. The Wizzybug loan scheme similarly reported a mean of 43.7 months compared to 29.8 months for children with spinal muscular atrophy [208]. In comparison, recent studies including children with spinal muscular atrophy type 1 report successful introduction of a dual joystick ride-on toy from 10–13 months [209].

Whether delayed diagnosis of cerebral palsy or delayed parent acceptance of motor prognosis contributes to delayed provision is unknown. Probability of a child requiring assistive devices and wheeled mobility (GMFCS III–V) can be determined between 2–5 months [210], but diagnosis and motor prognosis are still delayed in many regions, limiting provision of evidence-based interventions [211,212]. In comparison to parents of children with a newborn period diagnosis, such as arthrogryposis or multiple limb deficiencies, parents of children with cerebral palsy are often left with an unclear prognosis. This may result in searching for a “cure” or a way to “overcome” the disability, ideas that adults with cerebral palsy report interfere with developing a disability-positive identity or living a good life [213,214]. One recent study, using EM and MROC, included children with cerebral palsy from 12–32 (mean 21) months [83]. This suggests either that early diagnosis guidelines were implemented in study locations or that parents were more willing to consider trialing these more child and family-friendly devices.

4.2.2. Use, Access and Control Methods, and Relationships with Functional Classifications

Due to limited reporting, subgroup analyses were only possible for a limited number of studies, rather than across the review, and should be considered preliminary observations, rather than firm conclusions. For studies where PWC access method was clearly reported ($n = 21$), the proportional joystick was used by 79%, matching results from an Israeli loan program [172]. Adult studies estimate joystick use as 84–92% [215,216], results supported by a cross-sectional study where 21.7% of children with cerebral palsy used complex and alternate controls in comparison to 13.9% of adults [173]. This contrast between adult and child use may relate to contextual factors or differing expectations. For example, PWCs may only be provided for adults with cerebral palsy who are already proficient, while therapy and educational support may be more available for children with complex needs.

Children who use a joystick may be more likely to achieve proficient PWC use than switch users [80,171,172]. The proportional joystick allows control over both steering and speed, promoting learning of increasingly complex cause–effect relationships [217]. In the EM, children with cerebral palsy tended to pull the joystick [125] rather than push, as is more common with typically developing infants from 12 months [218] or children with other disabilities [169]. These differences may relate to muscle tone or movement disorders in children with cerebral palsy and/or lack of joystick adjustability in the EM.

Individualized joystick positioning or a specialized handle may be critical to refined steering control for those with limited manual abilities, muscle weakness, abnormal muscle tone, or movement disorders [125,209,219–221].

Few studies ($n = 22$) provided sufficient details to identify patterns between access sites, control methods or devices, and functional classifications. Where this detail was available, alternate controls (switches) and/or access sites (body parts other than the hand) were used mainly by those classified at GMFCS V and MACS V. There was, however, some unexpected variability, suggesting that other child-specific factors, such as movement disorders, accompanying impairments, or personal/cultural preferences, may be relevant.

Contextual factors such as therapist knowledge and funding or service delivery and provision models may also be influential. For example, head controls in North America are most commonly proximity sensor arrays [221], while mechanical switch head arrays may make fine control of steering challenging [118]. In Israel, combined use of mechanical head and tray switches was reported [92], while in Belgium, sensor-based head or head and foot controls were used [179].

Joystick rather than switch controls for MROC are now available, with some providing proportional rather than digital control [191]. The proportional joystick-operated Wizzybug was preferred by 59% of parents in one study, but need for more specialized postural support or joystick/switch options influenced preference for other devices [112]. Parents of children at GMFCS V who used the EM reported satisfaction despite its limitations in postural support and joystick positioning [85]. In contrast, parents have expressed frustration with difficulties in providing adequate tilt or specialized seating in MROC [127]. These differences may relate to differences in complexity of child profile and expectations or availability of various devices and complex seating or access/control adaptations in different settings.

4.3. Power Mobility Learning and Training

Children with cerebral palsy may require longer periods of training in comparison to other disability populations [208], and longer or more specialized training may be needed for children using alternate access sites or control methods [183]. After 6 months of uncontrolled practice at home, young children using hand-accessed switches typically did not progress beyond understanding cause–effect (ALP phase 3), while those using head switches were able to explore direction (ALP phase 5) [110]. After 3 weeks of intensive training, head-tray switch users did not achieve the level of proficiency required for a publicly funded PWC, but showed significant progress, with two achieving competent control of steering (ALP phase 6) [92]. These differences may be influenced by the different ages, intensity of practice, and availability of therapist support.

Studies in children with cerebral palsy [93] and children or adults with profound cognitive impairments [222] support the importance of practice intensity, length of time, variability of practice in different locations and settings, and professional support for learning. While practice time of more than 60 min per week appears to influence overall development in young children [84], breaking this up into several short sessions each week may be more effective than infrequent longer sessions [103]. It is also essential to consider quality of learning, active play, exploration, and interaction, not just time in the device [88].

In our review, the majority of studies did not report the training or learning approach or how parents or children were supported with learning, matching findings from a survey of North American therapists where few provided training [206]. Similarly, in the U.S., Go Baby Go programs modify and provide MROC, with limited follow-up [223]. In contrast, parents of children with SMA-1 perceived structured therapist coaching and support as essential to their motivation and confidence [209].

A recently completed systematic review confirmed limited and inconsistent reporting of intervention fidelity [224]. Training strategies should be tailored to individual cognitive, motor, and sensory needs [225,226], and many studies across our review reported individualized approaches, but no details were provided. Coaching, child-led, and caregiver-delivered approaches are recommended in pediatric rehabilitation [227], and in rehabilitation research, patient and public partnerships are increasingly recognized [228]. In this review, however, only a few more recent case reports emphasized coaching or parent–professional collaborative approaches [123,138–140].

Where studies reported training details, play-based and child-led approaches were commonly described, particularly for younger and more complex children. A previous systematic review identified these approaches in the strongest intervention designs [229]. One study noted differing trajectories for children starting at the same learning phase, with some achieving unexpected progress [92], reinforcing the importance of providing augmented mobility experiences for all children with mobility limitations [32], rather than limiting opportunities with preconceptions about which children will be successful [127].

In this review, two approaches to skills-based training were used in experimental studies: virtual reality and PWC training. The 2018 systematic review concluded that virtual reality training had mainly been used with typically developing children, and little evidence supported structured skills-based training [229]. An RCT completed since that time included 32 school-aged children in either 12 weeks of home-based virtual reality training or home and community-based PWC training. Both groups significantly improved skills in a joystick-controlled PWC, with no statistically significant differences between groups [89]. The other study measured significantly improved skills following 4 weeks of structured, adult-led, in-person training in 12 adolescents and young adults [98].

Our review findings suggest that different approaches may be suitable for different ages, abilities, and phases of learning. Emergent evidence supports use of task-oriented approaches with school-aged children or adolescents who already understand how to operate the PWC to refine specific skills. Process-based approaches like the ALP instrument and facilitating strategies focus on how the individual learns to control the body part and control device, promoting tool-use learning [225]. They provide a language to talk with parents and caregivers about the small successes and steps along the learning continuum.

4.4. Power Mobility Outcomes and Findings

In this review, experimental and quasi-experimental study designs measured overall development using validated norm-referenced measures; self-care or social and play skills using functional measures; or progress in power mobility learning and use. Statistically significant positive developmental change was measured in infants and preschool children in experimental studies, while achievement of parent or self-identified and meaningful goals was measured for all ages and in all devices within a wide range of study designs. Increased mobility functioning was mainly measured using the COPM or PEDI/PEDICAT, in experimental, quasi-experimental, and pre-post group designs, and was also a theme in qualitative or descriptive studies.

Although children using PWCs may achieve a different degree of independence in both indoor and outdoor mobility to other power mobility devices, similar benefits in emotional, physical, attention, learning, and communication development were measured or described in children using all devices and across the age span. While independence, freedom, control, and choice have different meanings for adolescents in comparison to toddlers, these were also described across all ages and devices.

Similarly, increased family, sibling, and peer participation were described across the review population. Enjoying movement for its own sake, playing games with siblings and

peers, were reported with younger children, while increased socialization and hanging out with friends were reported by and in relation to older children and adolescents. Parents, caregivers, therapists, and educational staff described increased sense of autonomy, engagement, and initiation in younger children and for children with additional communication or cognitive limitations.

Previous systematic reviews suggest that evidence strongly supports the use of power mobility to increase children's mobility and moderately supports improved participation, play, social interaction, and possibly quality of life in broader populations [32,36]. Since these reviews were published, emergent experimental evidence also supports a positive impact on development of young children at GMFCS IV and V.

4.5. Interdependence and the F-Words

Independence for the child has been reported to lead to greater independence for the whole family, freeing up parents for other activities and providing opportunities for the child, parents, and siblings to participate in activities together [208]. Independence was also a major theme in this review, as illustrated in Figure 9. Children with complex non-ambulant cerebral palsy, however, are rarely completely independent, and their use of assistive devices is often interdependent with and influenced by other relevant parties, including parents, caregivers, therapists, peers, and the general public. Rather than complete physical or cognitive independence, the goal may be to increase autonomy and engagement [13,230].

For all individuals and activities, there is a continuum from independence to interdependence, influenced by our social circle [231]. Interdependence emphasizes the relationships between the device (power mobility) and all relevant parties, as well as the context [230]. This concept of interdependence was discussed in two studies with young children [81,162,163]; however, even in studies where adolescents discussed how their indoor/outdoor PWC increased their independence with friends, they reported that they were rarely completely on their own [151,152].

The integration of the F-words [28,29] with the iHAAT [27], illustrated in Figure 10 with results and findings from this review, match the relationships proposed in the draft model, related to the use of supported standing and stepping devices [13]. In our more developed model, the central outcomes of well-being, health, happiness, development, and functioning are expanded to include all the F-words. These are influenced by and also influence the components of the human or person (including all persons interacting with the power mobility device), the activity (where occupational participation is mediated by the power mobility device), the context (physical, social, and attitudinal), and the specific device features.

We identified outcomes and experiences that could be mapped to each of the F-words, although some were more evident than others. Functioning was most highly reported, especially mobility functioning and power mobility learning or skill progression. Increased communication and learning abilities were measured on developmental tests, but through self-directed mobility, children were also able to communicate their interests or dislikes and to engage in self-directed learning and exploratory behaviors. While children's self-care abilities may not change, they may require less assistance from caregivers and more actively participate in self-care routines [78,93]. The common fear that using power mobility will reduce children's use of their motor skills has not been borne out by experimental research [78,83]. In contrast, children have been described to increase specific motor skills, such as use of hands and arms [17,156], or show more interest in other mobility methods following power mobility experience [56,232].

Fitness seems a more challenging concept to understand in relation to power mobility use but, according to the ICF domain of BSF, includes the influence on overall development, receptive-language development, and emotional and physical health. A positive influence on the sleep-wake cycle was also measured in a recent single-group study [116] and may relate to children having more age-typical opportunities for activity and exploration.

Friends, family, and fun outcomes were reported together in our model as they overlapped considerably. Happiness and joy were reported by parents in many studies, and relate to both the joy of independent mobility experiences and emotional health and fun for the child, parents, siblings, and others [159,160,208]. Increased interaction, play, and participation with siblings, family, and peers were highly reported across the age span and in all devices.

Future was specifically mentioned in a few studies, with parents describing how the PWC would be needed their whole life [149], and increased hope for the future [81]. Future life and opportunities may also be influenced by child autonomy, sense of self-efficacy, and motivation, findings that were raised in many studies across the review.

The concepts described in the integrated F-words iHAAT framework are illustrated by the experiences of our lived-experience contributor and full-time PWC user (BWF) below and in Figure 11.



Figure 11. The author B.W.F. at age 10; power soccer; operating camera through the PWC.

Ben's Lived Experience of Interdependence and the F-Words

I was at the age of four when my childhood OT, my guardians, and I collaborated for me to operate the PWC with a proximity head array at our local rehabilitation center. Prior to my introduction to the head array-controlled PWC, I was ambulant by using a MeyWalker, which was a walker assistive device. From the start of my elementary school years, I did an alternation between the MeyWalker and the PWC. Therefore, I did not become a full-time PWC user until we saw that the PWC would increase my educational and social possibilities. The educational possibilities included me gaining more of an efficient mode of interdependence, which was between the PWC's electronics and AAC (accommodative and alternative communication) devices to express my cognition. The social possibilities included broader options for play, such as being able to drive across the grass field to play soccer with my friends. I felt the presence of the F-words generally among my peers and the public during childhood. Given that my OT saw that I was functioning exceptionally with the head array and that the head array would be my tool that I could meaningfully contribute to society with, they focused on maintaining my head motor skills through my childhood and adolescent developments via complex seating systems. However, the F-words became less manifested in late childhood and throughout adolescence.

The components of my seating system were a rigid pelvic bar, bilateral upper body supports, and Velcro arm straps, which effectively supported my body to maintain my head array skills. My confidence to exert my independence with the head array within my supported seating system had morphed into body insecurities because I was being perceived by ill assumptions. The assumptions were such as that I must be fragile and be stuck within an uncontrollable body since I would have to be locked in within my seating system. A good example would be getting called out on by a school staff to stop racing around the parking lots within a good intention for my safety within the PWC while my friends were allowed to continue doing so, and I was left with uncertainty about the value of play after that. Many other situations were prevalent within my home life, too, and I did not feel the F-words being applied to me. However, despite the negative social encounters within the PWC, I could internally rebuild a positive relationship with the PWC, and then the F-words were being reapplied to my life. With the F-words reapplied, the PWC and the head array controls are my bodily extensions through which I could connect many other assistive devices that I contribute to society with.

4.6. Suggestions for Research

The findings of this review were limited by the lack of clear and consistent reporting of child classifications and profile. In addition to GMFCS and MACS levels, future studies should include descriptions of tone and movement disorders and accompanying impairments. Children with complex non-ambulant cerebral palsy are a heterogeneous population, and these additional factors may be associated with differences in power mobility meaning and experiences, outcomes, learning, and use.

The delay in providing power mobility opportunities to children with non-ambulant cerebral palsy has been illustrated in this review. Alternative approaches are needed to assist parents in recognizing potential learning benefits and reassurance that it will not interfere with development of other motor skills. Play-based introduction and experience may help to address reluctance and promote child and family-led exploration [74,111,112,124,125]. Further research addressing how best to support parents in this process is needed.

Increased development and availability of developmentally appropriate devices are also required. MROC may not provide the necessary postural support or control/access necessary for more complex children [127], although more complex modifications are available in some locations [104,191]. Depending on geographical location, different specialized pediatric power mobility devices are available. For example, the EM [169] is available in the U.S. and in the Nordic countries; Bugzi [112,233] and Wizzybug [112,208] are available through loan schemes in the UK; Baby Loco [234] is available in Japan. Platform devices are typically large and usually only available in institutional and research settings. Carry Loco is a small and inexpensive platform that can be used with children's manual wheelchair or other positioning devices, but is currently only available in Japan <https://www.mech.usp.ac.jp/~maw/KLP2016/home.html> (accessed on 22 May 2026). Low-cost, developmentally appropriate devices are needed for all locations and, in particular, for LMIC. In Brazil, for example, Nossa Casa [235] (www.nossacasa.org.br, accessed on 22 May 2026) and the Adapt project [139] support MROC adaptations for children with motor and cognitive disabilities.

Apart from studies specifically addressing training, support following device provision was noticeably lacking or not described for many children. This contrasts with provision of other complex assistive technologies, where extensive training is part of the intervention. As recommended by a recent systematic review, the core components of power mobility interventions must be described, and the fidelity of implementation, as

well as child and caregiver response, must be measured in order to advance research and clinical practice [225]. In qualitative studies, parents frequently commented on the need for knowledgeable therapist and technical support with device selection, fitting, and training.

Findings from this review suggest that approach to power mobility training depends on child age and profile, with play-based, child-led, and facilitating approaches being most appropriate for younger children and children with multiple and complex disabilities. Skills-based and virtual training may help children who have already achieved basic understanding of how to use the PWC to further develop skills.

Review findings also suggest that intensity of practice is important, with therapists coaching parents and caregivers. Some children may benefit from short blocks of intensive intervention to work on specific goals, interspersed with time using within daily life settings. Further research is needed to explore the relative effectiveness of different training models and approaches for children with complex non-ambulant cerebral palsy.

Children's use of alternate access or control methods for power mobility devices was incompletely explained by GMFCS and MACS levels, in the 22 studies where this detail was provided. Other child-specific factors, such as movement disorders, personal preferences, or contextual factors, may have influenced selection and use of access methods other than the hand-controlled proportional joystick. Further research is needed to examine the use of power mobility and the learning progression in children with complex non-ambulant cerebral palsy and particularly for those who use alternate access and control methods.

4.7. Limitations

Although we did not limit language, the search terms were in English, and only two non-English language publications were identified. We also did not exclude articles by publication status, but grey literature searches are challenging. Google Scholar searches were limited to four phrases, and since ranking changes over time, we may have identified different articles with these search terms at a different time. The field of pediatric power mobility is relatively small, and based on our clinical trial register and conference proceeding searches, as well as known author contact, we are confident that our search was relatively complete. It is possible, however, that we missed studies by unknown researchers or published in other languages.

This review aimed to map and describe power mobility usage and experience and retrieved a large number of studies with wide variability in design and purpose. Although quality rating was not relevant to this scoping review, we organized the studies in Supplementary Materials Table S3 under the main study design, giving an indication of relative strength of evidence. In visual presentation of significant and/or positive outcomes (Figure 8), a simple count of participants was used; however, apart from joystick/switch use and social-cognitive outcomes, all were predominantly supported by experimental or quasi-experimental evidence studies that also included the majority of participants. Quality rating and risk-of-bias assessment should be conducted as part of future systematic reviews addressing effectiveness of power mobility interventions for the various outcomes.

Review findings and our ability to group these according to GMFCS and MACS levels were limited by the lack of reporting in original studies. We described use, access and control methods according to GMFCS and MACS for a small number of studies, but were unable to evaluate across the review. Although GMFCS and MACS levels are associated, it could also be argued that lack of MACS reporting limited our ability to ensure that included children met our criteria of complex non-ambulant cerebral palsy. The official graphical representations accompanying the GMFCS materials (<https://canchild.ca/resources/42-gmfcs-e-r/>, accessed on 22 May 2026) may convey the idea that children at GMFCS V do not use power mobility, or if children do successfully use a PWC, it means they are GMFCS

IV. Results and findings from this review, however, illustrate that children classified as GMFCS V do successfully use power mobility, but our ability to draw strong associations between child profile, access/control methods, and power mobility usage is limited.

The possibility of publication and/or positivity bias must be considered since outcomes and experiences are mainly positive. Figures 9 and 10, however, illustrate common barriers and challenges raised in many studies across the review. Dropout rates reported were low, lack of adverse events or effects was specifically reported in a number of experimental and quasi-experimental studies, and non-significant results are noted throughout Supplementary Table S3. Formal publication bias evaluation is not undertaken in scoping reviews; however, a systematic review including 15 studies from this review previously determined no significant asymmetry or bias in relation to power mobility skill progression [36]. A comprehensive mixed-methods review that included 33 studies from this review also concluded that publication bias was not a significant issue, noting reporting of non-significant, null, or contrasting results in relation to multiple outcomes discussed within this review [32].

Lastly, while studies were identified across a wide range of geographical regions, it must be acknowledged that 99% of the evidence reviewed is based on studies from higher-resourced areas where device availability, funding structures, therapist training, and parent expectations differ from most LMIC. There is, however, considerable variability in device availability and funding structures across these more highly resourced settings, and similar environmental and attitudinal barriers and challenges were reported across all studies. While earlier and more broadly applied use of power mobility may be most appropriate to higher resourced settings, Brazil has emerged as a leader in promoting use of MROC and providing low-cost solutions that may also be applied in other LMIC.

5. Conclusions

Findings suggest that the experience and meaning of power mobility interventions may be predominantly positive in relation to fitness, functioning, friends, family, fun, and future outcomes, for children classified at both GMFCS IV and V from as young as 10 months of age, as illustrated in our integrated F-words iHAAT model. Children at GMFCS V may experience the most benefit from early childhood power mobility experiences since they are most limited in their opportunities for exploratory behavior and learning through other means. Parent, therapist, and educator preconceptions and knowledge, however, strongly influence which children have opportunities to use and experience power mobility. Children's experiences, learning, and the abilities demonstrated through their use of power mobility frequently change adult attitudes toward power mobility itself, as well as their perceptions of child potential. This reciprocal interaction illustrates the interdependence between children and other relevant parties, power mobility, activity/participation, and the environmental barriers and challenges that are consistently reported to limit use across all settings.

Dominant societal perceptions of power mobility as a last resort replacement for walking continue to influence all relevant parties, including parents and therapists. Parents need support to see the possibilities of power mobility interventions for exploration and tool-use learning, starting within the first year, to enhance overall development. Children with complex non-ambulant cerebral palsy need opportunities for development and learning, rather than waiting for them to demonstrate "readiness" for power mobility. While limitations of funding and support for power mobility use in LMIC must be acknowledged, developmentally and contextually appropriate devices are still needed for all regions, along with increased knowledge and support for providing power mobility opportunities, experiences, and training for children with more complex profiles.

Children with cerebral palsy may require longer periods of training than other disability groups. Statistically and clinically significant, positive outcomes have been reported for intensive play-based, child-led, facilitating, and caregiver-supported approaches for younger children and those with additional impairments. Predicting which children will develop goal-directed, safe, and functional community PWC use is difficult and influenced by the environment, opportunities, training, and support. Even children who may never become independent, autonomous PWC users experience learning opportunities through power mobility use. Rather than being limited by adult preconceptions or lack of knowledge, children with complex non-ambulant cerebral palsy require an appropriate match of device, access and control method, sufficient time, intensity of practice, and appropriate learning support to match their age, phase of learning, abilities, and context.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/disabilities6040064/s1>, Table S1: S1_PRISMA-ScR-10 July_2026. Table S2: Search details; Table S3: Studies included in the review [17,24,25,78–96,98,100–193].

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Abbreviations

The following abbreviations are used in this manuscript:

ALP	Assessment of Learning Powered mobility use
BCI	Brain Control Interface
BSF	Body Structure and Function
COPM	Canadian Occupational Performance Measure
EM	Explorer Mini
GAS	Goal Attainment Scaling
GMFCS	Gross Motor Function Classification System
ICF	International Classification of Functioning, Disability, and Health
iHAAT	Interdependence Human Activity Assistive Technology model
LMIC	Low- and Middle-Income Countries
MACS	Manual Abilities Classification System
MROC	Modified Ride-On toys or Cars
PEDI	Pediatric Evaluation of Disability Inventory
PEDI-CAT	PEDI-Computer Adaptive Test
PMP	Power Mobility Program
PMTT	Power Mobility Training Program
PWC	Power Wheelchair
PWSD	Power Wheelchair Standing Device
RCT	Randomized Controlled Trial
WhOM-YP	Wheelchair Outcome Measure for Young People
WSC	Wheelchair Skills Checklist
WST	Wheelchair Skills Test

References

- MacLennan, A.H.; Lewis, S.; Moreno-De-Luca, A.; Fahey, M.; Leventer, R.J.; McIntyre, S.; Ben-Pazi, H.; Corbett, M.; Wang, X.; Baynam, G.; et al. Genetic or other causation should not change the clinical diagnosis of cerebral palsy. *J. Child. Neurol.* **2019**, *34*, 472–476. [[CrossRef](#)] [[PubMed](#)]
- McIntyre, S.; Goldsmith, S.; Webb, A.; Ehlinger, V.; Hollung, S.J.; McConnell, K.; Arnaud, C.; Smithers-Sheedy, H.; Oskoui, M.; Khandaker, G.; et al. Global prevalence of cerebral palsy: A systematic analysis. *Dev. Med. Child. Neurol.* **2022**, *64*, 1494–1506. [[CrossRef](#)] [[PubMed](#)]
- Palisano, R.J.; Rosenbaum, P.; Bartlett, D.; Livingston, M.H. Content validity of the expanded and revised Gross Motor Function Classification System. *Dev. Med. Child. Neurol.* **2008**, *50*, 744–750. [[CrossRef](#)] [[PubMed](#)]
- Eliasson, A.C.; Krumlinde-Sundholm, L.; Rösblad, B.; Beckung, E.; Arner, M.; Öhrvall, A.-M.; Rosenbaum, P. The Manual Ability Classification System (MACS) for children with cerebral palsy: Scale development and evidence of validity and reliability. *Dev. Med. Child. Neurol.* **2006**, *48*, 549–554. [[CrossRef](#)] [[PubMed](#)]
- Carnahan, K.D.; Arner, M.; Häggglund, G. Association between gross motor function (GMFCS) and manual ability (MACS) in children with cerebral palsy. A population-based study of 359 children. *BMC Musculoskelet. Disord.* **2007**, *8*, 50. [[CrossRef](#)] [[PubMed](#)]
- Compagnone, E.; Maniglio, J.; Camposeo, S.; Vespino, C.; Losito, L.; De Rinaldis, M.; Gennaro, L.; Trabacca, A. Functional classifications for cerebral palsy: Correlations between the gross motor function classification system (GMFCS), the manual ability classification system (MACS) and the communication function classification system (CFCS). *Res. Dev. Disabil.* **2014**, *35*, 2651–2657. [[CrossRef](#)] [[PubMed](#)]
- Arner, M.; Eliasson, A.C.; Nicklasson, S.; Sommerstein, K.; Häggglund, G. Hand Function in Cerebral Palsy. Report of 367 Children in a Population-Based Longitudinal Health Care Program. *J. Hand Surg.* **2008**, *33*, 1337–1347. [[CrossRef](#)] [[PubMed](#)]
- Stadskleiv, K. Cognitive functioning in children with cerebral palsy. *Dev. Med. Child. Neurol.* **2020**, *62*, 283–289. [[CrossRef](#)] [[PubMed](#)]
- Khuc, T.H.H.; Karim, T.; Nguyen, V.A.T.; Giang, N.T.H.; Dũng, T.Q.; Dosseter, R.; Cao Minh, C.; Van Bang, N.; Badawi, N.; Khandaker, G.; et al. Associated impairments among children with cerebral palsy: Findings from a cross-sectional hospital-based study in Vietnam. *BMJ Open* **2024**, *14*, e075820. [[CrossRef](#)] [[PubMed](#)]
- Rauchenzauner, M.; Schiller, K.; Honold, M.; Baldissera, I.; Biedermann, R.; Tschiderer, B.; Albrecht, U.; Arnold, C.; Rostasy, K. Visual Impairment and Functional Classification in Children with Cerebral Palsy. *Neuropediatrics* **2021**, *52*, 383–389. [[CrossRef](#)] [[PubMed](#)]

11. Ghasia, F.; Brunstrom, J.; Gordon, M.; Tychsen, L. Frequency and severity of visual sensory and motor Deficits in children with cerebral palsy: Gross motor function classification scale. *Investig. Ophthalmol. Vis. Sci.* **2008**, *49*, 572–580. [\[CrossRef\]](#) [\[PubMed\]](#)
12. Novak, I.; Smithers-Sheedy, H.; Morgan, C. Predicting equipment needs of children with cerebral palsy using the Gross Motor Function Classification System: A cross-sectional study. *Disabil. Rehabil. Assist. Technol.* **2012**, *7*, 30–36. [\[CrossRef\]](#) [\[PubMed\]](#)
13. Paleg, G.S.; Williams, S.A.; Livingstone, R.W. Supported standing and supported stepping devices for children with non-ambulant cerebral palsy: An interdependence and F-Words focus. *Int. J. Environ. Res. Public Health* **2024**, *21*, 669. [\[CrossRef\]](#) [\[PubMed\]](#)
14. Anderson, D.; Campos, J.; Witherington, D.; Dahl, A.; Rivera, M.; He, M.; Uchiyama, I.; Barbu-Roth, M. The role of locomotion in psychological development. *Front. Psychol.* **2013**, *4*, 440. [\[CrossRef\]](#) [\[PubMed\]](#)
15. Sabet, A.; Feldner, H.; Tucker, J.; Logan, S.W.; Galloway, J.C. ON Time Mobility: Advocating for Mobility Equity. *Pediatr. Phys. Ther.* **2022**, *34*, 546–550. [\[CrossRef\]](#) [\[PubMed\]](#)
16. Huang, H.H. Perspectives on early power mobility training, motivation, and social participation in young children with motor disabilities. *Front. Psychol.* **2018**, *8*, 2330. [\[CrossRef\]](#) [\[PubMed\]](#)
17. Rosenberg, L.; Cohen, R.; Maeir, A.; Gilboa, Y. Effects of a powered mobility summer camp as perceived by school staff: A qualitative study. *Disabil. Rehabil. Assist. Technol.* **2023**, *18*, 783–790. [\[CrossRef\]](#) [\[PubMed\]](#)
18. Livingstone, R.; Paleg, G. Practice considerations for the introduction and use of power mobility for children. *Dev. Med. Child Neurol.* **2014**, *56*, 210–221. [\[CrossRef\]](#) [\[PubMed\]](#)
19. Livingstone, R.; Field, D. The child and family experience of power mobility: A qualitative synthesis. *Dev. Med. Child Neurol.* **2015**, *57*, 317–327. [\[CrossRef\]](#) [\[PubMed\]](#)
20. Livingstone, R.; Field, D. Systematic review of power mobility outcomes for infants, children and adolescents with mobility limitations. *Clin. Rehabil.* **2014**, *28*, 954–964. [\[CrossRef\]](#) [\[PubMed\]](#)
21. Feldner, H.A.; Logan, S.W.; Galloway, J.C. Why the time is right for a radical paradigm shift in early powered mobility: The role of powered mobility technology devices, policy and stakeholders. *Disabil. Rehabil. Assist. Technol.* **2016**, *11*, 89–102. [\[CrossRef\]](#) [\[PubMed\]](#)
22. Fehr, L.; Langbein, W.E.; Skaar, S.B. Adequacy of power wheelchair control interfaces for persons with severe disabilities: A clinical survey. *Development* **2000**, *37*, 353–360.
23. Montbaliu, E. *White Paper Evidence Based Development CoMoveIT Smart*; KU-Leuven: Brugge, Belgium, 2024. Available online: <https://www.comoveit.com/en/contact-2> (accessed on 22 May 2026).
24. Hammond, L.; Rowley, D.; Tuck, C.; Floreani, E.D.; Wieler, A.; Kim, V.S.-H.; Bahari, H.; Andersen, J.; Kirton, A.; Kinney-Lang, E. BCI move: Exploring pediatric BCI-controlled power mobility. *Front. Hum. Neurosci.* **2025**, *19*, 1456692. [\[CrossRef\]](#) [\[PubMed\]](#)
25. Field, D. Powered mobility: A literature review illustrating the importance of a multifaceted approach. *Assist. Technol.* **1999**, *11*, 10–33. [\[CrossRef\]](#)
26. Bektashi, S.; Nica, I.G.; Gakopoulos, S.; Konings, M.; Maes, R.; Cuyvers, B.; Aerts, J.-M.; Hallez, H.; Monbaliu, E. Exercise load and physical activity intensity in relation to dystonia and choreoathetosis during powered wheelchair mobility in children and youth with dyskinetic cerebral palsy. *Disabil. Rehabil.* **2022**, *44*, 4794–4805. [\[CrossRef\]](#) [\[PubMed\]](#)
27. Giesbrecht, E. Application of the Human Activity Assistive Technology model for occupational therapy research. *Aust. Occup. Ther. J.* **2013**, *60*, 230–240. [\[CrossRef\]](#) [\[PubMed\]](#)
28. Lee, F.N.; Balcazar, F.; Hsieh, K.; Sposato Bonfiglio, B.; Parker Harris, S.; Feldner, H.A. Factors impacting community living outcomes among former long-term nursing home residents using the interdependence-Human Activity Assistive Technology (i-HAAT) model. *Assist. Technol.* **2025**, *37*, 322–331. [\[CrossRef\]](#) [\[PubMed\]](#)
29. Rosenbaum, P.; Gorter, J.W. The “F-words” in childhood disability: I swear this is how we should think! *Child Care Health Dev.* **2012**, *38*, 457–463. [\[CrossRef\]](#) [\[PubMed\]](#)
30. Rosenbaum, P. The F-words for child development: Functioning, family, fitness, fun, friends and future. *Dev. Med. Child Neurol.* **2022**, *64*, 141–142. [\[CrossRef\]](#) [\[PubMed\]](#)
31. World Health Organization. *International Classification of Functioning, Disability & Health (ICF)*; World Health Organization: Geneva, Switzerland, 2001.
32. Bray, N.; Kolehmainen, N.; McAnuff, J.; Tanner, L.; Tuersley, L.; Beyer, F.; Grayston, A.; Wilson, D.; Tudor Edwards, R.; Noyes, J.; et al. Powered mobility interventions for very young children with mobility limitations to aid participation and positive development: The EMPoWER evidence synthesis. *Health Technol. Assess.* **2020**, *24*, 24500. [\[CrossRef\]](#) [\[PubMed\]](#)
33. Cheung, W.C.; Meadan, H.; Yang, H.W. Effects of powered mobility device interventions on social skills for children with disabilities: A systematic review. *J. Dev. Phys. Disabil.* **2020**, *32*, 855–876. [\[CrossRef\]](#)
34. James, D.; Pfaff, J.; Jeffries, L.M. Modified Ride-on Cars as Early Mobility for Children with Mobility Limitations: A Scoping Review. *Phys. Occup. Ther. Pediatr.* **2019**, *39*, 525–542. [\[CrossRef\]](#) [\[PubMed\]](#)
35. Hospodar, C.M.; Feldner, H.A.; Logan, S.W. Active mobility, active participation: A systematic review of modified ride-on car use by children with disabilities. *Disabil. Rehabil. Assist. Technol.* **2023**, *18*, 974–988. [\[CrossRef\]](#) [\[PubMed\]](#)

36. Naaris, M.; Bektashi, S.; Aufheimer, M.; Gerling, K.; Hallez, H.; Ortibus, E.; Konings, M.; Monbaliu, E. Effectiveness of wheeled mobility skill interventions in children and young people with cerebral palsy: A systematic review. *Dev. Med. Child Neurol.* **2023**, *65*, 1436–1450. [[CrossRef](#)] [[PubMed](#)]
37. Peters, M.D.J.; Marnie, C.; Tricco, A.C.; Pollock, D.; Munn, Z.; Alexander, L.; McInery, P.; Godfrey, C.M.; Khalil, H. Updated methodological guidance for the conduct of scoping reviews. *JBI Evid. Synth.* **2020**, *18*, 2119–2126. [[CrossRef](#)] [[PubMed](#)]
38. Arksey, H.; O'Malley, L. Scoping studies: Towards a methodological framework. *Int. J. Soc. Res. Methodol. Theory Pract.* **2005**, *8*, 19–32. [[CrossRef](#)]
39. Levac, D.; Colquhoun, H.; O'Brien, K.K. Scoping studies: Advancing the methodology. *Implement. Sci.* **2010**, *5*, 69. [[CrossRef](#)] [[PubMed](#)]
40. O'Brien, K.K.; Colquhoun, H.; Levac, D.; Baxter, L.; Tricco, A.C.; Straus, S.; Wickerson, L.; Nayar, A.; Moher, D.; O'Malley, L. Advancing scoping study methodology: A web-based survey and consultation of perceptions on terminology, definition and methodological steps. *BMC Health Serv. Res.* **2016**, *16*, 305. [[CrossRef](#)] [[PubMed](#)]
41. Tricco, A.C.; Lillie, E.; Zarin, W.; O'Brien, K.K.; Colquhoun, H.; Levac, D.; Moher, D.; Peters, M.D.J.; Horsley, T.; Weeks, L.; et al. PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Ann. Intern. Med.* **2018**, *169*, 467–473. [[CrossRef](#)] [[PubMed](#)]
42. Longo, E.; Monteiro, R.; Hidalgo-Robles, A.; Paleg, G.; Shrader, C.; de Campos, A.C. Intervention ingredients and F-words in early intervention for children with cerebral palsy functioning at GMFCS IV and V: A scoping review protocol. *Front. Rehabil. Sci.* **2023**, *4*, 1110552. [[CrossRef](#)] [[PubMed](#)]
43. Lindström, M.; Bäckström, A.C.; Henje, C.; Stenberg, G. 'When I use the electric wheelchair, I can be myself'—real-life stories about occupational identity construction. *Scand. J. Occup. Ther.* **2023**, *30*, 1368–1382. [[CrossRef](#)] [[PubMed](#)]
44. Logan, S.W.; Hospodar, C.M.; Feldner, H.A.; Huang, H.H.; Galloway, J.C. Modified Ride-On Car Use by Young Children with Disabilities. *Pediatr. Phys. Ther.* **2018**, *30*, 50–56. [[CrossRef](#)] [[PubMed](#)]
45. Ragonesi, C.; Chen, X.; Agrawal, S.; Galloway, J. Power mobility and socialization in preschool: Follow-up case study of a child with cerebral palsy. *Pediatr. Phys. Ther.* **2011**, *23*, 399–406. [[CrossRef](#)] [[PubMed](#)]
46. Ragonesi, C.; Chen, X.; Agrawal, S.; Galloway, J. Power mobility and socialization in preschool: A case study of a child with cerebral palsy. *Pediatr. Phys. Ther.* **2010**, *22*, 322–329. [[CrossRef](#)] [[PubMed](#)]
47. Spain, H.; Kraft, S.; Anson, C.; Wagor, C.; Futrell, N.; Coker-Bolt, P. The Effects of Low-Cost, Adapted Ride-on-Toys: A Case Series with Toddlers with Neuromuscular Disorders. *Am. J. Occup. Ther.* **2016**, *69*, 6911515166p1. [[CrossRef](#)]
48. Zeng, Q.; Burdet, E.; Teo, C.L. Evaluation of a collaborative wheelchair system in cerebral palsy and traumatic brain injury users. *Neurorehabil. Neural Repair* **2009**, *23*, 494–504. [[CrossRef](#)] [[PubMed](#)]
49. Zeng, Q.; Teo, C.L.; Rebsamen, B.; Burdet, E. Collaborative path planning for a robotic wheelchair. *Disabil. Rehabil. Assist. Technol.* **2008**, *3*, 315–324. [[CrossRef](#)] [[PubMed](#)]
50. Secoli, R.; Zondervan, D.; Reinkensmeyer, D. Using a smart wheelchair as a gaming device for floor-projected games: A mixed-reality environment for training powered-wheelchair driving skills. *Stud. Health Technol. Inform.* **2012**, *19*, 450–457. [[CrossRef](#)]
51. Sridhar, M. Ride-on Toy Cars to Advance Mobility and Development in Infants with Cerebral Palsy in the Home Setting: A Pilot Study. Bachelor's Thesis, University of Delaware, Newark, DE, USA, 2012.
52. Chung, K. A Qualitative Analysis of Perceived Barriers for the Explorer Mini and Modified Ride-On Toy Car and Recommended Modifications. Bachelor's Thesis, Oregon State University, Portland, OR, USA, 2023.
53. Drisdelle, S.; Power, L.; Thieu, S.; Sheriko, J. Developing an Immersive Virtual Reality Training System for Novel Pediatric Power Wheelchair Users: Protocol for a Feasibility Study. *JMIR Res. Protoc.* **2022**, *11*, 39140. [[CrossRef](#)] [[PubMed](#)]
54. Kenyon, L.K.; Farris, J.P.; Otieno, S. Empowering Functional Independence for Children with Severe Cerebral Palsy: A Randomized Controlled Trial Study Protocol. *Pediatr. Phys. Ther.* **2025**, *37*, 288–297. [[CrossRef](#)] [[PubMed](#)]
55. Allegritti, A.; Barnes, K.; Berndt, A. Impact of use of a ride-on toy car by children with mobility impairment. *Am. J. Occup. Ther.* **2018**, *72*, 02729490p1. [[CrossRef](#)]
56. Butler, C.; Okamoto, G.; McKay, T. Powered mobility for very young disabled children. *Dev. Med. Child Neurol.* **1983**, *25*, 472–474. [[CrossRef](#)] [[PubMed](#)]
57. Butler, C.; Okamoto, G.; McKay, T. Motorized wheelchair driving by disabled children. *Arch. Phys. Med. Rehabil.* **1984**, *65*, 95–97. [[PubMed](#)]
58. Cooper, R.; Tolerico, M.; Kaminski, B.; Spaeth, D.; Ding, D.; Cooper, R. Quantifying wheelchair activity of children: A pilot study. *Am. J. Phys. Med. Rehabil.* **2008**, *87*, 977–983. [[CrossRef](#)] [[PubMed](#)]
59. Gudjonsdottir, B.; Gudmundsdottir, S.B. Mobility devices for children with physical disabilities: Use, satisfaction and impact on participation. *Disabil. Rehabil. Assist. Technol.* **2021**, *18*, 722–729. [[CrossRef](#)] [[PubMed](#)]
60. Hasdai, A.; Jessel, A.; Weiss, P. Use of a computer simulator for training children with disabilities in the operation of a powered wheelchair. *Am. J. Nurs.* **1998**, *52*, 215–220. [[CrossRef](#)]

61. Hideshima, Y.; Asami, T.; Ichiba, M.; Matsuo, K.; Murata, T. A study on the effectiveness of training in the operation of an electric mobility aid in severely mentally and physically handicapped children. *Jpn. J. Compr. Rehabil. Sci.* **2024**, *15*, 8–16. [\[CrossRef\]](#) [\[PubMed\]](#)
62. Horne, A.; Ham, R. Provision of powered mobility equipment to young children: The Whizz-Kidz experience. *Int. J. Ther. Rehabil.* **2003**, *10*, 511–517. [\[CrossRef\]](#)
63. Huang, H.; Chang, C.; Tsai, W.; Chu, Y.; Lin, M.; Chen, C. Ride-On Cars with Different Postures and Motivation in Children with Disabilities: A Randomized Controlled Trial. *Am. J. Occup. Ther.* **2022**, *76*, 7603205030. [\[CrossRef\]](#) [\[PubMed\]](#)
64. Huang, H.H.; Chen, C.L. The use of modified ride-on cars to maximize mobility and improve socialization—a group design. *Res. Dev. Disabil.* **2017**, *61*, 172–180. [\[CrossRef\]](#) [\[PubMed\]](#)
65. Huang, H.H.; Chen, Y.M.; Huang, H.W. Ride-On Car Training for Behavioral Changes in Mobility and Socialization Among Young Children with Disabilities. *Pediatr. Phys. Ther.* **2017**, *29*, 207–213. [\[CrossRef\]](#) [\[PubMed\]](#)
66. Huang, H.H.; Chen, Y.M.; Huang, H.W.; Shih, M.K.; Hsieh, Y.H.; Chen, C.L. Modified Ride-On Cars and Young Children with Disabilities: Effects of Combining Mobility and Social Training. *Front. Pediatr.* **2018**, *5*, 299. [\[CrossRef\]](#) [\[PubMed\]](#)
67. Huang, H.H.; Huang, H.W.; Chen, Y.M.; Hsieh, Y.H.; Shih, M.K.; Chen, C.L. Modified ride-on cars and mastery motivation in young children with disabilities: Effects of environmental modifications. *Res. Dev. Disabil.* **2018**, *83*, 37–46. [\[CrossRef\]](#) [\[PubMed\]](#)
68. Huang, H.H.; Hsieh, Y.H.; Chang, C.H.; Tsai, W.Y.; Huang, C.K.; Chen, C.L. Ride-on car training using sitting and standing postures for mobility and socialization in young children with motor delays: A randomized controlled trial. *Disabil. Rehabil.* **2023**, *45*, 1453–1460. [\[CrossRef\]](#) [\[PubMed\]](#)
69. Huang, H.H.; Lee, Y.T.; Lai, C.L.; Lin, M.C. On-time power mobility and physical activity in toddlers with motor delays: A randomized controlled trial using body-worn sensors. *Assist. Technol.* **2025**, *37*, 111–119. [\[CrossRef\]](#) [\[PubMed\]](#)
70. Huang, H.H.; Tsai, W.Y.; Lin, Y.N.; Hung, C.Y.; Chan, A.T. Caregivers' Perceptions of Ride-On Cars and Behavioral Changes for Young Children with Motor Delays. *Pediatr. Phys. Ther.* **2024**, *36*, 42–51. [\[CrossRef\]](#) [\[PubMed\]](#)
71. Huang, H.H.; Chu, Y.W.; Chan, A.T.; Chen, C.L. A pilot randomised controlled trial of ride-on cars and postural combinations of standing and sitting for mobility and social function in toddlers with motor delays. *Disabil. Rehabil. Assist. Technol.* **2025**, *20*, 53–63. [\[CrossRef\]](#) [\[PubMed\]](#)
72. Jonasson, M. The AKKA-board—Performing mobility, disability and innovation. *Disabil. Soc.* **2014**, *29*, 477–490. [\[CrossRef\]](#)
73. Logan, S.W.; Feldner, H.A.; Bogart, K.R.; Catena, M.A.; Hospodar, C.M.; Raja Vora, J.; Smart, W.D.; Massey, W.V. Perceived Barriers Before and After a 3-Month Period of Modified Ride-On Car Use. *Pediatr. Phys. Ther.* **2020**, *32*, 243–248. [\[CrossRef\]](#) [\[PubMed\]](#)
74. Ross, S.M.; Catena, M.; Twardzik, E.; Hospodar, C.; Cook, E.; Ayyagari, A.; Inskeep, K.; Sloane, B.; MacDonald, M.; Logan, S.W. Feasibility of a modified ride-on car intervention on play behaviors during an inclusive playgroup. *Phys. Occup. Ther. Pediatr.* **2017**, *38*, 493–509. [\[CrossRef\]](#) [\[PubMed\]](#)
75. Torkia, C.; Ryan, S.E.; Reid, D.; Boissy, P.; Lemay, M.; Routhier, F.; Contardo, R.; Woodhouse, J.; Archambault, P.S. Virtual community centre for power wheelchair training: Experience of children and clinicians. *Disabil. Rehabil. Assist. Technol.* **2019**, *14*, 46–55. [\[CrossRef\]](#) [\[PubMed\]](#)
76. Uyama, S.; Anaki, K.H. Current status of the utilization of powered wheelchair in preschool children with locomotive disability in Japan. *Phys. Ther. Res.* **2016**, *19*, 13–23. [\[CrossRef\]](#) [\[PubMed\]](#)
77. Zondervan, D.K.; Secoli, R.; Darling, A.M.; Farris, J.; Furumasu, J.; Reinkensmeyer, D.J. Design and Evaluation of the Kinect-Wheelchair Interface Controlled (KWIC) Smart Wheelchair for Pediatric Powered Mobility Training. *Assist. Technol.* **2015**, *27*, 183–192. [\[CrossRef\]](#) [\[PubMed\]](#)
78. Jones, M.; McEwen, I.; Neas, B. Effects of power wheelchairs on the development and function of young children with severe motor impairments. *Pediatr. Phys. Ther.* **2012**, *24*, 131–140. [\[CrossRef\]](#) [\[PubMed\]](#)
79. Jones, M. Effects of Power Mobility on Young Children with Severe Motor Impairments. Available online: <https://www.clinicaltrials.gov/study/NCT01028833?cond=Children&term=poweredwheelchair&rank=6> (accessed on 2 March 2026).
80. Mockler, S.R.; McEwen, I.R.; Jones, M.A. Retrospective analysis of predictors of proficient power mobility in young children with severe motor impairments. *Arch. Phys. Med. Rehabil.* **2017**, *98*, 2034–2041. [\[CrossRef\]](#) [\[PubMed\]](#)
81. Currier, B.A.; Jones, M.A.; DeGrace, B.W. Experiences of families with young power wheelchair users. *J. Early Interv.* **2019**, *41*, 125–140. [\[CrossRef\]](#)
82. Molina-Cantero, A.J.; Biscarri-Triviño, F.; Gallardo-Soto, A.; Jaramillo-Pareja, J.M.; Monlina-Criado, S.; Díaz-Rodríguez, A.; Sierra-Martín, L. A Single-Button Mobility Platform for Cause–Effect Learning in Children with Cerebral Palsy: A Pilot Study. *Children* **2025**, *12*, 1077. [\[CrossRef\]](#) [\[PubMed\]](#)
83. Feldner, H.; Logan, S.; Otieno, S.; Fragomeni, A.; Kono, C.; Riordan, K.; Sloane, B.; Kenyon, L.K. Short-Term Powered Mobility Intervention is Associated with Improvements in Development and Participation for Young Children with Cerebral Palsy: A Randomized Clinical Trial. *Phys. Ther.* **2025**, *105*, pzae152. [\[CrossRef\]](#) [\[PubMed\]](#)

84. Logan, S.W.; Sloane, B.M.; Kenyon, L.K.; Feldner, H.A. Powered Mobility Device Use and Developmental Change of Young Children with Cerebral Palsy. *Behav. Sci.* **2023**, *13*, 399. [\[CrossRef\]](#) [\[PubMed\]](#)
85. Sloane, B.M.; Kenyon, L.K.; Logan, S.W.; Feldner, H.A. Caregiver perspectives on powered mobility devices and participation for children with cerebral palsy in Gross Motor Function Classification System level V. *Dev. Med. Child Neurol.* **2024**, *66*, 333–343. [\[CrossRef\]](#) [\[PubMed\]](#)
86. Kenyon, L.K.; Sloane, B.M.; Beers, L.N.; Chung, K.J.; Doty, J.; Erlenbeck, A.R.; Herrenkohl, M.; Logan, S.W.; Feldner, H.A. Tiny drivers, big decisions: Parental perceptions and experiences of power mobility device trials for young children with cerebral palsy. *Disabil. Rehabil. Assist. Technol.* **2025**, *20*, 1566–1573. [\[CrossRef\]](#) [\[PubMed\]](#)
87. Aldrich, N.J.; Kenyon, L.K.; Lambert, R.; Marsman, K.; Vasseur, M.; Sloane, B.; Logan, S.W.; Feldner, H.A. Quantifying Parental Perceptions of Their Experiences with Their Young Children’s Use of Power Mobility Devices. *Pediatr. Phys. Ther.* **2025**, *37*, 46–55. [\[CrossRef\]](#) [\[PubMed\]](#)
88. Sloane, B.M.; Hoffman, M.; Logan, S.W.; Kenyon, L.K.; Steele, K.M.; Feldner, H.A. Comparison of three tracking methods to assess usage of two pediatric powered mobility devices for young children with cerebral palsy. *Assist. Technol.* **2025**, *Early online*. [\[CrossRef\]](#)
89. Gefen, N.; Archambault, P.S.; Rigbi, A.; Weiss, P.L. Pediatric powered mobility training: Powered wheelchair versus simulator-based practice. *Assist. Technol.* **2023**, *35*, 389–398. [\[CrossRef\]](#) [\[PubMed\]](#)
90. Gefen, N.; Rigbi, A.; Weiss, P.L. Reliability and validity of pediatric powered mobility outcome measures. *Disabil. Rehabil. Assist. Technol.* **2020**, *17*, 882–887. [\[CrossRef\]](#) [\[PubMed\]](#)
91. Rosenberg, L.; Maeir, A.; Gilboa, Y. Feasibility study of a therapeutic mobility summer camp for children with severe cerebral palsy: Power Fun. *Phys. Occup. Ther. Pediatr.* **2020**, *40*, 395–409. [\[CrossRef\]](#) [\[PubMed\]](#)
92. Rosenberg, L.; Maeir, A.; Gilboa, Y. Evaluating a therapeutic powered mobility camp for children with severe cerebral palsy. *Can. J. Occup. Ther.* **2021**, *88*, 294–305. [\[CrossRef\]](#) [\[PubMed\]](#)
93. Bottos, M.; Bolcati, C.; Sciuto, L.; Ruggeri, C.; Feliciangeli, A. Powered wheelchairs and independence in young children with tetraplegia. *Dev. Med. Child Neurol.* **2001**, *43*, 769–777. [\[CrossRef\]](#) [\[PubMed\]](#)
94. Guerette, P.; Furumasu, J.; Tefft, D. The positive effects of early powered mobility on children’s psychosocial and play skills. *Assist. Technol.* **2013**, *25*, 39–48. [\[CrossRef\]](#) [\[PubMed\]](#)
95. Tefft, D.; Guerette, P.; Furumasu, J. The impact of early powered mobility on parental stress, negative emotions, and family social interactions. *Phys. Occup. Ther. Pediatr.* **2011**, *31*, 4–15. [\[CrossRef\]](#) [\[PubMed\]](#)
96. Field, D.A.; Borisoff, J.; Chan, F.H.N.; Livingstone, R.W.; Miller, W.C. Standing power wheelchairs and their use by children and youth with mobility limitations: An interrupted time series. *Disabil. Rehabil. Assist. Technol.* **2024**, *19*, 454–464. [\[CrossRef\]](#) [\[PubMed\]](#)
97. Kirby, R.L.; Miller, W.C.; Routhier, F.; Demers, L.; Mihailidis, A.; Polgar, J.M.; Rushton, P.W.; Titus, L.; Smith, C.; McAllister, M.; et al. Effectiveness of a Wheelchair Skills Training Program for Powered Wheelchair Users: A Randomized Controlled Trial. *Arch. Phys. Med. Rehabil.* **2015**, *96*, 2017–2026.e3. [\[CrossRef\]](#) [\[PubMed\]](#)
98. Naaris, M.; Konings, M.; Ortibus, E.; Monbaliu, E. Wheelchair skills training improves power mobility and participation in young people with cerebral palsy. *Dev. Med. Child Neurol.* **2024**, *66*, 1653–1663. [\[CrossRef\]](#) [\[PubMed\]](#)
99. Rushton, P.W.; Kirby, R.L.; Routhier, F.; Smith, C. Measurement properties of the Wheelchair Skills Test—Questionnaire for powered wheelchair users. *Disabil. Rehabil. Assist. Technol.* **2016**, *11*, 400–406. [\[CrossRef\]](#) [\[PubMed\]](#)
100. Naaris, M.; Konings, M.; Vanmechelen, I.; Ravers, D.; Ortibus, E.; Monbaliu, E. Psychometric Properties of the Wheelchair Skills Test and the Wheelchair Skills Test-Questionnaire: Validity, Reliability, and Responsiveness in Children and Young Adults with Cerebral Palsy—Exploratory Study. *Phys. Occup. Ther. Pediatr.* **2026**, *46*, 115–131. [\[CrossRef\]](#) [\[PubMed\]](#)
101. Ziegler, K.; Da Silva, C.P.; Mitchell, K.; Baxter, M.F.; Bickley, C. The impact of modified ride-on car use on trunk control and development in children with disabilities: A feasibility study. *Assist. Technol.* **2025**, *Early online*. [\[CrossRef\]](#) [\[PubMed\]](#)
102. Ziegler, K.; Da Silva, C.P.; Mitchell, K.; Baxter, M.F.; Bickley, C. Caregiver and child satisfaction with modified ride-on car use in young children with disabilities: A qualitative study. *Disabil. Rehabil. Assist. Technol.* **2025**, *Early online*. [\[CrossRef\]](#) [\[PubMed\]](#)
103. Arps, K.; Darr, N.; Katz, J. Effect of adapted motorized ride-on toy use on developmental skills, quality of life, and driving competency in nonambulatory children age 9–60 months. *Assist. Technol.* **2023**, *35*, 83–93. [\[CrossRef\]](#) [\[PubMed\]](#)
104. Aceros, J.; Lundy, M. The Effects of Power Mobility on Self-Care, Mobility, and Social Function in Very Young Children with Severe Multiple Developmental Impairments. *Front. Rehabil. Sci.* **2025**, *6*, 1551536. [\[CrossRef\]](#) [\[PubMed\]](#)
105. Floreani, E.D.; Rowley, D.; Kelly, D.; Kinney-Lang, E.; Kirton, A. On the feasibility of simple brain-computer interface systems for enabling children with severe physical disabilities to explore independent movement. *Front. Hum. Neurosci.* **2022**, *16*, 1007199. [\[CrossRef\]](#) [\[PubMed\]](#)

106. Floreani, E.D.; Rowley, D.; Khan, N.; Kelly, D.; Robu, I.; Kirton, A.; Kinney-Lang, E. Unlocking Independence: Exploring Movement with Brain-Computer Interface for Children with Severe Physical Disabilities. In Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS, Virtual, 31 October–4 November 2021. [[CrossRef](#)] [[PubMed](#)]
107. Felix, J.B.; de Campos, A.C.; Logan, S.W.; Machado, J.; Souza Monteiro, K.; Longo, E. Go Zika Go: Feasibility study with modified motorized ride-on cars for the mobility of children with Congenital Zika Syndrome (CZS). *Disabil. Rehabil. Assist. Technol.* **2024**, *19*, 2665–2678. [[CrossRef](#)] [[PubMed](#)]
108. Barreto, A.S.; Felix, J.B.; Feldner, H.; Figueiredo, M.T.; Maceo, G.K.; Coutinho, D.N.; Gadelha, M.d.S.; Monteiro, K.; Longo, E. Experiences of children with congenital Zika syndrome while using motorized mobility: A qualitative study using the photovoice method. *Disabil. Rehabil. Assist. Technol.* **2024**, *19*, 3089–3099. [[CrossRef](#)] [[PubMed](#)]
109. Livingstone, R.; Field, D. Exploring young children’s activity and participation change following six months’ power mobility experience. *Br. J. Occup. Ther.* **2021**, *84*, 713–722. [[CrossRef](#)]
110. Livingstone, R.W.; Field, D.A. Exploring change in young children’s power mobility skill following several months’ experience. *Disabil. Rehabil. Assist. Technol.* **2023**, *18*, 285–294. [[CrossRef](#)] [[PubMed](#)]
111. Livingstone, R.W.; Field, D.A.; Sanderson, C.; Pineau, N.; Zwicker, J.G. Beginning Power Mobility: Parent and therapist perspectives. *Disabil. Rehabil.* **2022**, *44*, 2832–2841. [[CrossRef](#)] [[PubMed](#)]
112. Livingstone, R.; Bone, J.; Field, D. Beginning Power Mobility: An exploration of factors associated with child use of early power mobility devices and parent device preference. *J. Rehabil. Assist. Technol. Eng.* **2020**, *7*, 1–12. [[CrossRef](#)] [[PubMed](#)]
113. Field, D.A.; Livingstone, R.W. Parents’ and therapists’ satisfaction with four early childhood power mobility devices. *Can. J. Occup. Ther.* **2022**, *89*, 364–375. [[CrossRef](#)] [[PubMed](#)]
114. Kenyon, L.K.; Farris, J.P.; Veety, L.; Kleikamp, B.; Harrington, K.; Jenkinson, J.; Montgomery, A.; Otieno, S.; Russell, I.M.; Zondervan, D.K. The IndieTrainer system: A small-scale trial exploring a new approach to support powered mobility skill acquisition in children. *Disabil. Rehabil. Assist. Technol.* **2024**, *19*, 2953–2961. [[CrossRef](#)] [[PubMed](#)]
115. Aldrich, N.J.; Vanderest, D.; Slowik, K.; Farris, J.P.; Zondervan, D.K.; Kenyon, L.K. Parental perceptions and gender as predictors of changes in children’s understanding of how to use a power wheelchair. *Disabil. Rehabil. Assist. Technol.* **2025**, *20*, 2750–2765. [[CrossRef](#)] [[PubMed](#)]
116. Sloane, B.M.; Logan, S.W.; Sy, J.R.T.; Brombach, R.K.; Stevens-Rose, A.; Dietch, J.R. Effect of a Power Mobility Intervention on the Sleep Health of Toddlers with Cerebral Palsy. *Phys. Occup. Ther. Pediatr.* **2025**, Early online. [[CrossRef](#)] [[PubMed](#)]
117. Nisbet, P.; Craig, J.; Odor, P.; Aitken, S. “Smart” wheelchairs for mobility training. *Technol. Disabil.* **1996**, *5*, 49–62. [[CrossRef](#)]
118. Nisbet, P. Assessment and training of children for powered mobility in the UK. *Technol. Disabil.* **2002**, *14*, 173–182. [[CrossRef](#)]
119. Kenyon, L.K.; Massingill, B.; Farris, J.P. Using a child’s power mobility learner group to tailor power mobility interventions: A case series. *Disabil. Rehabil. Assist. Technol.* **2023**, *18*, 791–797. [[CrossRef](#)] [[PubMed](#)]
120. Kenyon, L.K.; Farris, J.P.; Gallagher, C.; Hammond, L.; Webster, L.M.; Aldrich, N.J. Power Mobility Training for Young Children with Multiple, Severe Impairments: A Case Series. *Phys. Occup. Ther. Pediatr.* **2017**, *37*, 19–34. [[CrossRef](#)] [[PubMed](#)]
121. McCourt, E.; Casey, J. Electrically powered indoor/outdoor chair performance for children aged 7 to 9 years. *Br. J. Occup. Ther.* **2016**, *79*, 584–590. [[CrossRef](#)]
122. McGarry, S.; Moir, L.; Girdler, S. The Smart Wheelchair: Is it an appropriate mobility training tool for children with physical disabilities? *Disabil. Rehabil. Assist. Technol.* **2012**, *7*, 372–380. [[CrossRef](#)] [[PubMed](#)]
123. Sloane, B.M.; Case, F.; Quinn, E.; Sanford-Keller, H.; Logan, S.W. Modified Ride-on Car Intervention for Children with Profound Intellectual and Multiple Disabilities: A Case Series. *Pediatr. Phys. Ther.* **2023**, *35*, 277–283. [[CrossRef](#)] [[PubMed](#)]
124. Ingraham, K.A.; Zaino, N.L.; Feddema, C.; Hoffman, M.E.; Gijbels, L.; Sinclair, A.; Meltzoff, A.N.; Kuhl, P.K.; Feldner, H.A.; Steele, K.M. Quantifying Joystick Interactions and Movement Patterns of Toddlers with Disabilities Using Powered Mobility with an Instrumented Explorer Mini. *IEEE Trans. Neural Syst. Rehabil. Eng.* **2025**, *33*, 431–440. [[CrossRef](#)] [[PubMed](#)]
125. Zaino, N.L.; Ingraham, K.A.; Hoffman, M.E.; Feldner, H.A.; Steele, K.M. Quantifying toddler exploration in different postures with powered mobility. *Assist. Technol.* **2025**, *37*, 93–101. [[CrossRef](#)] [[PubMed](#)]
126. Gohlke, J.H.; Kenyon, L.K. Exploring powered wheelchair standing device use in children and adults: A longitudinal case series. *Disabil. Rehabil. Assist. Technol.* **2022**, *19*, 699–711. [[CrossRef](#)] [[PubMed](#)]
127. Pritchard-Wiart, L.; Bragg, E.; Thompson-Hodgetts, S. The Young Movers Project: A Case Series Describing Modified Toy Car Use as an Early Movement Option for Young Children with Mobility Limitations. *Phys. Occup. Ther. Pediatr.* **2019**, *39*, 598–613. [[CrossRef](#)] [[PubMed](#)]
128. Logan, S.W.; Feldner, H.A.; Galloway, J.C.; Huang, H.H. Modified Ride-on Car Use by Children with Complex Medical Needs. *Pediatr. Phys. Ther.* **2016**, *28*, 100–107. [[CrossRef](#)] [[PubMed](#)]
129. Logan, S.W.; Hospodar, C.M.; Bogart, K.R.; Catena, M.A. Real world tracking of modified ride-on car usage in young children with disabilities. *J. Mot. Learn. Dev.* **2019**, *7*, 336–353. [[CrossRef](#)] [[PubMed](#)]

130. Butler, C. Effects of powered mobility on self-initiated behaviors of very young children with locomotor disability. *Dev. Med. Child. Neurol.* **1986**, *28*, 325–332. [CrossRef] [PubMed]
131. Deitz, J.; Swinth, Y.; White, O. Powered mobility and preschoolers with complex developmental delays. *Am. J. Occup. Ther.* **2002**, *56*, 86–96. [CrossRef] [PubMed]
132. Gantschnig, B.; Rönnefeld, S.; Nilsson, L. Powered mobility training in young children with cerebral palsy. *Orthop. Tech.* **2020**, *7*, 42–49.
133. Kenyon, L.K.; Farris, J.P.; Aldrich, N.J.; Rhodes, S. Does power mobility training impact a child's mastery motivation and spectrum of EEG activity? An exploratory project. *Disabil. Rehabil. Assist. Technol.* **2018**, *13*, 665–673. [CrossRef] [PubMed]
134. Kenyon, L.K.; Farris, J.P.; Aldrich, N.J.; Usoro, J.; Rhodes, S. Changes in Electroencephalography Activity in Response to Power Mobility Training: A Pilot Project. *Physiother. Can.* **2020**, *72*, 260–270. [CrossRef] [PubMed]
135. Kenyon, L.K.; Aldrich, N.J.; Behl, S.L.; Bazany, S.G.; McDonagh, E.R.; Miller, W.C. Enabled to Stand: A Single-subject Research Design Study Exploring Pediatric Power Wheelchair Standing Device Use. *Pediatr. Phys. Ther.* **2024**, *36*, 316–327. [CrossRef] [PubMed]
136. Kenyon, L.K.; Aldrich, N.J.; Farris, J.P.; Chesser, B.; Walenta, K. Exploring the Effects of Power Mobility Training on Parents of Exploratory Power Mobility Learners: A Multiple-Baseline Single-Subject Research Design Study. *Physiother. Can.* **2021**, *73*, 76–89. [CrossRef] [PubMed]
137. Adelola, I.; Cox, S.; Rahman, A. Virtual environments for powered wheelchair learner drivers: Case studies. *Technol. Disabil.* **2009**, *21*, 97–106. [CrossRef]
138. An, M.; Kim, J. Family-Professional Collaboration on Modified Ride-on Car Intervention for Young Children: Two Case Reports. *Phys. Occup. Ther. Pediatr.* **2024**, *44*, 198–215. [CrossRef] [PubMed]
139. Bicalho Saraiva, B.; Facchin, A.C.E.; da Silva, R.R.A.; de Oliveira, D.R.; Brighenti, I.C.S.; Filgueras, F.A.; Lima, H.M.; Bastos, F.d.S.; Chaga, P.S.d.C. The use of adapted motorized vehicles with controlled acceleration: Focus on child's acceptance. *Assist. Technol.* **2025**, Early online. [CrossRef] [PubMed]
140. Catena, M.A.; Sloane, B.M.; Feldner, H.A.; Kenyon, L.K.; Logan, S.W. Initial fidelity of a powered mobility intervention: A case report. *Phys. Educ. Sport Pedagog.* **2026**, *31*, 144–158. [CrossRef]
141. Doherty, J. Single-Switch Driving. Mobility Management. Available online: <https://mobilitymgmt.com/single-switch-driving/> (accessed on 2 March 2026).
142. Huang, H.H.; Galloway, J.C. Modified ride-on toy cars for early power mobility: A technical report. *Pediatr. Phys. Ther.* **2012**, *24*, 149–154. [CrossRef] [PubMed]
143. Huang, H.H.; Ragonesi, C.B.; Stoner, T.; Peffley, T.; Galloway, J.C. Modified toy cars for mobility and socialization: Case report of a child with cerebral palsy. *Pediatr. Phys. Ther.* **2014**, *26*, 76–84. [CrossRef] [PubMed]
144. Huhn, K.; Guarrera-Bowlby, P.; Deutsch, J. The clinical decision-making process of prescribing power mobility for a child with cerebral palsy. *Pediatr. Phys. Ther.* **2007**, *19*, 254–260. [CrossRef] [PubMed]
145. Kenyon, L.K.; Farris, J.; Brockway, K.; Hannum, N.; Proctor, K. Promoting Self-exploration and Function Through an Individualized Power Mobility Training Program. *Pediatr. Phys. Ther.* **2015**, *27*, 200–206. [CrossRef] [PubMed]
146. Livingstone, R.W.; Chin, A.J.; Paleg, G.S. Power Mobility, Supported Standing and Stepping Device Use in the First Two Years of Life: A Case Report of Twins Functioning at GMFCS V. *Disabilities* **2023**, *3*, 507–524. [CrossRef]
147. Ragonesi, C.; Galloway, J. Short-term, early intensive power mobility training. *Pediatr. Phys. Ther.* **2012**, *24*, 141–148. [CrossRef] [PubMed]
148. Berry, E.; McLaurin, S.; Sparling, J. Parent/caregiver perspectives on the use of power wheelchairs. *Pediatr. Phys. Ther.* **1996**, *8*, 146–150. [CrossRef]
149. Cerruti, M.; Biondi, R. Timely insertion of electronic wheelchair in overall rehabilitation plan for cerebral palsy in young children: Investigation on the opinion of parents. *Sci. Riabil.* **2010**, *12*, 14–23.
150. Durkin, J. Discovering powered mobility skills with children: 'responsive partners' in learning. *Int. J. Ther. Rehabil.* **2009**, *16*, 331–342. [CrossRef]
151. Evans, S.; Neophytou, C.; De Souza, L.; Frank, A. Young people's experiences using electric powered indoor—Outdoor wheelchairs (EPIOCs): Potential for enhancing users' development? *Disabil. Rehabil.* **2007**, *29*, 1281–1294. [CrossRef]
152. Gudgeon, S.; Kirk, S. Living with a powered wheelchair: Exploring children's and young people's experiences. *Disabil. Rehabil. Assist. Technol.* **2015**, *10*, 118–125. [CrossRef] [PubMed]
153. Kenyon, L.K.; Mortenson, W.B.; Miller, W.C. "Power in Mobility": Parent and therapist perspectives of the experiences of children learning to use powered mobility. *Dev. Med. Child Neurol.* **2018**, *60*, 1012–1017. [CrossRef] [PubMed]
154. Kenyon, L.K.; Blank, K.; Meengs, J.; Schultz, A.M. "Make it fun": A qualitative study exploring key aspects of power mobility interventions for children. *Disabil. Rehabil. Assist. Technol.* **2023**, *18*, 304–312. [CrossRef] [PubMed]
155. Kenyon, L.K.; Harrison, K.L.; Huettner, M.K.; Johnson, S.B.; Miller, W.C. Stakeholder perspectives of pediatric powered wheelchair standing devices: A qualitative study. *Dev. Med. Child Neurol.* **2021**, *63*, 969–975. [CrossRef] [PubMed]

156. Nilsson, L.; Nyberg, P. Driving to learn: A new concept for training children with profound cognitive disabilities in a powered wheelchair. *Am. J. Occup. Ther.* **2003**, *57*, 229–233. [[CrossRef](#)] [[PubMed](#)]
157. Pituch, E.; Rushton, P.W.; Ngo, M.; Heales, J.; Poulin Arguin, A. Powerful or Powerless? Children's, Parents', and Occupational Therapists' Perceptions of Powered Mobility. *Phys. Occup. Ther. Pediatr.* **2018**, *39*, 276–291. [[CrossRef](#)] [[PubMed](#)]
158. Wiart, L.; Darrah, J.; Hollis, V.; Cook, A.; May, L. Mothers' perceptions of their children's use of powered mobility. *Phys. Occup. Ther. Pediatr.* **2004**, *24*, 3–21. [[CrossRef](#)] [[PubMed](#)]
159. Sonday, A.; Gretschesel, P. Empowered to play: A case study describing the impact of powered mobility on the exploratory play of disabled children. *Occup. Ther. Int.* **2016**, *23*, 11–18. [[CrossRef](#)] [[PubMed](#)]
160. Jahan, I.; Islam, S. Powered mobility in low- and middle-income countries: Caregivers' perspective from Bangladesh. *Dev. Med. Child Neurol.* **2024**, *66*, 276–277. [[CrossRef](#)] [[PubMed](#)]
161. Cheng, H.Y.K.; Hu, S.Y.; Ju, Y.Y.; Yu, Y.C. Exploring Growth-Stage Variations in Home Use of Positioning and Mobility Assistive Technology for Children with GMFCS IV Cerebral Palsy: Parental Insights and Challenges. *Bioengineering* **2025**, *12*, 241. [[CrossRef](#)] [[PubMed](#)]
162. Feldner, H. Impacts of early powered mobility provision on disability identity: A case study. *Rehabil. Psychol.* **2019**, *64*, 130–145. [[CrossRef](#)] [[PubMed](#)]
163. Feldner, H.A.; Logan, S.W.; Galloway, J.C. Mobility in pictures: A participatory photovoice narrative study exploring powered mobility provision for children and families. *Disabil. Rehabil. Assist. Technol.* **2019**, *14*, 301–311. [[CrossRef](#)] [[PubMed](#)]
164. Abuatiq, R.A.; Feldner, H.A. Picture Me Moving: A Photovoice Study of Families and Children with Motor Disabilities Using Modified Ride-on Toy Cars. *Pediatr. Phys. Ther.* **2026**, *38*, 78–86. [[CrossRef](#)] [[PubMed](#)]
165. Barchus, R.; Barroero, C.; Schnare, W.; Dean, S.M.; Feldner, H.A. "Kind of Empowered": Perceptions of Socio-Emotional Development in Children Driving Ride-on Cars. *Rehabil. Psychol.* **2023**, *68*, 155–163. [[CrossRef](#)] [[PubMed](#)]
166. Nesbitt, C.C.; Pace, A.; Feldner, H.A. Preliminary Data: Powered Mobility Intervention with Language Monitoring for Children with Cerebral Palsy. *Perspect. ASHA Spec. Interest Groups* **2023**, *8*, 825–833. [[CrossRef](#)]
167. Hoffman, M.E.; Steele, K.M.; Froehlich, J.E.; Winfree, K.N.; Feldner, H.A. Off to the park: A geospatial investigation of adapted Ride-on car usage. *Disabil. Rehabil. Assist. Technol.* **2023**, *19*, 1890–1898. [[CrossRef](#)] [[PubMed](#)]
168. Dean-Hergert, S.M.; Papazian, C.; Barchus, R.; Barroero, C.; Schnare, W.; Logan, S.W.; Feldner, H.A.; Winfree, K.N. Ready, Set, Move! Tracking Children's Modified Ride-On Car Use with a Custom Data Logger. *Pediatr. Phys. Ther.* **2024**, *36*, 53–60. [[CrossRef](#)] [[PubMed](#)]
169. Plummer, T.; Logan, S.W.; Morress, C. Explorer Mini: Infants' Initial Experience with a Novel Pediatric Powered Mobility Device. *Phys. Occup. Ther. Pediatr.* **2020**, *41*, 192–208. [[CrossRef](#)] [[PubMed](#)]
170. Wiart, L.; Darrah, J.; Cook, A.; Hollis, V.; May, L. Evaluation of powered mobility use in home and community environments. *Phys. Occup. Ther. Pediatr.* **2003**, *23*, 59–75. [[CrossRef](#)] [[PubMed](#)]
171. Gefen, N.; Rigbi, A.; Weiss, P.L. Predictive model of proficiency in powered mobility of children and young adults with motor impairments. *Dev. Med. Child Neurol.* **2019**, *61*, 1416–1422. [[CrossRef](#)] [[PubMed](#)]
172. Gefen, N.; Weiss, P.L.; Rigbi, A.; Rosenberg, L. Lessons learned from a pediatric powered mobility lending program. *Disabil. Rehabil. Assist. Technol.* **2024**, *19*, 2250–2259. [[CrossRef](#)] [[PubMed](#)]
173. Frank, A.O.; De Souza, L.H. Problematic clinical features of children and adults with cerebral palsy who use electric powered indoor/outdoor wheelchairs: A cross-sectional study. *Assist. Technol.* **2016**, *29*, 68–75. [[CrossRef](#)] [[PubMed](#)]
174. Frank, A.O.; De Souza, L.H. Recipients of electric-powered indoor/outdoor wheelchairs provided by a national health service: A cross-sectional study. *Arch. Phys. Med. Rehabil.* **2013**, *94*, 2403–2409. [[CrossRef](#)] [[PubMed](#)]
175. Rodby-Bousquet, E.; Hägglund, G. Use of manual and powered wheelchair in children with cerebral palsy: A cross-sectional study. *BMC Pediatr.* **2010**, *10*, 59. [[CrossRef](#)] [[PubMed](#)]
176. Rodby-Bousquet, E.; Paleg, G.; Casey, J.; Wizert, A.; Livingstone, R. Physical risk factors influencing wheeled mobility in children with cerebral palsy: A cross-sectional study. *BMC Pediatr.* **2016**, *16*, 165. [[CrossRef](#)] [[PubMed](#)]
177. Palisano, R.J.; Tieman, B.L.; Walter, S.D.; Bartlett, D.J.; Rosenbaum, P.L.; Russell, D.; Hanna, S.E. Effect of environmental setting on mobility methods of children with cerebral palsy. *Dev. Med. Child Neurol.* **2003**, *45*, 113–120. [[CrossRef](#)] [[PubMed](#)]
178. Kilde, A.; Evensen, K.A.I.; Kløve, N.; Rodby-bousquet, E.; Lydersen, S.; Klevberg, G.L. Early independent wheeled mobility in children with cerebral palsy: A Norwegian population-based registry study. *J. Clin. Med.* **2025**, *14*, 923. [[CrossRef](#)] [[PubMed](#)]
179. Bekteshi, S.; Konings, M.; Nica, I.G.; Gakopoulos, S.; Aerts, J.M.; Hallez, H.; Monbaliu, E. Dystonia and choreoathetosis presence and severity in relation to powered wheelchair mobility performance in children and youth with dyskinetic cerebral palsy. *Eur. J. Paediatr. Neurol.* **2020**, *29*, 118–127. [[CrossRef](#)] [[PubMed](#)]
180. Bekteshi, S.; Nica, I.G.; Cuyvers, B.; Gakopoulos, S.; Hallez, H.; Monbaliu, E.; Aerts, J.-M. Automated monitoring of movement disorders in dyskinetic cerebral palsy during powered mobility. *medRxiv* **2025**. [[CrossRef](#)]

181. Bekteshi, S.; Konings, M.; Nica, I.G.; Gakopoulos, S.; Vanmechelen, I.; Aerts, J.-M.; Hallez, H.; Monbaliu, E. Development of the Dyskinesia Impairment Mobility Scale to measure presence and severity of dystonia and choreoathetosis during powered mobility in dyskinetic cerebral palsy. *Appl. Sci.* **2019**, *9*, 3481. [[CrossRef](#)]
182. Field, D.A.; Miller, W.C. The Wheelchair Outcome Measure for Young People (WhOM-YP): Modification and metrics for children and youth with mobility limitations. *Disabil. Rehabil. Assist. Technol.* **2022**, *17*, 192–200. [[CrossRef](#)] [[PubMed](#)]
183. Furumasu, J.; Guerette, P.; Tefft, D. Relevance of the Pediatric Powered Wheelchair Screening Test for children with cerebral palsy. *Dev. Med. Child Neurol.* **2004**, *46*, 468–474. [[CrossRef](#)] [[PubMed](#)]
184. Krasovsky, T.; Shammah, C.; Addes, A.; Brezner, A.; Barak, S. The Development and Evaluation of the Powered Mobility Function Scale (PMFS) for Children and Adolescents with Cerebral Palsy. *Dev. Neurorehabil.* **2021**, *24*, 338–347. [[CrossRef](#)] [[PubMed](#)]
185. Liu, W.Y.; Chen, F.J.; Lin, Y.H.; Kuo, C.H.; Lien, H.Y.; Yu, Y.J. Postural alignment in children with bilateral spastic cerebral palsy using a bimanual interface for powered wheelchair control. *J. Rehabil. Med.* **2014**, *46*, 39–44. [[CrossRef](#)] [[PubMed](#)]
186. Huggins, M.; Gallen, D. A training program for operation of a head-controlled electric wheelchair. *Physiother. Can.* **1984**, *36*, 204–207. [[PubMed](#)]
187. Morère, Y.; Bourhis, G.; Cosnuau, K.; Guilmois, G.; Blangy, E.; Rumilly, E. ViEW: A wheelchair simulator for driving analysis. *Assist. Technol.* **2020**, *32*, 125–135. [[CrossRef](#)] [[PubMed](#)]
188. Kakimoto, A.; Suzuki, S.; Sekiguchi, Y. Development of a cart for independent mobility assistance for non-ambulatory children. In Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Minneapolis, MN, USA, 2–6 September 2009. [[CrossRef](#)] [[PubMed](#)]
189. Fradasari, F.E.; Arifin, A.; Hermawan, N. Electric Wheelchair Performance Testing with Joystick Control Command for Cerebral Palsy Subject. In Proceedings of the International Seminar on Intelligent Technology and Its Applications: Leveraging Intelligent Systems to Achieve Sustainable Development Goals, ISITIA, Surabaya, Indonesia, 26–27 July 2023. [[CrossRef](#)]
190. Marchal-Crespo, L.; Furumasu, J.; Reinkensmeyer, D.J. A robotic wheelchair trainer: Design overview and a feasibility study. *J. Neuroeng. Rehabil.* **2010**, *7*, 40. [[CrossRef](#)] [[PubMed](#)]
191. Aceros, J.; Lundy, M. Enhanced Steering and Drive Adaptations of Modified Ride-On Toy Cars for Improved Directional Control in Very Young Children with Severe Multiple Developmental Impairments. *Front. Pediatr.* **2020**, *8*, 567. [[CrossRef](#)] [[PubMed](#)]
192. Restrepo, P.; Velásquez, J.; Múnera, S.; Quintero Valencia, C.A. Adapting ride-on toy cars as a tool to promote leisure: A feasibility study in Colombia. *Assist. Technol.* **2021**, *33*, 217–222. [[CrossRef](#)] [[PubMed](#)]
193. Gefen, N.; Rigbi, A.; Archambault, P.S.; Weiss, P.L. Comparing children’s driving abilities in physical and virtual environments. *Disabil. Rehabil. Assist. Technol.* **2021**, *16*, 653–660. [[CrossRef](#)] [[PubMed](#)]
194. Nilsson, L.; Durkin, J. Assessment of learning powered mobility use—Applying grounded theory to occupational performance. *J. Rehabil. Res. Dev.* **2014**, *51*, 963–974. [[CrossRef](#)] [[PubMed](#)]
195. Furumasu, J.; Guerette, P.; Tefft, D. The development of a powered wheelchair mobility program for young children. *Technol. Disabil.* **1996**, *5*, 41–48. [[CrossRef](#)]
196. Law, M.; Baptiste, S.; McColl, M.; Opzoomer, A.; Polatajko, H.; Pollock, N. The Canadian Occupational Performance Measure: An outcome measure for occupational therapy. *Can. J. Occup. Ther.* **1990**, *57*, 82–87. [[CrossRef](#)] [[PubMed](#)]
197. Kiresuk, T.; Smith, A.; Cardillo, J. *Goal Attainment Scaling: Application, Theory and Measurement*; Lawrence Erlbaum Associates: Hillsdale, NJ, USA, 1994.
198. Haley, S.; Coster, W.; Ludlow, L. *Pediatric Evaluation of Disability Inventory: Development, Standardization and Administration Manual*; New England Medical Center Publications: Boston, MA, USA, 1992.
199. Haley, S.M.; Coster, W.I.; Kao, Y.C.; Dumas, H.M.; Fragala-Pinkham, M.A.; Kramer, J.M.; Ludlow, L.H.; Moed, R. Lessons from use of the Pediatric Evaluation of Disability Inventory: Where do we go from here? *Pediatr. Phys. Ther.* **2010**, *22*, 69–75. [[CrossRef](#)] [[PubMed](#)]
200. Nilsson, L.; Durkin, J. The ALP-instrument—Assessment of Learning Powered mobility use, version 2.0. *J. Rehabil. Res. Design.* **2014**, *51*, 963. [[CrossRef](#)]
201. Kenyon, L.K.; Farris, J.; Veety, L.; Zondervan, D.K. The IndieTrainer system: A clinical trial protocol exploring use of a powered wheelchair training intervention for children with cerebral palsy. *Disabil. Rehabil. Assist. Technol.* **2024**, *19*, 1579–1589. [[CrossRef](#)] [[PubMed](#)]
202. Kenyon, L.K.; Farris, J.P.; Cain, B.; King, E.; VandenBerg, A. Development and content validation of the Power Mobility Training Tool. *Disabil. Rehabil. Assist. Technol.* **2018**, *13*, 10–24. [[CrossRef](#)] [[PubMed](#)]
203. Gibson, B.E.; Teachman, G.; Wright, V.; Fehlings, D.; Young, N.L.; McKeever, P. Children’s and parents’ beliefs regarding the value of walking: Rehabilitation implications for children with cerebral palsy. *Child Care Health Dev.* **2012**, *38*, 61–69. [[CrossRef](#)] [[PubMed](#)]
204. Feldner, H.A. Supportive Mobility Across the Lifespan in Cerebral Palsy: A qualitative study. *Dev. Med. Child Neurol.* **2022**, *64*, 1392–1401. [[CrossRef](#)] [[PubMed](#)]

205. Feldner, H.A.; Keithley, K.; Ingraham, K.A.; Fragomeni, A.; Zaino, N.; Gijbels, L.; Sinclair, A.; Meltzoff, A.N.; Kuhl, P.K.; Steele, K.M. Learning powered mobility: Caregiver perceptions of young children's capabilities and device impact. *Disabil. Rehabil. Assist. Technol.* **2026**, Early online. [[CrossRef](#)] [[PubMed](#)]
206. Kenyon, L.K.; Jones, M.; Livingstone, R.; Breau, B.; Tsotsoros, J.; Williams, K.M. Power mobility for children: A survey study of American and Canadian therapists' perspectives and practices. *Dev. Med. Child Neurol.* **2018**, *60*, 1018–1025. [[CrossRef](#)] [[PubMed](#)]
207. Kenyon, L.K.; Jones, M.; Breau, B.; Tsotsoros, J.; Gardner, T.; Livingstone, R. American and Canadian therapists' perspectives of age and cognitive skills for paediatric power mobility: A qualitative study. *Disabil. Rehabil. Assist. Technol.* **2020**, *15*, 692–700. [[CrossRef](#)] [[PubMed](#)]
208. Evans, N.; Baines, R. Trends, goals and outcomes for children and families using early powered mobility in a charitable loan scheme. *J. Enabling Technol.* **2017**, *11*, 138–147. [[CrossRef](#)]
209. Ródenas-Martínez, M.; de Andrés-Beltrán, B.; Plasencia-Robledo, M.; Coello-Villalón, M.; Díaz-López, C.I.; Palomo-Carrión, R. Power mobility in children with motor impairments: Adaptations in electric toy cars to improve handling in natural environments—A case series. *Disabil. Rehabil. Assist. Technol.* **2025**, *20*, 3014–3026. [[CrossRef](#)] [[PubMed](#)]
210. Einspieler, C.; Bos, A.; Kriebler-Tomantschger, M.; Alvarado, E.; Barbosa, V.M.; Bertoncelli, N.; Burger, M.; Chorna, O.; Del Secco, S.; DeRegnier, R.A.; et al. Cerebral Palsy: Early Markers of Clinical Phenotype and Functional Outcome. *J. Clin. Med.* **2019**, *8*, 1616. [[CrossRef](#)] [[PubMed](#)]
211. Williams, S.A.; Alzahr, W.; Mackey, A.; Hogan, A.; Battin, M.; Sorhage, A.; Stott, S.N. "It Should Have Been Given Sooner, and We Should Not Have to Fight for It": A Mixed-Methods Study of the Experience of Diagnosis and Early Management of Cerebral Palsy. *J. Clin. Med.* **2021**, *10*, 1398. [[CrossRef](#)] [[PubMed](#)]
212. Hidalgo-Robles, Á.; Merino-Andrés, J.; Cisse, M.R.S.; Pacheco-Molero, M.; León-Estrada, I.; Gutiérrez-Ortega, M. The Pathway Is Clear but the Road Remains Unpaved: A Scoping Review of Implementation of Tools for Early Detection of Cerebral Palsy. *Children* **2025**, *12*, 941. [[CrossRef](#)] [[PubMed](#)]
213. Honan, I.; Finch-Edmondson, M.; Imms, C.; Novak, I.; Hogan, A.; Clough, S.; Bonyhady, B.; McIntyre, S.; Elliot, C.; Wong, S.; et al. Is the search for cerebral palsy 'cures' a reasonable and appropriate goal in the 2020s? *Dev. Med. Child Neurol.* **2022**, *64*, 49–55. [[CrossRef](#)] [[PubMed](#)]
214. Dahl, O.; Monrad, M. The tragedy of promising happiness through overcoming disability. *Soc. Sci. Med.* **2025**, *367*, 117769. [[CrossRef](#)] [[PubMed](#)]
215. Dolan, M.J.; Henderson, G.I. Control devices for electrically powered wheelchairs: Prevalence, defining characteristics and user perspectives. *Disabil. Rehabil. Assist. Technol.* **2017**, *12*, 618–624. [[CrossRef](#)] [[PubMed](#)]
216. Henderson, G.I.; Dolan, M.J.; Geggie, C.J. A review and appraisal of clinically prevalent control devices for electrically powered wheelchairs. *Technol. Disabil.* **2013**, *25*, 221–232. [[CrossRef](#)]
217. Nilsson, L.; Eklund, M. Driving to learn: Powered wheelchair training for those with cognitive disabilities. *Int. J. Ther. Rehabil.* **2006**, *13*, 517–527. [[CrossRef](#)]
218. Ingraham, K.A.; Feldner, H.A.; Steele, K.M. Forward first: Joystick interactions of toddlers during digital play. *PLoS ONE* **2024**, *19*, 0316097. [[CrossRef](#)] [[PubMed](#)]
219. Dicianno, B.E.; Cooper, R.A.; Coltellar, J. Joystick Control for Powered Mobility: Current State of Technology and Future Directions. *Phys. Med. Rehabil. Clin. N. Am.* **2010**, *21*, 79–86. [[CrossRef](#)] [[PubMed](#)]
220. Ogata, Y.; Katsumura, M.; Yano, K.; Nakao, T.; Hamada, A.; Torii, K. Joystick grip for electric wheelchair for tension-athetosis-type cerebral palsy. In *Proceedings of the 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Berlin, Germany, 23–27 July 2019*; IEEE: Piscataway, NJ, USA, 2019; pp. 1666–1669. [[CrossRef](#)] [[PubMed](#)]
221. Lange, M. Power mobility: Alternate access methods. In *Seating and Wheeled Mobility: A Clinical Resource Guide*; Minkel, J., Lange, M., Eds.; Slack Incorporated: Thorofare, NJ, USA, 2018; pp. 179–198.
222. Nilsson, L.; Nyberg, P.; Eklund, M. Training characteristics important for growing consciousness of joystick-use in people with profound cognitive disabilities. *Int. J. Ther. Rehabil.* **2010**, *17*, 588–595. [[CrossRef](#)]
223. Ziegler, K.; Da Silva, C.P.; Mitchell, K.; Baxter, M.F.; Bickley, C. Descriptive Study of GoBabyGo Program Practices and Evaluation Processes. *Pediatr. Phys. Ther.* **2025**, *37*, 65–70. [[CrossRef](#)] [[PubMed](#)]
224. Sloane, B.M.; Logan, S.W.; Sloane, B.M.; Logan, S.W. Fidelity of power mobility interventions for young children with disabilities: A systematic review. *Disabil. Rehabil. Assist. Technol.* **2026**, Early online. [[CrossRef](#)] [[PubMed](#)]
225. Nilsson, L.; Kenyon, L. Assessment and Intervention for Tool-Use in Learning Powered Mobility Intervention: A Focus on Tyro Learners. *Disabilities* **2022**, *2*, 304–316. [[CrossRef](#)]
226. Kamaraj, D.C.; Dicianno, B.E.; Cooper, R.A. A participatory approach to develop the power mobility screening tool and the power mobility clinical driving assessment tool. *Biomed. Res. Int.* **2014**, *2014*, 541614. [[CrossRef](#)] [[PubMed](#)]
227. Akhbari Ziegler, S.; Hadders-Algra, M. Coaching approaches in early intervention and paediatric rehabilitation. *Dev. Med. Child Neurol.* **2020**, *62*, 569–574. [[CrossRef](#)] [[PubMed](#)]

228. Jesus, C.; Regalado, I.C.R.; Monteiro, K.S.; Magalhães, A.G.; Chagas, P.d.C.S.; Faria, D.C.M.; Córdova, V.G.; Álvarez-Aguado, I.; Namisango, E.; Morris, C.; et al. From theory to practice in training health researchers in patient and public involvement: A scoping review protocol. *Syst. Rev.* **2025**, *14*, 242. [[CrossRef](#)] [[PubMed](#)]
229. Kenyon, L.K.; Hostnik, L.; McElroy, R.; Peterson, C.; Farris, J.P. Power mobility training methods for children: A systematic review. *Pediatr. Phys. Ther.* **2018**, *30*, 2–8. [[CrossRef](#)] [[PubMed](#)]
230. Bennett, C.L.; Brady, E.; Branham, S.M. Interdependence as a frame for assistive technology research and design. In *Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility, Galway, Ireland, 22–24 October 2018*; Association for Computing Machinery: New York, NY, USA, 2018; pp. 161–173. [[CrossRef](#)]
231. White, G.W.; Simpson, J.L.; Gonda, C.; Ravesloot, C.; Coble, Z. Moving from independence to interdependence: A conceptual model for better understanding community participation of centers for independent living consumers. *J. Disabil. Policy Stud.* **2010**, *20*, 233–240. [[CrossRef](#)]
232. Paulsson, K.; Christofferson, M. Psychosocial aspects on technical aids—How does independent mobility affect the psychosocial and intellectual development of children with physical disabilities? In *Proceedings of the 2nd International Conference on Rehabilitation Engineering RESNA, Ottawa, ON, Canada, 17–22 June 1984*; Rehabilitation Engineering Society of North America: Washington, DC, USA, 1984; pp. 282–286.
233. El Bizanti, K. How can we improve access to early powered mobility? A review of completed Bugzi loans. *Physiotherapy* **2020**, *107*, e210–e211. [[CrossRef](#)]
234. Fujita, H. Early Introduction of Power Mobility Devices for Children with Fukuyama Congenital Muscular Dystrophy and Its Psychological Impact on Caregivers: A Case Report. *Pediatr. Rep.* **2023**, *15*, 403–413. [[CrossRef](#)] [[PubMed](#)]
235. Airoidi, M.J.; Vieira, B.S.; Teplicky, R.; Chalfun, D.; Bonfim, R.G.A.S.; Mancini, M.C.; Rosenbaum, P.; Brandão, M.B. Information and Empowerment of Families of Children with Cerebral Palsy in Brazil: The Knowledge Translation Role of Nossa Casa Institute. *Front. Rehabil. Sci.* **2021**, *2*, 709983. [[CrossRef](#)] [[PubMed](#)]

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