# Physiotherapy Interventions for School-aged Non-ambulatory Children with Cerebral Palsy Combined with Intellectual Disability – An Integrative Review

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## ABSTRACT

Physiotherapists in Aotearoa New Zealand, face challenges implementing evidence-based practice (EBP) for non-ambulatory children with cerebral palsy and intellectual disabilities (NACCPID) working within Hoffman's model of EBP. Key challenges in the evidence component include limited NACCPID specific research. This project aims to review the literature on physiotherapy interventions for school-aged NACCPID to inform clinical practice and identify areas for future research within the Aotearoa New Zealand context. An integrative review was conducted, following Kutcher and LeBaron's (2022) method. A systematic search, conducted in 2023, yielded 2,240 articles that were narrowed to 24 after applying inclusion criteria. Coding and thematic analysis were conducted in NVivo 12 following content analysis methods. Final codes were organised within the Te Whare Tapa Whā framework through collaborative review with a cultural advisor. This enabled a holistic view of health, addressing physical, mental, social, and spiritual wellbeing, incorporating Māori perspectives. Ten themes were generated relating to physiotherapy interventions for NACCPID: 1) individual needs; 2) self-esteem and positive emotions; 3) body systems; 4) optimising ability to move the body; 5) using the body to perform a task; 6) collaboration; 7) (in)dependence; 8) participation and inclusion; 9) resourcing; and, 10) accessible environments. Notably, power wheelchair training appears to have significant beneficial effects across all aspects of health, and it is important that the child and families' individual needs, wants, likes, circumstances, and values are considered when choosing an intervention.

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Key Words: Cerebral Palsy, Children, Cognitive Impairment, Physiotherapy Modalities, Severe Disability

## INTRODUCTION

Cerebral palsy (CP) is a spectrum of disorders of movement and posture (Rosenbaum et al., 2007). In Aotearoa New Zealand the estimated prevalence of CP is two per 1,000 live births (Mackey et al., 2022). The Gross Motor Function Classification System (GMFCS) is a five-level ordinal scale based on self-directed movement allowing clinicians to describe the physical ability of the person with CP. Therefore it is particularly useful to physiotherapists in their treatment planning (Palisano et al., 2007). Higher levels of GMFCS, specifically level IV and V, describe people who are non-ambulatory and primarily use wheelchairs as their mode of mobility. In Aotearoa New Zealand, 32% of children on the New Zealand Cerebral Palsy Register are classified as GMFCS IV or V (Mackey et al., 2022). Increasing GMFCS level is strongly correlated with declining intellectual function (Dalvand et al., 2012; Himmelmann et al., 2006). As intellectual function is important for understanding and following instructions, and motor task performance, it is a key consideration for physiotherapists when deciding on treatment options.

The physiotherapy profession in Aotearoa New Zealand and globally encourages evidence-based practice (EBP) to enhance the quality and effectiveness of care and uphold professional standards (Physiotherapy Board of New Zealand, 2020). There are challenges for physiotherapists working within the traditional EBP model proposed by Hoffmann et al. (2013) when treating NACCPID (Figure1). This model encourages the integration of best research evidence, clinical expertise, the patient's values and unique set of circumstances, and the practice context of the work.

Practice context, such as workplace policies, resources, disciplinary norms, and ethics are a crucial consideration in the management of NACCPID. In Aotearoa New Zealand, the majority of NACCPID meet the physical disability criteria of the Ministry of Education Ongoing Resourcing Scheme (ORS), which entitles them to physiotherapy within the education system (Ministry of Education, 2024a). Physiotherapists working in this field are mandated to support students learning alongside their peers (Ministry of Education, 2025). This focus on accessing the curriculum may limit physiotherapists' ability to take a holistic approach to the child's health and wellbeing, as reported by parents (Silva, 2022).

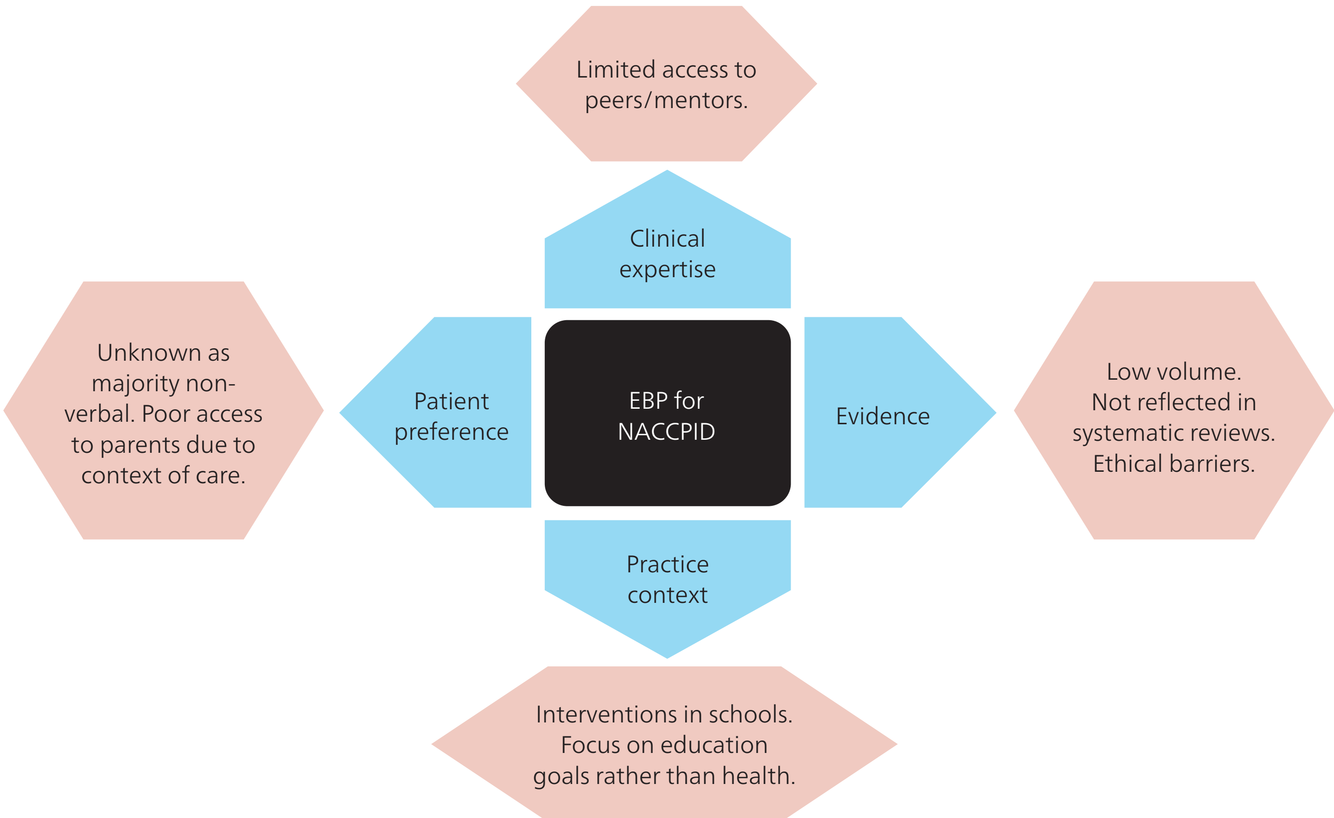
Determining patient preference for NACCPID is challenging as the majority of these children are non-verbal and have difficulties communicating due to intellectual disabilities (Jain et al., 2016). Using parents as proxies for gaining preferences is not ideal, especially given the limited interaction opportunities created by government-funded school transport for NACCPID (Ministry of Education, 2024b), which restricts parent–staff communication during drop-off and pick-up times.

Access to clinical expertise can also be difficult for physiotherapists working with these children. There is a paucity of school-based physiotherapists, which can make it challenging to access additional expertise when needed. This is reflected by Buhler et al. (2024), finding that only 45 physiotherapists of 5,582 working in Aotearoa New Zealand (< 1%) worked in Ministry of Education learning support services, including special schools.

Although the challenges to EBP for physiotherapists working with NACCPID in Aotearoa New Zealand are multifactorial, this project will specifically focus on the evidence component of the EBP model. A significant challenge in informing physiotherapy practice for NACCPID is the scarcity of higher levels of evidence. There is significantly less research involving GMFCS IV and V children compared to those who are ambulant (Bailes et al., 2021; O'Connor et al., 2019). This is reflected in systematic reviews on CP, which have very few primary research sources that include children with GMFCS IV and V (Novak et al., 2020). This disparity may stem from the ethical challenges of conducting large-scale trials involving children with lower intellectual capacity, as ethical principles, designed to protect vulnerable populations, often then restrict research with them (Spaul et al., 2020). This problem has led to the UK Medical Research Council calling for a framework of review that places emphasis on a larger range of studies, not just randomised controlled trials,

**Figure 1**

*Barriers to Implementation of EBP for NACCPID*




*Note.* EBP = evidence-based practice; NACCPID = non-ambulatory children with cerebral palsy and intellectual disabilities.

when evaluating complex interventions (Levack et al., 2024). This points to the need to consider not only higher levels of evidence for this population, but also smaller studies or case reports (Levack et al., 2024).

Further, the dominance of a biomedical approach in research and practice continues to shape EBP in physiotherapy (Maric & Nicholls, 2020). This focus often neglects important influences on health, such as spirituality and social connections, which can disconnect the person from their health issue (Nicholls, 2014). As health systems vary globally, it is essential to find suitable health frameworks that meet the needs of the local population for optimal health outcomes (van der Graaf et al., 2018).

In the context of Aotearoa New Zealand, Durie (1985) suggested Te Whare Tapa Whā as a holistic health model, connecting taha tinana (physical wellbeing), taha hinengaro (mental and emotional wellbeing), taha whānau (family and social wellbeing), taha wairua (spiritual wellbeing), and taha whenua (land and resources). Durie (1985) emphasised that these aspects are interconnected and need to be balanced for a person to thrive. Adopting this health framework may be more suitable for research and knowledge translation for disability and rehabilitation in Aotearoa New Zealand, ensuring best practice guidelines address all areas of health, including contextual challenges to EBP faced by physiotherapists.

The aim of this project is to review the literature on physiotherapy interventions for school-aged NACCPID to inform clinical practice and identify areas for future research within the Aotearoa New Zealand context.

## METHODS

An integrative review, based on Kutcher and LeBaron's (2022) method was selected. This review used the Te Whare Tapa Whā framework (Durie, 2011). Although integrative reviews are not required to be guided by a framework (Kutcher & LeBaron, 2022), using one ensures the findings are most relevant to physiotherapists working in Aotearoa New Zealand. NACCPID were defined as GMFCS IV and V only for this review. Within the research team, KA has over 10 years' clinical experience in Aotearoa New Zealand working with NACCPID, JB is a qualitative researcher and paediatric nurse with expertise in integrative reviews, JH has research experience in paediatrics and clinical physiotherapy experience, and MA has significant experience within Aotearoa New Zealand health systems implementing culturally competent care.

A systematic literature search was conducted in March and April 2023 using the online databases CINAHL (EBSCO), Medline via OVID, Scopus, PEDRO, and Google Scholar. Grey literature was sought through a Google Search and Tu Whera (University research repository) followed by manual searches of reference lists (Table 1).

Five sources outlining physiotherapy clinical practice for CP informed the key words (Barber, 2008; Bekteshi et al., 2023; Dodd et al., 2010; Hartley, 2002; Miller, 2007). Intellectual disability was not included as a search term due to its frequent absence from the keywords or MESH headings. The suitability of interventions for those with intellectual disability was identified in the review process by KA and JH based on clinical experience. Inclusion and exclusion criteria are presented in Table 2.

### Search outcomes

Using the PRISMA 2020 guidelines (Page et al., 2021) the search yielded 2,240 articles across the databases and registers (EBSCO CINAHL = 296; Scopus = 593; Ovid Medline = 425; PEDRO = 810; Google Scholar = 113; Tu Whera = 3) and 304 records of other sources (Google search = 49; citation searching = 255) (Figure 2). After removing duplicates, 1,590 titles and abstracts were reviewed by KA, leading to the exclusion of 1,013 articles with 620 remaining for full-text review. This number remained high because it was not possible to determine from the title and abstract whether 80% of participants were GMFCS IV and V, met the age

**Table 1**

*Search Terms*

| Search | Search terms |
|---|---|
| S1 | ("cerebral palsy" OR cp OR "spastic quadriplegi*")<br>AND |
| S2 | (child* OR adolescen* OR youth or teen* OR "young adult*" OR school*)<br>AND |
| S3 | ("non ambula*" OR wheelchair* OR "GMFCS IV" OR "GMFCS V")<br>AND |
| S4 | (care* OR manage* OR interven* OR treat* OR aid* OR equipment* OR stand* OR frame* OR walker* OR "gait trainer*" OR seat* OR strength* OR skill* OR activit* OR prevent* OR contracture* OR "muscle length*" OR routine* OR physiotherap* OR rehab* OR *therap* OR " hippothera*" OR " hydrotherap*" OR "balanc*" OR "move*" OR "electrical stim" OR "motor function*" OR "neurodevelopmental therap" OR "neuro-developmental therap") |

*Note.* S = search.

**Table 2**

*Inclusion and Exclusion Criteria for Literature Search With Justifications*

| | Terms | Justification |
|---|---|---|
| Inclusion criteria | At least 80% of population studied are classified as GMFCS IV and/or V or are parents/caregivers/ families/ physiotherapists of children classified as GMFCS IV and/or V | Predominant non-ambulant studies, acknowledging some research may not have specifically isolated non-ambulant children |
| | At least 80% of population studied are classified as spastic quadriplegia or are parents/ caregivers/ families/ physiotherapists of children classified as spastic quadriplegia | Clinically other terms exist for GMFCS IV and V, most commonly "spastic quadriplegia", which was the main term prior to GMFCS levels being introduced |
| | Over 80% of population studies are aged 5–18 years | School aged in Aotearoa New Zealand and GMFCS level appears established by age 4 (Park, 2020) |
| | Physiotherapy interventions | Exposure being studied |
| | Studies in English | Researchers own language to allow for sufficient understanding |
| Exclusion criteria | Wheelchair or seating prescriptions | |
| | GMFCS I–III studies | |
| | Spastic diplegia and hemiplegia studies | |
| | Studies with adults | |
| | Studies with children under the age of 5 years | |
| | Physiotherapy assessments | |
| | Review studies but reference lists reviewed for relevant primary studies | To ensure primary studies are identified and individually reviewed |
| Years | 2007–date | GMFCS levels became established with their current definitions (Palisano et al., 2007) and therefore became dominant motor classification term for cerebral palsy |
| Types of studies | Primary research | A key component of an integrative review is that it uses multiple types of sources and studies |
| | Quantitative | |
| | Qualitative | |
| | Grey literature | |

*Note.* GMFCS = Gross Motor Function Classification System. Wheelchair and seating prescription studies were excluded after discussion. Rationale included that wheelchair and seating prescription crosses between occupational therapy and physiotherapy practice in Aotearoa New Zealand and is not taught in the undergraduate physiotherapy curriculum.

criteria, or had cognitive impairments. Full-text consideration by KA and JH, excluded 596 articles, bringing the total included articles to 24 for final analysis. The full search strategy for each database is presented in Appendix A.

### Data evaluation

Included studies were critically appraised using the Mixed Methods Appraisal Tool (MMAT) (Hong, Fàbregues, et al., 2018). However, because the MMAT does not use a scoring system or quality comparison for each article (Hong, Fàbregues, et al., 2018), the MMAT results did not influence the presentation of the findings and therefore are not reported in this paper. Further information can be provided by the authors upon request.

### Data analysis

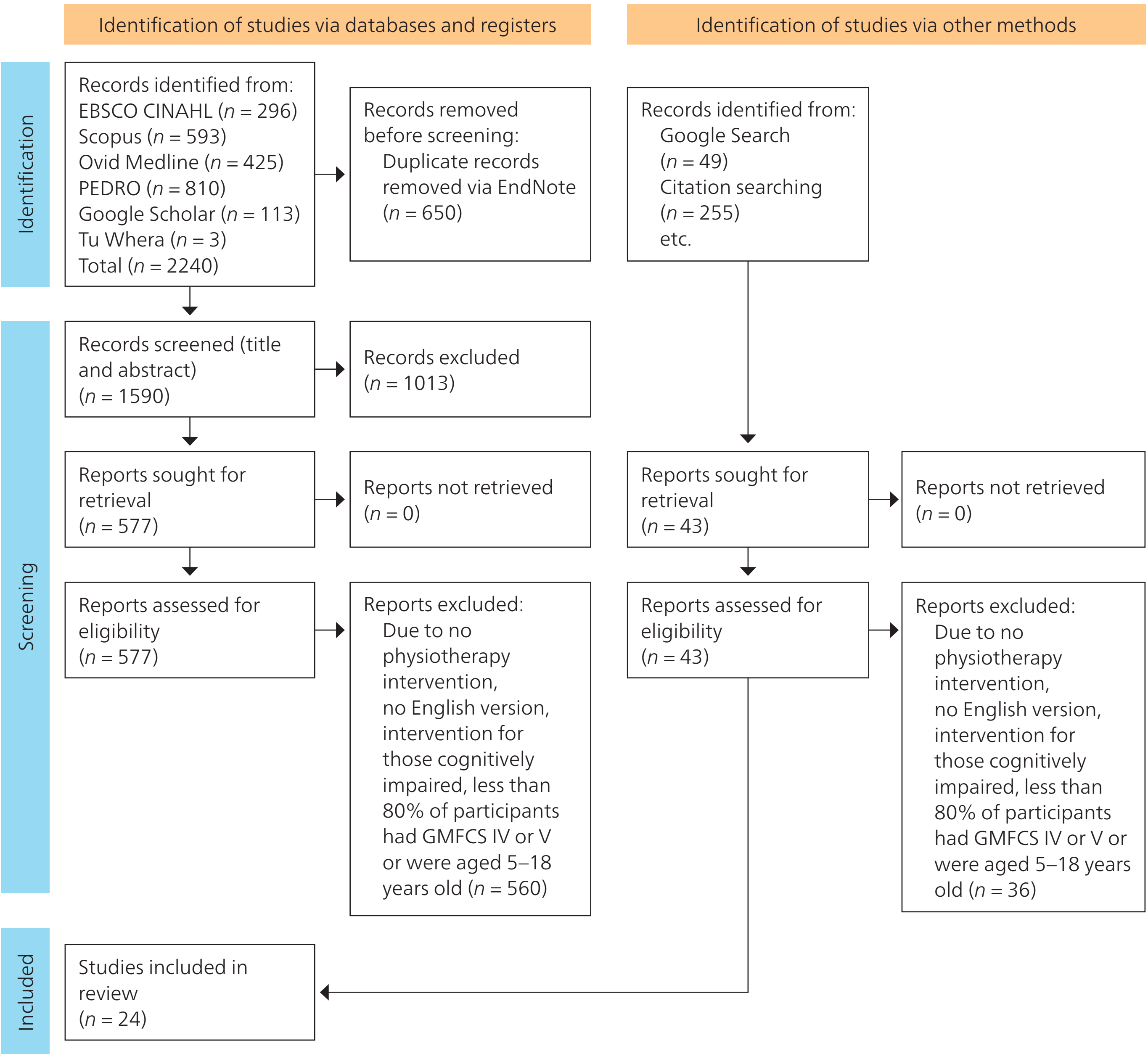
Information was extracted by KA from the literature regarding study aims, sample, intervention, design, outcome measures, results, and conclusions. Qualitative content analysis, specifically conventional content analysis, was used as it is appropriate when there is limited knowledge in the area and allows for analysis of diverse study types (Hsieh & Shannon, 2005; Vaismoradi et al., 2013).

Data management and analysis approaches defined by Hsieh and Shannon (2005) and Willis et al. (2016) were followed. Data management involved collecting the data in PDF format, printing the information, and reading and re-reading the data to achieve immersion. Observations and reflections were highlighted and handwritten, alongside maintaining a reflexive journal to document initial thoughts, keywords, and analysis.

The data were coded using NVivo 12 © software, generating over 70 keywords that were reviewed and collapsed into 31 codes that reflected groups of keywords. Codes with minimal data or similarities were merged to ensure no codes were discarded entirely. These codes and their relationships were

**Figure 2**

*PRISMA Flow Diagram for Integrative Review*




*Note.* GMFCS = Gross Motor Function Classification System

discussed over three meetings between KA, JB, and JH, and between KA and a cultural advisor (MA) over a four-month timeframe to ensure a robust analytical approach. Where there was uncertainty or disagreement in codes or definitions, they were was extensively discussed until consensus was gained. Credibility was maximised through the process of prolonged immersion, peer conversation, and extensive engagement between the four reviewers (Bradshaw et al., 2017; Colorafi & Evans, 2016; Vaismoradi et al., 2013).

Following the inductive coding process, the codes were then deductively coded against the Te Whare Tapa Whā model by KA and MA. This step of mapping to an existing model is additional to the process outline by Kutcher and LeBaron (2022); however, this ensured specific relevance to Aotearoa New Zealand, which was a priority for the authors. Understanding each component's representation from a Pākehā researcher perspective was a crucial part of this process in order to ensure culturally clinical relevance. For the purposes of this review, definitions of the Te Whare Tapa Whā

**Table 3**

*Definitions for Components of Te Whare Tapa Whā*

| Component | Definition |
|---|---|
| Taha wairua | Refers to the individual's spirit or soul; their identity. It is an internal compass to guide the direction of individual towards health and purpose. |
| Taha hinengaro | The person's mind, thoughts, and feelings, and influences how they feel, think, and communicate. |
| Taha tinana | The person's physical dimension; about the body. |
| Taha whānau | The extended kinship system; the collective surrounding a person that supports their health and goals. |
| Taha whenua | Connection and kinship to the land, including the environment and land-based resources. |

domains were derived from Durie (2011), Wilson et al. (2021), and korero with MA (Table 3).

The deductive process required extensive discussions, as Te Whare Tapa Whā emphasises the integration of all aspects of health (Durie, 2011). While many codes could fit under multiple components, each was placed in the area with the strongest connection, as determined by MA. These codes were then grouped into subthemes within each domain of Te Whare Tapa Whā.

### Description of studies

Preliminary analysis identified six types of physiotherapy intervention in the reviewed studies: 1) functional movement (Asano et al., 2021; Elshafey et al., 2022); 2) gaming (Shih et al., 2011); 3) power wheelchair training (PWT) (Kenyon et al., 2021; Kenyon et al., 2015; McGarry et al., 2012; Rosenberg, Cohen, et al., 2021; Rosenberg, Maeir, et al., 2021); 4) night time positioning equipment (NTPE) (Hill et al., 2009; Underhill et al., 2012; Wood & Brown, 2022); 5) static standing frames (SStF) (Barbier et al., 2022; Capati et al., 2020; Dalén et al., 2010; Gibson et al., 2009; Goodwin et al., 2019; Israeli-Mendlovic et al., 2014; Rivi et al., 2014); and 6) dynamic standing frames (DStF) (Diot et al., 2021; Grodon et al., 2023; Lauruschkus et al., 2023; Lauruschkus et al., 2022; Lundström et al., 2022; Tornberg & Lauruschkus, 2020). All interventions were deemed applicable in Aotearoa New Zealand by KA and JH and the tables were organised within these categories (Tables 4–9).

The studies were from England (*n* = 6) (Goodwin et al., 2019; Grodon et al., 2023; Hill et al., 2009; Shih et al., 2011; Underhill et al., 2012; Wood & Brown, 2022), Sweden (*n* = 5) (Dalén et al., 2010; Lauruschkus et al., 2023; Lauruschkus et al., 2022; Lundström et al., 2022; Tornberg & Lauruschkus, 2020), USA (*n* = 3) (Capati et al., 2020; Kenyon et al., 2021; Kenyon et al., 2015), Israel (*n* = 3) (Israeli-Mendlovic et al., 2014; Rosenberg, Cohen, et al., 2021; Rosenberg, Maeir, et al., 2021), Australia (*n* = 2) (Gibson et al., 2009; McGarry et al., 2012), Japan (*n* = 1) (Asano et al., 2021), Egypt (*n* = 1) (Elshafey et al., 2022), France (*n* = 1) (Barbier et al., 2022), Italy (*n* = 1) (Rivi et al., 2014), and Canada (*n* = 1) (Diot et al., 2021). No studies were found from Aotearoa New Zealand.

Participants included children, parents, caregivers, educational staff, paediatricians, physiotherapists, and occupational therapists (Tables 4–9). Of the 267 participants who were children with CP, 129 were classified as GMFCS IV, 124 as GMFCS V, two with spastic quadriplegia, and two as GMFCS III (included due to 80% being GMFCS IV and V). Among these participants, 93 were female and 135 were male, while gender was not reported for 39 participants across five studies.

Sample size ranged from one to 36, with five studies focusing on a single child. Three studies included participants who were not children with CP, which included 23 parents or caregivers, and five focus groups (number of participants not reported) of educational professionals, parents, and clinicians. Eighteen studies used quantitative methods, including three randomised controlled trials, while three were qualitative, and three used mixed methods with over 35 different primary and secondary outcome measures combined across all studies (Tables 4–9).

## FINDINGS

Ten key themes relating to physiotherapy interventions for NACCPID were derived from the data and grouped under the most relevant domains of Te Whare Tapa Whā (Figure 3). It is valuable to note that the results presented for functional movement and gaming are minimal due to only three studies being found using these interventions. Therefore, the other four interventions are primarily reported, with functional movement and gaming, reported only as applicable.

### Taha wairua

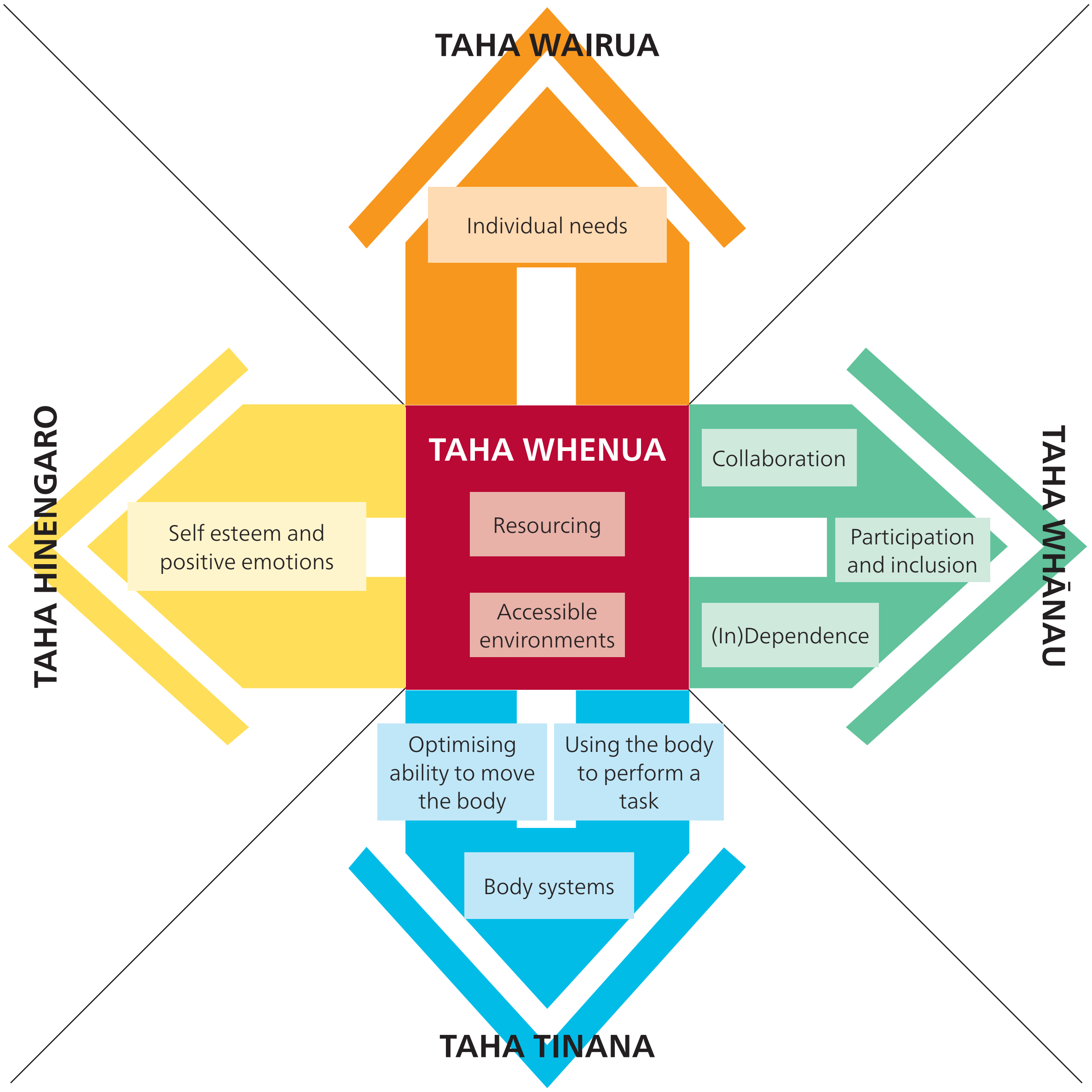
A key theme of "individual needs" for NACCPID was identified within the taha wairua (spiritual welling) domain of Te Whare Tapa Whā.

#### *Theme 1. Individual needs*

Included articles highlighted that the unique nature of each child, with a diversity in clinical presentations, was a crucial component that influences physiotherapy interventions for NACCPID (Diot et al., 2021; Gibson et al., 2009; Goodwin et al., 2019; Grodon et al., 2023; Rivi et al., 2014; Rosenberg, Maeir, et al., 2021). The unique and varied presentations of children with NACCPID were reflected in the use of single-subject research designs in five studies included (Asano et al., 2021; Capati et al., 2020; Diot et al., 2021; Kenyon et al., 2015; Rivi et al., 2014). This diversity affected the tolerance and outcome of the interventions, between different children (Barbier et al., 2022; Diot et al., 2021; Elshafey et al., 2022; Goodwin et al., 2019; Lauruschkus et al., 2023; Rosenberg,

**Figure 3**

*Physiotherapy Interventions for NACCPID Within the Te Whare Tapa Whā Framework*




*Note.* NACCPID = non-ambulatory children with cerebral palsy and intellectual disabilities.

Maeir, et al., 2021; Tornberg & Lauruschkus, 2020) and across standardised interventions for the same child (Diot et al., 2021; Hill et al., 2009; Tornberg & Lauruschkus, 2020; Underhill et al., 2012). Overall, the included studies suggested that a personalised and flexible approach to physiotherapy interventions is recommended (Barbier et al., 2022; Goodwin et al., 2019; Grodon et al., 2023; Lauruschkus et al., 2023).

Seven studies highlighted that investing time to understand each child's motivators and preferences is a crucial component of care (Goodwin et al., 2019; Grodon et al., 2023; Kenyon et al., 2021; Kenyon et al., 2015; McGarry et al., 2012; Rosenberg, Maeir, et al., 2021; Shih et al., 2011). Similarly, as increased frequency of intervention is recommended (Asano et al., 2021; Grodon et al., 2023; McGarry et al., 2012; Rosenberg, Maeir, et al., 2021), providing an intervention that is engaging enough to facilitate the repetition and practice required for motor learning is important. Multiple studies showed that creating a fun, engaging, and purposeful interaction with the environment is important for positive outcomes (Asano et al., 2021; Kenyon et al., 2021; Lauruschkus et al., 2023; McGarry et al., 2012; Rosenberg, Maeir, et al., 2021; Shih et al., 2011). Included articles also highlighted the need for equipment to be personally adapted

**Table 4**

*Functional Exercise Studies*

| Author | Purpose/aims | Sample | Intervention description | Research design | Outcome measures | Results and conclusions |
|---|---|---|---|---|---|---|
| Asano et al. (2021) | Report the case of a child with CP whose motor function decreased due to home confinement in Covid-19 and a description of the subsequent recovery process | *n* = 1<br>7-year-old boy<br>Spastic quadriplegic CP<br>GMFCS IV | 4-month suspension of physiotherapy during COVID home confinement<br>Resumption of physiotherapy – 1 x week of 90 min = dynamic sitting, dynamic standing, posture control, gait training (overall 22 sessions over 8 months) | Quantitative, case study | GMFM 88 overall and dimension (standing)<br>GAS | During home confinement:<br>• Decline in overall GMFM-88 from 34.5% to 31.9% mainly due to decline in dimension D (12.8 to 5.1)<br>• GAS dropped from 1 to –2<br>GAS after physiotherapy:<br>• 1 at 4 months post<br>• 0 at 5 months post<br>• 1 at 8 months post<br>• GMFM-88 resumed to pre-confinement level at 8 months post<br>• Motor recovery took twice as long to recover as it took to decline |
| Elshafey et al. (2022) | Evaluate the effects of a core stability exercise programme on balance, co-ordination, and severity of ataxia in children with cerebellar ataxic CP | *n* = 36 analysed<br>Age 5–9 years old<br>GMFCS IV<br>Sex: not reported | Control group = standard physiotherapy 1 hr, 3 x week, for 2 months<br>Intervention group = selected physiotherapy programme, 1 hr 3 x week plus core stability programme for 30 min<br>Frequency of repetitions of each exercise dependent on tolerance and increased according to ability | Quantitative, RCT | SARA<br>BESS<br>BOT-2 - subtests 4 and 7 (bilateral and upper limb co-ordination respectively)<br>HUMAC | • Statistically significant ↑ in all measured variables post interventions ($p > 0.05$)<br>• Stronger effects in intervention group in all variables ($p > 0.05$) |

*Note.* BESS = Balance Error Scoring Systems scale; BOT = Bruininks-Oseretsky test of motor proficiency; CP = cerebral palsy; GAS = Goal Attainment Scale; GMFCS = Gross Motor Function Classification System; GMFM = Gross Motor Function Measure; HUMAC = HUMAC Balance System scoring ; RCT = randomised controlled trial; SARA = Scale for Assessment and Rating of Ataxia.

**Table 5**

*Gaming Studies*

| Authors | Purpose/aims | Sample | Intervention description | Research design | Outcome measures | Results and conclusions |
|---|---|---|---|---|---|---|
| Shih et al. (2011) | Assess if young adults with profound multiple disabilities would be able to actively correct their abnormal head posture with a head positioning correcting programme | $n = 2$<br>Aged 17 and 18 years old<br>Spastic quadriplegic CP<br>Sex: 1 female, 1 male | Nintendo Wii controller placed on head with headband<br>Baseline: Without video feedback (21 and 18 sessions)<br>Intervention: When subject keeps head in critical value range favourite video will play. When out of range video stopped. Head angle had to be within critical range for 2 s to activate (60 sessions)<br>Session duration = 3 min | Quantitative, within-series (ABAB) design | Time maintaining upright head position | Significantly different ($p < 0.01$) increase in time of head in upright position during intervention phases for both subjects |

*Note.* CP = cerebral palsy.

**Table 6**

*Power Wheelchair Training Studies*

| Authors | Purpose/aims | Sample | Intervention description | Research design | Outcome measures | Results and conclusions |
|---|---|---|---|---|---|---|
| Kenyon et al. (2015) | Describe development and implementation of a programme using power wheelchair trainer to enable individual with severe impairments to participate in power mobility training | $n = 1$<br>18 years old<br>GMFCS V<br>Female | Use of trainer using head switches, 60 min 2 x week for 12 weeks | Quantitative, case study | Power mobility screen<br>CPCHILD<br>Subjective parent reports | • ↑ CPCHILD post intervention<br>• ↑ power mobility screen post intervention<br>• Subjective improvement in ability to stop the trainer<br>• Parent report: more content, more interactive, more aware of surroundings |

| Authors | Purpose/aims | Sample | Intervention description | Research design | Outcome measures | Results and conclusions |
|---|---|---|---|---|---|---|
| Kenyon et al. (2021) | Investigate the effect of power mobility training to learners with CP on parenting stress, parents' perception of their children, and children's attainment of power mobility skills | *n* = 3<br>Age 5–8 year olds<br>GMFCS V<br>Female: Male = NR | Power mobility training, 45–60 min using trainer system, 8-week intervention phase, 2 x week sessions | Quantitative, non-concurrent, multiple baseline single subject (AB) design | PSI-4-SF<br>CPCHILD<br>COPM<br>ALP<br>Wheelchair skills checklist | • ↓ parental stress in 2/3 parents<br>• ↑ parental stress due to child behaviour in 1/3 parents<br>• ↓ parental stress as child's behaviour easier to manage in 1/3 parents<br>• ↑ COPM scores for performance and satisfaction<br>• Power mobility skills retained at follow-up<br>• Learned to use switches<br>• Improved cause-and-effect skills in other activities, especially communication devices (2 with eye gaze, 1 with multi-switch communication device) |
| McGarry et al. (2012) | Describe the impact of a mobility training programme using the smart wheelchair in driving skills and psychosocial outcomes for children with physical disabilities | *n* = 4<br>Age 5-13yo<br>GMFCS V<br>Sex: Female 2, male, 2<br>Mild-severe cognitive impairment | Smart wheelchair mobility training programme at the centre 2 x 1 hr sessions/ week over 8 weeks | Mixed-methods, multiple case study design | Modified powered mobility programme<br>Semi-structured interviews with parents | • ↑ switching ability<br>• More use of arm<br>• Happier than usual<br>• ↑ child's confidence and affect<br>• ↑ looking around<br>• ↑ scanning and choosing meaning more options for communication devices, accessibility, and inclusion<br>• ↑ motivation to attempt tasks<br>• ↑ developmental progression in play<br>• ↑ independence |
| Rosenberg, Cohen, et al. (2021) | Explore the effects of a therapeutic powered mobility summer camp for severe CP as perceived by school staff | 12 staff with single interviews devoted to each of the 19 campers<br>All children at summer camp were GMFCS IV & V | Power fun camp, 5 x week, for 3 weeks, alongside regular day camp at special education school<br>Campers received PMD to use throughout camp<br>2 x hr sessions daily of games to learn PMD skills | Qualitative Induction qualitative descriptive with phenomeno-logical theoretical framework | Semi-structured interviews | Themes:<br>• Acquisition of new skills: Ability to move independently, new physical skills, cognitive skills<br>• Changes in behaviour: ↑ motivation, ↑ activity, mischievousness, emotional expression<br>• Social aspects: Relationships with peers and staff, new communication skills<br>• Self-image: Independence builds empowerment, ↑ self-efficacy, enhance social status |

| Authors | Purpose/aims | Sample | Intervention description | Research design | Outcome measures | Results and conclusions |
|---|---|---|---|---|---|---|
| Rosenberg, Maeir, et al. (2021) | Examine the effectiveness of power fun, a therapeutic powered mobility camp | *n* = 24<br>Age 7–20 years old<br>GMFCS IV:V =11:13<br>Sex: Female 8, male 16 | Power fun camp, 5 x week, for 3 weeks, alongside regular day camp at special education school<br>Campers received PMD to use throughout camp<br>2 x hr sessions daily of games to learn PMD skills | Quantitative, non-randomised repeated measures with participants acting as own control | PMP<br>ALP<br>GAS<br>WhOM-YP<br>Interviews | • Statistically significant ↑ PMP, retained at follow-up with 1 child achieving enough ability to become eligible for government funded powerchair<br>• Statistically significant ↑ ALP, retained at follow-up<br>• 70% of functional goals achieved<br>• Statistically significant ↑ WhOM-YP, retained at follow-up<br>• 88% enjoyed camp (happy emoji)<br>• 73% reported ↑ interaction with peers<br>• 71% chose "driving by myself" when asked which activity they enjoyed most |

*Note:* ALP = assessment of learning-powered mobility; COPM = Canadian Occupational Performance Measure; CP = cerebral palsy; CPCHILD = Caregiver Priorities & Child Health Index of Life with Disabilities; GMFCS = Gross Motor Function Classification System; GAS = Goal Attainment Scaling; NR = not reported; PMD = powered mobility device; PMP = power mobility performance; PSI-4-SF = Parenting Stress Index–Short Form; WhOM-YP = wheelchair outcome measure for young people.

**Table 7**

*Night Time Positioning Equipment Studies*

| Authors | Purpose/aims | Sample | Intervention description | Research design | Outcome measures | Results and conclusions |
|---|---|---|---|---|---|---|
| Hill et al. (2009) | Explore the influence of NTPE on sleep quality and respiratory function in children with severe CP | *n* = 10<br>Age 5.3–16.7 years old<br>All GMFCS IV:V but ratio not reported<br>Sex: Female 5, male 5 | Sleeping in NTPE<br>Sleeping unsupported<br>Order randomised<br>At least 3 nights between tests | Quantitative, repeated measures | PSQ: Snoring and daytime sleepiness subscales<br>Polysomnography: Video<br>Sleep staging scored | • No significant difference in sleep quality measures in NTPE<br>• NTPE = ↑ overnight SpO2 in 3 children & ↓ in 6 children<br>• Children with no evidence of obstructive respiratory events had significantly ↓ mean SpO2 than typically developing children<br>• Mean SpO2 (all) = 95% or greater in NTPE. Greater variation when unsupported<br>• When unsupported, 3 went below 95%<br>• ↑ non-respiratory arousal compared to typically developing children |

| Authors | Purpose/aims | Sample | Intervention description | Research design | Outcome measures | Results and conclusions |
|---|---|---|---|---|---|---|
| Underhill et al. (2012) | Investigate the effect that sleeping in a sleep system has on the sleep-wake patterns and pain levels for children with CP | *n* = 11<br>Age 5–15 years old<br>GMFCS III:IV:V = 2:1:8 (82% GMFCS IV and V)<br>Sex: Female 4, male 7 | Sleeping in NTPE, 4 nights<br>Sleeping out of NTPE, 4 nights<br>Order randomised | Mixed-methods, cross-over design | Actigraphy<br>PPP<br>Chailey Sleep Questionnaire<br>Sleep diaries<br>Supplementary interviews | • Sleep system had no significant effect on pain levels or sleep-wake patterns<br>• Varying responses between participants |
| Wood and Brown (2022) | Investigate effects of sleep systems on sleep quality and quantity, and pain for young people with CP and outcomes for carers | *n* = 4<br>Age 6–16 years old<br>GMFCS V<br>No sleep system in place<br>Sex: Female 2, male 2 | Prescribed Symmetri-sleep sleep system provided to use overnight | Mixed-methods, non-randomised, exploratory | Chailey Sleep Questionnaire<br>Neutral zero joint range assessment<br>PPP<br>Sleep diaries<br>GAS light verbal outcome measure | • 3/4 positive changes in sleep quantity, with ↓ number of night-time waking<br>• 2/4 less restless and required less turning<br>• No change in pain<br>• Statistically significant improvement at completion in 6 of 7 goals in all GAS scores |

*Note.* CP = cerebral palsy; GMFCS = Gross Motor Function Classification System; GAS = Goal Attainment Scale; NTPE = night time positioning equipment; PPP = Paediatric Pain Profile; PSQ = Paediatric Sleep Questionnaire; SpO2 = oxyhaemoglobin.

**Table 8**

*Static Standing Frame Studies*

| Authors | Purpose/aims | Sample | Intervention description | Research design | Outcome measures | Results and conclusions |
|---|---|---|---|---|---|---|
| Barbier et al. (2022) | Compare the bone health of children with severe CP who use a static standing frame in real life to those who do not | *n* = 24<br>GMFCS IV: V = 9:15<br>Age 4–18 years old<br>Sex: Female 11, male = 13 | Study group: 13 using passive standing frame approx. 30 min/day<br>Control: 11 not using standing frame | Quantitative, retrospective cross- sectional study | BMC<br>BMD (in total body less head, lumbar spine, left proximal femur)<br>Blood samples | • BMC (TBLH) significantly higher in standing frame group<br>• Trend for higher BMD in standing frame group but not significantly different<br>• Bone reabsorption markers higher in control group<br>• Standing frames reduce bone reabsorption and improve overall BMC |

| Authors | Purpose/aims | Sample | Intervention description | Research design | Outcome measures | Results and conclusions |
|---|---|---|---|---|---|---|
| Capati et al. (2020) | Can an adolescent with CP and 40° knee and/or hip flexion contractures benefit from a standing programme, after being non-weight bearing for many years? | *n* = 1<br>16 year old boy<br>GMFCS IV:V = 0:1 | SF with "knee and hip contracture system" recommended 90 min/day 5 x week; actual 60 min 3 x week<br>Knee and hip extension and upright inclination ↑ weekly to point of discomfort for 15 months | Quantitative, case study | Knee and hip PROM<br>FLACC<br>Parent survey | • ↑ hip and right knee PROM after 15 months<br>• Left knee PROM maintained<br>Family reported:<br>• ↑ ease in bathing, diapering, changing clothes<br>• ↑ ease of transferring in and out of wheelchair because legs "straighter" and "relaxed"<br>• ↑ activity and participation when watching television with brother while in SF<br>• ↓ pain during BM<br>• ↓ use of suppositories and time spent in bowel care<br>• SF use was highest level of activity and participation throughout typical day<br>• No quantitative change in pain |
| Dalén et al. (2010) | Evaluate whether standing time associates with bone density and/or hip dislocation in children with severe CP | *n* = 18<br>Age 3–18 years old (89% 5–18 years old)<br>GMFCS IV:V = 3:15<br>Sex: female 7, male 11 | Standing shell 40 min/day, 1–2 x day for 1 week, repeated after 2 week intermission | Quantitative, non-randomised, cross-sectional, descriptive | MAS<br>BMD<br>IGF-I<br>Time in standing shell | • No association between standing time and whole body BMD<br>• Standing shell use may ↑ hip instability in children with spasticity<br>• ↑ body weight = ↑ lumbar spine BMD<br>• ↓ nutrition may negatively influence hip stability<br>• Body weight may have greater impact on spine BMD than using standing shell |
| Gibson et al. (2009) | Determine whether static weight-bearing in a SF affected hamstring length and ease of ADLs in non-ambulant children with CP | *n* = 5<br>Age 6–9 years old<br>GMFCS IV:V = 1:4<br>Sex: Female 1, male 4 | Intervention: SF for 1 hr, 5 days per week, for 6 weeks,<br>Control: followed by 6 weeks of not using SF<br>Each phase repeated | Quantitative, non-randomised, single subject | Popliteal angle<br>Written feedback regarding ease of ADLs | • SF use significantly ↑ hamstring length<br>• Hamstring length ↓ after stopped SF use<br>• Mild ↑ in ADL ease during SF use<br>• High compliance with the standing regime was achieved (85% of intended sessions completed) |

| Authors | Purpose/aims | Sample | Intervention description | Research design | Outcome measures | Results and conclusions |
|---|---|---|---|---|---|---|
| Goodwin et al. (2019) | Explore professionals' and parents' experiences and views of SF use in educational settings | Educational professionals, parents and clinicians (paediatricians, physiotherapists, and occupational therapists) working with children with GMFCS IV and V (5 x focus groups) | 5 x focus groups | Qualitative, focus groups, framework method analysis, thematic analysis | Focus groups | Overarching theme of "flexibility" in SF use:<br>• "balancing education and therapy" – education professionals juggle different priorities from healthcare professionals within multi-disciplinary teams<br>• "young people's autonomy": SF use should be centred on the individual and their needs<br>• "working within logistical boundaries": Ideal SF use not always possible due to logistical issues (e.g., staffing , environment, SF availability)<br>• "competence and confidence": Educational staff felt they lacked training to confidently position child in SF |
| Israeli-Mendlovic et al. (2014) | To describe and compare HR and HRV at rest, during activity and passive standing among children with non-ambulant CP, and to describe association between daily physical activity and HRV | *n* = 30<br>Age 6–12 years old<br>GMFCS IV:V = 17:13<br>Sex: Female 13, male 17 | GMFM assessment, 2 min of repeated performance of highest activity achieved in GMFM and passive standing | Quantitative, non-randomised, cross-sectional | HR<br>HRV<br>Questionnaire | • GMFCS IV = ↑HR and ↓ HRV during GMFM assessment, the repeated task and passive standing<br>• GMFCS V = no effect noted<br>• No significant difference in HR or HRV with activity level |
| Rivi et al. (2014) | To determine effects of the SF on BF in children with CP including effects on frequency of induction of BM, characteristics of the stool and pain due to constipation and/or evacuation | *n* = 1<br>5 year old boy<br>GMFCS IV:V = 0:1 | SF use min 5 x week, aiming for 30 min to 1 hr per session | Quantitative, within series design, case study | Daily diary<br>Bristol Stool Scale<br>Questionnaire about burden of care | • No effect on frequency of evacuations or stool characteristics<br>• ↓ BM inductions<br>• ↓ pain suffered by child<br>• ↓ burden on caregivers |

*Note.* ADL = activities of daily living; BF = bowel function; BM = bowel motion; BMC = bone mineral content; BMD = bone mineral density; CP = cerebral palsy; FLACC = Face, Legs, Activity, Cry, Consolability scale; GMFCS = Gross Motor Function Classification System; GMFM = Gross Motor Function Measure; HR = heart rate; HRV= heart rate variability; IGF-I = insulin-like growth factor-I levels; MAS = modified Ashworth scale; PROM = passive range of movement; SF = standing frame; TBLH = total body less head.

**Table 9**

*Dynamic Standing Frame Studies*

| Author | Purpose/aims | Sample | Intervention description | Research design | Outcome measures | Results and conclusions |
|---|---|---|---|---|---|---|
| Diot et al. (2021) | Investigate usage and impact of robotic lower limb gait trainer in individual with CP over 3 months | *n* = 1<br>7 year old girl<br>GMFCS V | Trexo home robotic gait trainer over 12 week<br>Time/intensity and volume of use based on what was meaningful for participants family and caregivers | Quantitative, case study, observational | ECAB<br>ROM<br>MAS<br>MTS<br>Daily diary<br>Trexo use records | • ↑ head control<br>• ↓ knee flexor spasticity<br>• No loss in ROM (clinical team concerned about loss of ROM)<br>• ↑ frequency and quality (softer, easier to pass) of BM |
| Grodon et al. (2023) | Explored whether Innowalk Pro, robotic rehabilitation trainer could influence QOL, joint ROM, spasticity, and functional goals in the lower limb in children with CP | *n* = 27<br>Age 5–18 years old<br>GMFCS IV:V = 15:12<br>Sex: Female 10, male 17 | 30 min of Innowalk Pro per day, 4 x week, for 6 weeks | Quantitative, single-arm, pre-post test design | CPCHILD<br>ROM<br>MTS<br>GAS | • QOL statistically ↑, was further improved at 6 weeks post-intervention and maintained above pre-intervention level after 3 months (mainly for secondary school-aged children)<br>• Main changes in components 2 (positioning, transferring and mobility) and 3 (comfort and emotions)<br>• Knee extension improved post intervention but this was not maintained<br>• No change in tone<br>• 88% of patients met or exceeded functional goals |
| Lauruschkus et al. (2022) | Compare effects of SF vs Innowalk on health-related QOL, costs, and cost- effectiveness in non-ambulant CP | *n* = 20<br>Age 5–17 years old<br>GMFCS IV:V = 11:9<br>Sex: Female 9, male 11<br>18 participants with intellectual disability | 4 month SStF and 4 month Innowalk for ≥ 30 min with at least 2 week washout period between | Quantitative, RCT, cross- over design, participants acting as own controls | CPCHILD<br>Questionnaires<br>CPUP protocol<br>Cost: Information from caregivers, healthcare personnel, orthopaedic engineers, and product specialists | • Statistically significant difference in QOL between Innowalk and SStF ($p = 0.017$)<br>• Communications and interactions ↑after Innowalk more than SStF<br>• Clinically relevant ↑ QOL after Innowalk<br>• ↑ in satisfaction, alertness, fatigability, ability to focus, BF, medication, and pain within and between both groups: Innowalk > SStF in all categories except alertness<br>• BF improved with Innowalk (less constipation than SStF)<br>• ↓ pain locations with Innowalk<br>• Innowalk is the preferred option for families<br>• Innowalk = higher costs from societal and healthcare provider perspectives, than SF |

| Author | Purpose/aims | Sample | Intervention description | Research design | Outcome measures | Results and conclusions |
|---|---|---|---|---|---|---|
| Lauruschkus et al. (2023) | Explore the lived experience of physical activity of parents themselves and for their children with CP who are non-ambulant | 11 parents of children with CP who are non-ambulant who participated in a study of exercise effects of dynamic standing (above) | Semi-structured interviews | Qualitative, descriptive inductive design, hermeneutic phenomeno-logical approach | Interviews | • Theme 1: "Being aware of health benefits while struggling with family time". Parents experienced physical activity for their children and themselves as important but difficult<br>• Theme 2: "Being dependent". The children were perceived as being dependent on other people, accessible environments, and equipment for participating in physical activity<br>• Theme 3: "Getting hope in a challenging life situation". The opportunity for their children to become physically active regularly through an assistive device gave parents hope for a better life<br>• No parents reported negative effects of general physical activity or of physical activity in the DStF |
| Lundström et al. (2022) | Assess the effect of 30 min of dynamic standing exercise on blood glucose and blood lactate levels in children and adolescents with CP who are non-ambulant | *n* = 24<br>Age 5–17 years old (median = 12 years)<br>GMFCS IV:V = 13:11<br>Sex: Female 9, male 15 | Innowalk use with standing angle between 70°–85°, cadence 30–70 cadence/min (pace adapted to participant comfort) for 30 min | Quantitative, single-arm, pre-post test design | Capillary blood sample | • 42% had resting hyperlactatemia<br>• Intervention lowered lactate levels most in those with the highest level of lactate at rest<br>• Higher GMFCS level = higher resting level of blood lactate<br>• No change in blood glucose levels |
| Tornberg and Lauruschkus (2020) | Compare the effects of 4 months of static standing vs dynamic standing on PROM and spasticity in the hip in non-ambulant children with CP | *n* = 20<br>Age 5–17 years old<br>GMFCS IV:V = 11:9<br>Sex: Female 9, male 11 | Static standing: 30–90 min<br>Innowalk: 30–60 min with up to 50 rpm<br>4 months of either intervention with minimum wash-out of 2 weeks in between | Quantitative, repeated measures with a crossover design | PROM<br>MAS | • ↑ PROM in all directions of hip after dynamic standing<br>• ↓ spasticity after dynamic standing in all directions of hip but not statistically significant<br>• ↑ PROM in hip extension only in static standing |

*Note.* BF = bowel function; BM = bowel movements; CP = cerebral palsy; CPCHILD = Caregiver Priorities and Child Health Index of Life with Disabilities; CPUP = cerebral palsy follow-up programme; DStF = dynamic standing frame; ECAB = Early Clinical Assessment of Balance; GAS = Goal Attainment Scale; GMFCS = Gross Motor Function Classification System; MAS = modified Ashworth scale; MTS = Modified Tardieu Scale; SF = standing frame; SStF = static standing frame; QOL = quality of life; PROM = passive range of movement; ROM = range of movement; rpm = revolutions per minute.

to maximise both comfort and function (Capati et al., 2020; Dalén et al., 2010; Grodon et al., 2023; Rosenberg, Maeir, et al., 2021; Tornberg & Lauruschkus, 2020).

## Taha hinengaro

A key theme of "self-esteem and positive emotions" was identified within the taha hinengaro (mental and emotional wellbeing) domain of Te Whare Tapa Whā. The included studies offered limited attention to the facets associated with taha hinengaro, despite Asano et al. (2021) noting that children with CP experience significant mental health problems. The outcomes relating to "self-esteem and positive emotions" reported in the included articles were mostly secondary outcome measures.

### *Theme 2. Self-esteem and positive emotions*

Of the six types of physiotherapy interventions identified in the included studies, standing frames and PWT were the primary interventions reported to have an impact on self-esteem and positive emotions for NACCPID. Barbier et al. (2022) found that standing frames improved children's self-esteem, while Capati et al. (2020) reported children being happy and smiling while using the frames. Grodon et al. (2023) made a similar point when reporting significant improvement in the emotional component of the Caregiver Priorities and Child Health Index of Life with Disabilities (CPCHILD) questionnaire after using dynamic standing interventions. However a differing perspective was reported by teachers in the education setting, who felt that children who were placed in SStF when others were working sitting at their desks could negatively influence self-esteem (Goodwin et al., 2019).

A number of PWT studies reported that parents saw an increase in positive emotions such as smiling after their NACCPID experienced PWT (Kenyon et al., 2021; Kenyon et al., 2015; McGarry et al., 2012; Rosenberg, Cohen, et al., 2021). Therefore, PWT was seen to be a positive influence on psychosocial wellbeing (McGarry et al., 2012; Rosenberg, Cohen, et al., 2021). These findings are comparable to Diot et al. (2021), who found that parents and caregivers reported a sense of pride evoked by a NACCPID using the Trexo DStF. However, it is unclear how this was measured.

## Taha tinana

Three themes, "body systems", "optimising the body to move", and "using the body to perform a task", were identified within the taha tinana (physical wellbeing) domain of Te Whare Tapa Whā and were abundant within articles reviewed.

### *Theme 3. Body systems*

*Skeletal system*

Several studies highlighted challenges related to the skeletal system in NACCPID, which are crucial considerations for physiotherapy interventions. NACCPID are at risk of osteopenia and osteoporosis due to their lower bone mass (Barbier et al., 2022; Dalén et al., 2010; Lundström et al., 2022), increasing the risk of fractures (Dalén et al., 2010). Dalén et al. (2010) indicated that poor nutrition and anti-epilepsy medication influence bone health in NACCPID, while Lundström et al. (2022) found that chronic hyperlactatemia, common in this population, negatively affects bone formation. This suggests that lower bone mass in NACCPID may be multi-factorial. Studies by Barbier et al. (2022) and Capati et al. (2020), highlight that a higher severity of CP increases the risk of skeletal issues, such as dislocated hips and acetabular dysplasia. Hill et al. (2009) noted minimal evidence supporting NTPE use to reduce hip subluxation.

Articles suggest supported standing improves bone mineral density (BMD) (Dalén et al., 2010; Lauruschkus et al., 2023; Rivi et al., 2014), although the superiority of static versus dynamic standing is unclear (Lauruschkus et al., 2023). Rivi et al. (2014) suggested that skeletal alignment and increased leg loading may improve BMD, although these were not measured outcomes. Clinically, standing frames are thought to support bone health and this was evident from clinical reasoning in medical records (Barbier et al., 2022). Barbier et al. (2022) found that children using standing frames had a trend towards improved BMD and less bone reabsorption markers compared to the control group, though the difference was not statistically significant. Gibson et al. (2009) reported that standing frames are widely used to manage BMD for NACCPID, making it ethically challenging to remove its use, just to demonstrate its effect within clinical trials.

*Cardiovascular and respiratory systems*

Included studies identified that physical inactivity by NACCPID can negatively impact cardiovascular and respiratory function (Barbier et al., 2022; Israeli-Mendlovic et al., 2014; Lundström et al., 2022). Clinical reasoning for choosing SStF and DStF are often based on promotion of increased cardiorespiratory function, although direct evidence is limited (Barbier et al., 2022; Lundström et al., 2022). An example of limited evidence is shown by Rivi et al. (2014) who suggests a positive impact on respiratory function when reporting more spontaneous coughing, but this is only in one child when in their standing frame.

Included studies reported mixed findings regarding the impact of NTPE on the respiratory system. In the study by Hill et al. (2009), mean SpO2 increased in three children and decreased in six when using NTPE. However, all children maintained SpO2 at 95% or above when using NTPE, compared to drops to 93% for children when sleeping unsupported, suggesting potential risks of non-use. Hill et al. (2009) also noted a higher risk of unexplained death in sleep for children with severe CP, suggesting that any NTPE may reduce this risk.

Included studies highlighted the impact of standing frames on the cardiovascular system. One study by Israeli-Mendlovic et al. (2014) found that static standing improved mean heart rate and heart rate variability in GMFCS IV children compared to rest but not in GMFCS V children. Israeli-Mendlovic et al. (2014) suggested that this outcome might be due to additional brain injuries in children with GMFCS V, which could impair autonomic cardiac system adjustments to postural changes like transitioning from lying down to standing. Improved vascular supply to the feet using a DStF is inferred by Lauruschkus et al. (2022), noting parents reported warmer feet in their child after use.

*Gastrointestinal and urinary systems*
Included studies note that bowel dysfunction, such as constipation, is common for NACCPID, possibly caused by reduced mobility (Diot et al., 2021; Israeli-Mendlovic et al., 2014). Bowel habits are a significant factor affecting the quality of life for these children and families, highlighting the importance of interventions that target bowel function (Diot et al., 2021; Rivi et al., 2014). From included studies, evidence indicates that parental and expert opinion supports standing frame use for improving digestion (Barbier et al., 2022; Rivi et al., 2014). Rivi et al. (2014) found that daily standing frame use was associated with improved frequency of self-initiated bowel motions and reduced pain from constipation. Similarly, DStF also improved bowel motion (Diot et al., 2021; Lauruschkus et al., 2022), although the specific mechanism for this is unclear.

### *Theme 4. Optimising ability to move the body*
In line with the traditional views of physiotherapy, many outcomes for NACCPID identified in the included studies focus on optimising motor control, maintaining alignment by managing contractures, and managing spasticity and tone.

*Postural and motor control*
Postural and motor control may affect quality of life in NACCPID (Diot et al., 2021), making it an essential consideration for physiotherapists. Evidence suggests that PWT could improve motor control of the head (McGarry et al., 2012), arms (McGarry et al., 2012), and hands (McGarry et al., 2012; Rosenberg, Cohen, et al., 2021), with PWT, SStF, and functional exercise all improving upright postural control (Dalén et al., 2010; Elshafey et al., 2022; McGarry et al., 2012; Rivi et al., 2014; Rosenberg, Cohen, et al., 2021). Shih et al. (2011) reported improved head control in two children through activating motivating games, and similar findings were observed with DStF (Diot et al., 2021) and SStF use (Rivi et al., 2014). Barbier et al. (2022) attributed improvements in postural and motor control to standing frames stimulating the use of anti-gravity muscles.

*Contractures and range of movement (ROM)*
Contractures can occur in NACCPID due to decreased physical activity, muscle weakness, and poor posture (Asano et al., 2021; Diot et al., 2021; Gibson et al., 2009; Wood & Brown, 2022). A small decrease in ROM can significantly impact NACCPID (Tornberg & Lauruschkus, 2020), including future access to beneficial standing equipment (Capati et al., 2020). Therefore, maintaining ROM is recommended to enhance quality of life in these children (Diot et al., 2021). Underhill et al. (2012) and Wood and Brown (2022) suggest that NTPE can prevent joint deformity long term and, similarly, good body alignment in an upright position in standing frames supports the prevention of contractures at the knees, hips, and especially of the hamstrings (Capati et al., 2020; Dalén et al., 2010; Gibson et al., 2009).

Included studies that focused on standing frame interventions reported variable impact of DStF on lower limb ROM. While two studies reported improvements in lower limb ROM (Grodon et al., 2023; Tornberg & Lauruschkus, 2020) with more significant changes in dynamic standing compared to static standing (Tornberg & Lauruschkus, 2020), Diot et al. (2021) found no overall improvement. However, no loss in ROM was observed by Diot et al. (2021), indicating a role for standing frames in limiting contractures as a child grows. Importantly, this review noted that knee ROM reduced after a break from the use of the DStF, reinforcing its suitability to prevent contractures (Grodon et al., 2023).

*Spasticity and muscle tone*
Spasticity is a common co-morbidity in NACCPID (Diot et al., 2021), which can fluctuate with age (Tornberg & Lauruschkus, 2020), potentially impacting skeletal alignment, such as contributing to hip dislocation (Dalén et al., 2010). However, since many factors influence tone and spasticity, isolating the impact of a singular intervention is challenging (Diot et al., 2021) and the absence of spasticity exacerbation could be viewed as positive. Overall, DStF shows potential benefits on tone for NACCPID (Grodon et al., 2023; Lauruschkus et al., 2023), with no definitive impact on spasticity being the most negative conclusion (Diot et al., 2021). Tornberg and Lauruschkus (2020) support this notion, finding a reduction in hip spasticity during DStF use; however, this was not maintained after four months. Similarly, Wood and Brown (2022) report that the National Institute for Health and Care Excellence guidelines advocate using postural management equipment, such as NTPE, to help manage spasticity, despite this not being specific to NACCPID.

### *Theme 5. Using the body to perform a task*
The progression from optimising the body to move is then how well a person can use that body to perform a task. Themes constructed from the literature regarding this primarily looked at physical activity or function.

*Physical activity*
As reported in the included literature, reduced physical activity and increased sedentary time are common for NACCPID (Diot et al., 2021; Israeli-Mendlovic et al., 2014; Lauruschkus et al., 2023; Lauruschkus et al., 2022; Lundström et al., 2022), with increasing physical and cognitive impairment leading to decreasing amounts and intensity of physical activity (Lauruschkus et al., 2023). Children with CP express a desire to participate in physical activity, when provided with appropriate support (Lauruschkus et al., 2023). Physical activity is associated with positive health outcomes in disabled children (Smith, Rigby et al., 2022), and is a predictor of quality of life in children with CP (Lauruschkus et al., 2022), while sedentary behaviour can lead to detrimental metabolic effects (Lundström et al., 2022).

Caregivers reported small positive changes in physical activity measured in one PWT study (Rosenberg, Cohen, et al., 2021), with SStF suggested as a suitable adjunct to maintain activity (Capati et al., 2020). Lauruschkus et al. (2023) indicated DStFs allowed for purposeful physical activity with perceived health benefits by parents; however, achieving physical activity requires a significant amount of adult support, expensive equipment, and supportive environments.

Only one study investigated the physiological benefits of exercise (Lundström et al., 2022), finding no significant change in blood glucose levels with DStF use. However, they noted 42% of participants had hyperlactatemia at rest, with higher GMFCS levels being most affected. Importantly, DStF exercise lowered lactate levels in this group, suggesting potential positive metabolic effect from exercise.

*Function*
The literature reports that NACCPID experience significant functional restrictions across multiple domains, including daily activities, participation, and physical activity (Asano et al., 2021; Israeli-Mendlovic et al., 2014; Kenyon et al., 2021; Lauruschkus et al., 2023; Lauruschkus et al., 2022). Included studies highlighted the range of adaptive equipment required to assisted function. In all PWT studies there were improvements in wheelchair skills (Kenyon et al., 2021; Kenyon et al., 2015; McGarry et al., 2012; Rosenberg, Cohen, et al., 2021; Rosenberg, Maeir, et al., 2021). A wide variety of outcome measures were used to assess this, including some that rely on skills to be performed on command, which could be challenging for NACCPID. Rosenberg, Cohen, et al. (2021) noted a subjective improvement in sitting skills after PWT for NACCPID.

The ability to perform a supported stand is crucial for transfers and for ease of caregivers supporting activities of daily living (ADLs) such as changing clothes, bathing, and toileting for NACCPID (Capati et al., 2020; Gibson et al., 2009). Asano et al. (2021) found a decline in the standing component of the GMFM-88 when related exercises ceased with improvement when functional exercise resumed. Equipment such as standing frames supporting a static stand are reported by parents and school staff to positively influence functional outcomes and ADLs (Capati et al., 2020; Gibson et al., 2009). Similarly, Lauruschkus et al. (2022) reported improved gross motor function with DStF use, compared to static standing, attributed to increased strength, improving alignment for function, and encouraging relaxation (Capati et al., 2020; Gibson et al., 2009; Goodwin et al., 2019). Similarly, Wood and Brown (2022) report that the use of NTPE, which maintains alignment and may encourage relaxation, helped one participant get out of bed and into a chair in the mornings, where this activity was previously challenging.

One study showed that DStF helped 88% of participants to meet or exceed their functional goals (Grodon et al., 2023), with positioning, transferring, and the mobility component of the CPCHILD also improving. However, Grodon et al. (2023) also found these gains returned to their baseline level after a 6–12 week break from use, highlighting the need for ongoing intervention.

### Taha whānau

Themes for taha whānau (family wellbeing) that were derived from the articles were "collaboration", "(in)dependence", and "participation and inclusion".

*Theme 6. Collaboration*
Throughout the included studies it is evident that collaboration is important, as a significant number of people are involved in the care of NACCPID. This includes family and whānau, educators, caregivers, teacher aides, healthcare professionals, and technicians from many various organisations and environments (Capati et al., 2020; Gibson et al., 2009; Goodwin et al., 2019; Lauruschkus et al., 2023). Lauruschkus et al. (2023) emphasise the importance of having the correct ongoing support to provide stability for families, yet finding appropriate support people can be challenging. Collaboration is required to provide the optimal care through the child's day (Capati et al., 2020).

The involvement of multiple caregivers means physiotherapy interventions can occur in many settings, particularly in schools where SStF are often used (Dalén et al., 2010; Gibson et al., 2009; Goodwin et al., 2019; Rivi et al., 2014). Goodwin et al. (2019) elaborated by commenting that the school setting has the potential to create tensions between school staff, the child, families, and therapists when healthcare interventions are expected to be delivered by educators in a school environment, as each party may have different priorities for the child.

*Theme 7. (In)Dependence*
There is consensus that NACCPID's restriction in function leads to passivity and increased dependence on others (Lauruschkus et al., 2023; McGarry et al., 2012; Tornberg & Lauruschkus, 2020). McGarry et al. (2012) noted that this passivity can also increase frustration in the child, causing developmental problems. Many included studies highlighted the role of adaptive equipment in supporting independence, for example, the role of PWT in facilitating independent movement regardless of cognitive limitations (Kenyon et al., 2015; Rosenberg, Maeir, et al., 2021). Included studies suggested PWT is a positive tool that fosters autonomy, self-exploration, and independent initiation, giving more meaningful life experience, thus reducing passivity and dependence (Kenyon et al., 2021; Kenyon et al., 2015; McGarry et al., 2012; Rosenberg, Cohen, et al., 2021; Rosenberg, Maeir, et al., 2021). Additionally, parents' positive perception of their child's abilities may help break the negative dependence cycle, (Kenyon et al., 2021). Another benefit of PWT is that it enables children to attend motivating activities independently (McGarry et al., 2012). Kenyon et al. (2015) also observed non-verbal communication such as driving away from caregivers to avoid non-preferred activities. DStF are also reported to help reduce parental dependence, as the child could be independent and safe while exercising without direct parental support (Lauruschkus et al., 2023).

*Theme 8. Participation and inclusion*
Lauruschkus et al. (2023) suggest participation for NACCPID means the child must be both present and involved, which is in agreement with the family of participation-related constructs used in physiotherapy for CP (Imms et al., 2017). Imms et al. (2017) suggested that attendance refers to the act of "being there", and involvement includes engagement, motivation, and physical participation. NACCPID's aetiological restriction in function subsequently limits attendance, further exacerbating functional limitations (Kenyon et al., 2015; McGarry et al., 2012; Rosenberg, Cohen, et al., 2021).

PWT was unanimously recognised for improving participation by supporting better engagement and motivation in exploration, play, and communication (Kenyon et al., 2021;

Kenyon et al., 2015; McGarry et al., 2012; Rosenberg, Cohen, et al., 2021; Rosenberg, Maeir, et al., 2021). This is theorised to result from changes in sensory stimulation and body positioning that increase alertness, although this theory is untested (McGarry et al., 2012).

Included studies that focused on standing frames indicated that participation was positively facilitated by providing access to meaningful occupation and engagement. However, a direct measurement of participation was not conducted in any of these studies (Capati et al., 2020; Goodwin et al., 2019; Rivi et al., 2014). Similar findings by Diot et al. (2021) and Lauruschkus et al. (2023) found that DStFs allowed for meaningful participation in school subjects, such as physical education, which may otherwise be limited for NACCPID, and was valued by both the child and the parent (Lauruschkus et al., 2023).

Children with CP experience restrictions in social participation (Asano et al., 2021), with parents expressing a desire for their child to have friends (Lauruschkus et al., 2023). Lauruschkus et al. (2023) emphasise that inclusion requires more than social presence; it requires meaningful involvement.

Different interventions showed varying results for supporting inclusion. Included studies suggested SStF use has variable effects on inclusion. Capati et al. (2020) found that achieving upright standing enabled a child to engage in family activities. Standing is also suggested to be beneficial in the school environment (Goodwin et al., 2019; Rivi et al., 2014). Children were reported to be more involved with learning when standing, which gave them a different perspective of the world (Goodwin et al., 2019) and had more meaningful, upright social interactions with staff and peers when in standing frames (Rivi et al., 2014). However, Goodwin et al. (2019) also noted standing frames were often incompatible with other socially necessary equipment, such as communication set-ups, and their size created a physical barrier, thereby limiting inclusion.

Included studies suggest PWT facilitates social inclusion and age-appropriate activities in NACCPID with their peers (Kenyon et al., 2021; Kenyon et al., 2015; McGarry et al., 2012; Rosenberg, Cohen, et al., 2021; Rosenberg, Maeir, et al., 2021) with observations from the participants (Rosenberg, Maeir, et al., 2021), parents (Kenyon et al., 2021; McGarry et al., 2012), caregivers (Rosenberg, Cohen, et al., 2021), and researchers (Kenyon et al., 2021; Kenyon et al., 2015). Peers seemed to view the child more as an equal when they were in a power wheelchair, enhancing social connections (Rosenberg, Cohen, et al., 2021).

### Taha whenua

Although not always included in Te Whare Tapa Whā, taha whenua is important when discussing physiotherapy interventions for NACCPID due to themes being generated regarding "resourcing" and "accessible environments".

#### *Theme 9. Resourcing*

Included articles highlighted that setting up and training caregivers to use equipment, such as SStF and DStF, incurs a substantial time cost. Diot et al. (2021) suggested this to only be when first setting up the equipment. However, Goodwin et al. (2019) reported that the time taken to adjust frames, gain suitable knowledge, and train confident staff within adequate staffing levels were barriers to ongoing standing frame use in schools. Capati et al. (2020) echoed this sentiment, noting that limited access to trained carers restricted standing frame use. Concerns were expressed by classroom staff in their ability to manage the disabled child and their equipment (Goodwin et al., 2019). Gibson et al. (2009) noted that school staff and physiotherapy resourcing to provide suitable standing frame use in mainstream schools in South Australia were inadequate, and standing frame use for their study was only achievable due to the provision of a physiotherapy assistant to aid implementation.

Interventions that can occur without the need for an appointment and do not significantly impact parental time, such as DStF use, are seen as beneficial to parents (Diot et al., 2021). However, even when these factors are optimised, a significant number of non-use days at school are reported (Diot et al., 2021).

The time taken to provide physiotherapy interventions is extensive, with optimal dosage for adaptive equipment use undecided in many situations (Capati et al., 2020; Gibson et al., 2009). Variation in recommended treatment dosage is shown in Table 10 and reinforces the view of Dalén et al. (2010) that time spent and number of interventions vary from child to child, with optimal dosage being difficult to ascertain (Capati et al., 2020; Dalén et al., 2010; Gibson et al., 2009).

For PWT, the skills gained must be practised to retain them, further increasing the time required to optimise outcomes (McGarry et al., 2012). Importantly, children with more significant physical and cognitive disabilities need longer and intensive PWT practise time than children who have less severe impairments (Kenyon et al., 2021).

There is agreement that cost, size, and difficulty transporting equipment are negative factors influencing the acceptability of powered mobility, SStF, and DStF use for both families and schools (Diot et al., 2021; Goodwin et al., 2019; Kenyon et al., 2021; Lauruschkus et al., 2023). Similarly, commercial gaming technology cost could be a barrier to use and, therefore, affordability of gaming consoles for home and school environments are recommended when designing gaming-style interventions (Shih et al., 2011). DStF are more costly than standing frames; however, they provide better outcomes for quality of life (Lauruschkus et al., 2022).

#### *Theme 10. Accessible environments*

NACCPID, who have difficulty standing or transferring, often have limited access to resources that support physical activity (Grodon et al., 2023). Accessible environments are essential for NACCPID, as travel time to these locations is tiring for them (Lauruschkus et al., 2023). Recommended features include level surfaces, multi-use spaces such as gymnasiums and malls, and accessible changing rooms to support meaningful interventions for NACCPID (Diot et al., 2021; Lauruschkus et al., 2023). Adequate space in the home

**Table 10**

*Variations in Treatment Dose*

| Intervention and reference | Time required | Number of times | Overall length of intervention |
|---|---|---|---|
| PWT (Kenyon et al., 2021) | 45–60 min | 2 days per week | 8 weeks |
| PWT (McGarry et al., 2012) | 60 min | 2 consecutive days per week | 8 weeks |
| PWT (Rosenberg, Maeir, et al., 2021) | 2 hours a day | 5 days per week | 3 weeks |
| Functional physiotherapy exercises (Asano et al., 2021) | 90 min | 1 day per week | Indefinitely |
| Functional physiotherapy exercises (Elshafey et al., 2022) | 90 min | 3 days per week | 2 months |
| Gaming (Shih et al., 2011) | 3 min | 3–5 sessions per day | 60 sessions |
| DStF (Grodon et al., 2023) | 30 min | 4 days per week | 6 weeks |
| DStF (Lauruschkus et al., 2023) | 30–90 min | Every day | Indefinitely |
| SStF (Barbier et al., 2022) | 60–840 min | Over a week | Unspecified |
| SStF (Capati et al., 2020) | 90 min day | 5 days per week | 15 months |
| SStF (Dalén et al., 2010) | 40 min | 1–2 times per days | 1 week |
| SStF (Gibson et al., 2009) | 60 min | 5–7 days per week | 6 weeks |

*Note.* DStF = dynamic standing frame; PWT = power wheelchair training; SSfF = static standing frame.

environments is also required to allow the use of equipment such as standing frames (Capati et al., 2020).

According to Tornberg and Lauruschkus (2020), integrating interventions into the children's everyday environments facilitates their use; on the other hand, Goodwin et al. (2019) suggested that providing interventions in a school setting can disrupt other learners. Therefore, consideration must be given to how NACCPID needs are integrated into all their environments.

## DISCUSSION

This integrative review aimed to explore the existing literature on physiotherapy interventions for school-aged NACCPID to inform clinical practice and suggest areas for future research within the Aotearoa New Zealand context. Six interventions with 10 key themes related to physiotherapy interventions for NACCPID were derived from the data and mapped to Te Whare Tapa Whā domains. It was evident that these themes encompassed aspects beyond the traditional physical focus typically associated with physiotherapy. However, the outcomes reported across the studies demonstrated considerable variability, reflecting the heterogeneity of the population. Additionally, significant resource considerations were identified, as five out of the six interventions required specialised equipment, impacting their feasibility and implementation.

The findings emphasise the critical importance of adopting personalised approaches to physiotherapy care. The review highlighted the individuality of NACCPID, indicating that physiotherapists must employ flexible, tailored strategies that are grounded in a comprehensive understanding of the child's motivations and preferences. Communication barriers, frequently observed in children with intellectual disabilities (Doherty et al., 2020), necessitate the use of alternative communication methods to effectively ascertain the child's preferences. However, as discussed in the introduction, the context of care within education in Aotearoa New Zealand requires additional time to facilitate whānau engagement to explore preferences. Time constraints can restrict opportunities for individualised care regardless of setting (Doherty et al., 2020). Consequently, it is imperative for physiotherapists to prioritise discussions about the child's current likes and dislikes, ensuring these preferences are incorporated into intervention planning. Employing tools such as the F-words framework (Rosenbaum & Gorter, 2012) may facilitate the initiation of meaningful conversations with caregivers, supporting a more collaborative and child-centred approach to care.

The interventions identified in this review showed benefits for physical health, independence, participation, emotional wellbeing, and quality of life for NACCPID, supporting inclusion and long-term functional outcomes. Given the alignment of physiotherapy within a biomedical model focusing on physical aspects of care, most articles measured body system outcomes with the emphasis on optimising the body for movement and task performance.

Although the cause of CP is non-progressive, secondary impairments in NACCPID, such as contractures, develop as the child grows (Gilette Children's Speciality Healthcare, 2022). In NACCPID, the musculoskeletal system often grows faster than a child can strengthen, limiting the ability to provide adequate postural support for the increasing load, which can result in declining function into adulthood (Diot et al., 2021). This progression of secondary impairments highlights the need for proactive, rather than reactive, physiotherapy interventions focusing on maintaining ROM, supporting postural control, and minimising functional decline as the child develops.

SStF, DStF, and NTPE all support the maintenance of lower limb ROM with both types of standing frames providing potential to improve ROM (DStF more than SStF). This is supported by expert opinion (McLean et al., 2022; Paleg et al., 2022), identifying standing frames as a valuable modality for preventing lower limb contractures. Similarly, SStF, DStF, and NTPE were not associated with increased spasticity, with DStF having the most notable, though temporary, positive influence on hip spasticity. Measuring spasticity remains challenging, both clinically and methodologically, as the reliability of the most commonly used assessment tools, the Modified Ashworth Scale and the Modified Tardieu Scale, is contentious (McLean et al., 2022). Consequently, spasticity measurement may be more appropriately used as an assessment tool rather than as a primary outcome measure in research.

All interventions, with the exception of NTPE, positively influence postural and motor control, primarily of the head, trunk, and upper limbs (Dalén et al., 2010; Diot et al., 2021; Elshafey et al., 2022; McGarry et al., 2012; Rivi et al., 2014; Rosenberg, Cohen, et al., 2021; Shih et al., 2011). Although physical activity for NACCPID is understandably restricted, it remains highly valued by children and their families (Lauruschkus et al., 2023). The key modality identified in this review to support an increase in physical activity is DStF. However, motivational factors were found to be crucial for PWT, SStF, DStF, gaming, and functional movement. This highlights the importance of incorporating strategies to enhance motivation in order to optimise outcomes.

Clinically, spasticity, tone, range of motion, contractures, and postural and motor control are closely interconnected. Therefore, it is important for clinicians to recognise that the interventions in this review do not worsen these core components and may provide improvements. The evidence provides strong support for implementing these interventions with NACCPID to help prevent secondary complications associated with CP.

This review indicates that maintaining range of motion, supporting and promoting postural and motor control, and maximising physical activity are integral in enhancing function for individuals with NACCPID. Functional gains were specifically linked to the intervention type, such as PWT improving sitting function and skills specific to powerchair use and practising standing improving standing outcome measures. Of clinical importance, Murphy et al. (2021) noted that the ability of individuals with CP to perform a standing pivot transfer over their lifetime cannot be overestimated. They found that only non-ambulatory CP adults who regularly used standing frames could perform this transfer, underscoring the long-term benefits standing frames can have on function. This provides substantial justification for standing frame use in NACCPID. This task-specific approach is aligned with systematic reviews encouraging task-specific training in CP (Novak et al., 2020). Consequently, it is reasonable for physiotherapists to work on gaining or maintaining a standing transfer as the minimum for NACCPID, using equipment or techniques tailored to the individual child's needs.

This review suggests that enhancing functional skills may provide opportunity for more independence, participation, and inclusion. As opportunities for independence are scarce for NACCPID and passivity can lead to frustration and behavioural challenges, PWT provide a valuable means to reduce dependence on caregivers, benefitting the child and the caregiver. This review emphasises the importance of early PWT access for all NACCPID. Findings are less conclusive for the impact of both SStF and DStF on reducing dependence, echoing experiences of non-ambulatory children with CP without intellectual disability who reported that standing frames were beneficial for certain tasks but limited independent mobility (Goodwin et al., 2017). Therefore, standing frames may be a more suitable adjunct for goals not related to (in)dependence.

NACCPID encounter substantial barriers in all components of participation; however, this review indicates that PWT, SStF, and DStF may facilitate attendance in activities by promoting independent mobility in a similar physical position as their peers. However, practical challenges associated with the use of standing frames, corroborated by the perspectives of non-ambulatory children using standing frames, (Goodwin et al., 2017), must be considered in clinical decision making.

Given the review's findings that improving independent movement and standing can enhance a child's independence, participation, and inclusion, selecting multifunctional equipment, such as standing power chairs, is a logical approach. As such, evaluating the cost–benefit of funding standing powerchairs for children with NACCPID in Aotearoa New Zealand is warranted.

This review identified limited evidence supporting a direct positive impact of the interventions on the cardiovascular and respiratory systems. Where evidence was available, it suggested that the potential risk of adverse outcomes from non-implementation (such as NTPE) supports the justification for intervention, provided it is well tolerated by the child.

Physiotherapy interventions can promote holistic outcomes for children with NACCPID as, in this review, positive outcomes were observed in areas beyond those traditionally monitored by physiotherapists. As reported by the included studies, standing frames (static and dynamic) have a positive effect on BMD in NACCPID, aligning with past research (McLean et al., 2022; Paleg et al., 2013). Additionally, standing frames were associated with improved bowel function and a reduction in pain related to constipation (Barbier et al., 2022; Diot et al., 2021; Lauruschkus et al., 2022; Rivi et al., 2014). The impact of standing frames on self-esteem had mixed perceptions, depending on who reported the outcomes, highlighting challenges in assessing outcomes in a population that is often non-verbal. These differing perspectives echo those of non-ambulatory children without intellectual disability who report varying experiences of standing frame use based on setting (school versus home), age, and activity (Hughes & Campbell, 2014). This highlights the importance of customising interventions to meet individual needs and emphasises the need for physiotherapists to actively monitor the perceived effects of interventions.

Additionally, incorporating input from all team members is vital to obtain a comprehensive understanding of care and outcomes. This review highlighted the extensive network of people involved in caring for NACCPID and the potential for competing professional priorities. A structured system for regular multidisciplinary team review, importantly including whānau, discussing priorities, benefits, and risks of interventions, would aid all professionals working with this population. This aligns with the person- and whānau-centred care model for physiotherapy in Aotearoa New Zealand, which emphasises collaborative, inclusive decision making but also recognises persistent challenges in balancing diverse perspectives and shared power within multidisciplinary teams (Darlow & Williams, 2018). Alongside this, a bi-annual holistic assessment for children with CP has been recommended (Sarathy et al., 2019), and integrating both subjective and objective outcomes measures could enhance a more holistic approach to care. How these recommendations could be implemented in a special education context will require further consideration and collaboration with all stakeholders.

Equipment provision features heavily in the interventions identified in this review. It was also demonstrated that providing equipment creates challenges for physiotherapists due to cost, accessibility, and caregiver training. Training caregivers to use specialised equipment is essential so they can support the child, yet securing these caregivers appears challenging in the school and home settings. Acknowledgement of this issue within this review is reassuring, as, from the experience of the principal investigator, this is a common dilemma for physiotherapists in Aotearoa New Zealand, highlighting a need for effective solutions at both an organisational and governmental level.

Equipment that can be integrated into purposeful everyday activities, such as PWT and standing frames, appears to be beneficial in providing a therapeutic outcome. However, the cost of the equipment (specifically PWT, SStF, DStF, and, to a lesser extent gaming), and barriers regarding storage and transporting equipment, are especially pertinent in providing equitable care. Evidence indicates that PWT can significantly improve physical, behavioural, language, and emotional development for NACCPID (Kenyon et al., 2021; Kenyon et al., 2015; McGarry et al., 2012; Rosenberg, Cohen, et al., 2021; Rosenberg, Maeir, et al., 2021), with limited adverse outcomes reported. However, power mobility is not universally funded in Aotearoa New Zealand. Recommending powered mobility over manual mobility for NACCPID poses significant resourcing questions due to the potential higher cost and maintenance of powerchairs. This review supports an argument that the provision of a powerchair should be the priority of all equipment for NACCPID, but acknowledges that further research is required to evaluate the impact of powered wheelchairs on quality of life for NACCPID and their families.

While SStF are standard care within Aotearoa New Zealand for NACCPID, this review suggested DStF may provide more benefits, yet they are only currently available if privately funded. As seen in this review, DStF provide positive opportunities for NACCPID; therefore, it would be prudent to evaluate the cost benefits of this intervention within the Aotearoa New Zealand context. An individualised approach to equipment provision could reduce the need for multiple devices, potentially lowering costs and storage requirements while optimising outcomes. However, current disability support policies in Aotearoa New Zealand remain fragmented and often reactive, lacking the flexibility and responsiveness required to support timely, equitable access to appropriately tailored equipment for children with complex needs, as highlighted in recent critiques of funding pathways and service coordination (Smith, Blamires et al., 2022).

## LIMITATIONS

This review explored the literature on physiotherapy interventions for school-aged NACCPID. Only six types of interventions potentially applicable to the Aotearoa New Zealand health care system were identified in this study. In contrast to the extensive number of interventions identified in systematic reviews for CP as a whole, this suggests an imbalance between ambulatory and non-ambulatory CP representation in the literature. One possible cause could be a publishing bias favouring higher levels of evidence, which often overlooks case studies and small number of participant studies that may report the effect of other interventions. DStF appeared extensively in this review (a quarter of all studies included), despite being so expensive that it is not offered in the public system within Aotearoa New Zealand. This reflects the emerging nature of new technologies and potentially suggests the influence of private corporations on research funding. This may be the reason fewer glamorous, grassroots interventions appear to be studied or published.

Although this integrative review followed guidelines by Kutcher and LeBaron (2022) and provided quality appraisal through the MMAT appraisal, it must be taken within the constraints of the quality of the studies found. There are methodological limitations in all studies, such as many single case studies or studies having between two and five subjects meaning generalisation must be applied cautiously. As the MMAT is not designed to "score" the literature or influence the presentation of the results (Hong, Pluye, et al., 2018) it allows the presentation of valuable, real-world approaches that could be used with NACCPID.

It is acknowledged that the search strategy and criteria for defining "physiotherapy" may have overlooked some interventions. Additionally, the absence of "intellectual disability" as a search term introduced subjectivity in assessing the suitability of interventions for children with intellectual disabilities. While the principal investigator's 10 years of experience with this population provided valuable insight, it is recognised that some suitable interventions may have been missed. Moreover, excluding walking therapies resulted in the omission of partial body weight-supported treadmill training, which could be relevant for GMFCS IV and V children. The perspectives of children with CP were limited in this review; however, some perspectives were captured by Rosenberg, Maeir, et al. (2021) when assessing the outcomes of PWT. The child's perspective is crucial in physiotherapy care and the inclusion of the perspective of non-ambulatory children with CP would have enriched the findings, particularly those without intellectual disability who may have a more robust communication system in place.

Within the Aotearoa New Zealand context, a limitation is the lack of studies undertaken, particularly with Indigenous populations. However, the use of Te Whare Tapa Whā as a framework helped to provide an Aotearoa New Zealand-specific lens to this review, which has the potential to help to give local relevance to international research, and is therefore a strength of this review. As codes were reviewed with the cultural advisor MA, it was anticipated that the Māori concept of health, as a more holistic model, would be reflected within this review. However, as KA, JB, and JH are Tauiwi, it is acknowledged that a Māori researcher or a clinician who has practised more within Aotearoa New Zealand may have generated alternative data. Also, when codes were placed within Te Whare Tapa Whā, they were only placed in the one aspect with which it was felt to have the strongest connection. This dramatically simplifies the understanding that all components of Te Whare Tapa Whā are interlinked, and it is acknowledged that the themes and codes presented may translate across other aspects than the one they are presented in.

Although strengthening the review findings to the Aotearoa New Zealand context, the use of the Te Whare Tapa Whā framework, being unique to Aotearoa New Zealand, does limit the disseminations of this review internationally. If the findings were to be presented to an international community, it may be appropriate to use an internationally recognised framework such as the F-Words (Rosenbaum & Gorter, 2012), alongside Te Whare Tapa Whā. This would help to contextualise findings across multiple cultures. The use of Te Whare Tapa Whā raises awareness of Indigenous models of practice that potentially are more suitable with complex disability than the biomedical models.

## CONCLUSION

This review highlights that all the interventions presented have both potential benefits and risks to NACCPID and their whānau. Notably PWT appears to have significant beneficial effects across all aspects of health, as mapped to the domains of the Te Whare Tapa Whā model. We recommend the use of this intervention as early as possible. However, only six interventions were found in the literature pertaining to physiotherapy interventions for NACCPID. This gives limited scope of evidence for physiotherapists to use within EBP, and ways to highlight other potential interventions based on sound science need to be considered to support EBP. Choice of intervention must consider the child and families' individual needs, wants, likes, and values. If the goal of the treatment chosen aligns with its highlighted benefits, and these outweigh potential risks, then it appears the intervention should be tried with the outcomes being meticulously monitored. Systems need to monitor the child as they grow and have the flexibility to change interventions as circumstances change.

## DISSEMINATION OF FINDINGS

The findings of this study guide physiotherapists in understanding the possible benefits, potential harms, and considerations for each condition. For these findings to be understood by children and their whānau, they were depicted in diagrammatic form using modified Boardmaker© (2024, Tobbi Dynavox LLC) visuals. This system is widely used to support communication for NACCPID in Aotearoa New Zealand aiding its potential understanding for NACCPID. Videos were then created using language and symbols common when communicating with NACCPID. These were formulated in conjunction with an experienced speech and language therapist and special education deputy principal who work with NACCPID, with English, Māori, and New Zealand Sign Language versions created. These videos can be found here:

Standard: https://youtu.be/eG8pL1ojUwg?si=ne6EQ8h51pdHZAcm

Māori: https://youtu.be/mAyb8cUMm8E?si=wldp2BiRZFNXHdjh

New Zealand Sign Language: https://youtu.be/lR7ZCGCwyBM

## KEY POINTS

1. Physiotherapy interventions for NACCPID presented have potential benefits and risks to the children and their whānau.
2. Power wheelchair training has shown significant beneficial effects for NACCPID across all aspects of health, as presented within the Te Whare Tapa Whā model.
3. The choice of intervention should consider the child and families' individual needs, wants, likes, and values.

4. If the goal of the treatment chosen aligns with its recognised benefits, and these outweigh potential risks, then the intervention should be attempted with the outcomes monitored carefully.

## DISCLOSURES

No funding was obtained for the study, and no conflicts of interest are present.

## PERMISSIONS

No permissions were required.

## CONTRIBUTIONS OF AUTHORS

Conceptualisation and methodology, KA; validation, JB and JH; formal analysis, KA, MA, JB, and JH; data curation, KA, MA, JB, and JH; writing – original draft, KA; writing – review and editing, MA, JB, and JH; supervision, JB and JH.

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# Appendix A

## SEARCH STRATEGY AND DOCUMENTATION

**Part 1. EBSCO CINAHL, 27 March 2023**

| No. | Search terms | Total citations | Title and abstract screened | Full text article reviewed | Duplicates removed manually | Full text articles retrieved |
|---|---|---|---|---|---|---|
| S1 | "cerebral palsy" or cp or "spastic quadriplegi*" | 24395 | | | | |
| S2 | child* or adolescen* or youth or teen* or "young adult*" or school* | 1206579 | | | | |
| S3 | "non ambula*" or wheelchair* or "GMFCS IV" or "GMFCS V" | 7196 | | | | |
| S4 | care* OR manage* OR interven* OR treat* OR aid* OR equipment* OR stand* OR frame* OR walker* OR "gait trainer*" OR seat* OR strength* OR skill* OR activit* OR prevent* OR contracture* OR "muscle length*" OR routine* OR physiotherap* OR rehab* OR *therap* OR " hippothera*" OR " hydrotherap*" OR "balanc*" OR "move*" OR "electrical stim" OR "motor function" OR "neurodevelopmental therap" OR "neuro-developmental therap" | 4079195 | | | | |
| S5 | S1 AND S2 AND S3 AND S4 | 296 | 296 | 76 | 0 | 8 |

*Note.* GMFCS = Gross Motor Function Classification System; S = search.

**Part 2. Scopus, 27 March 2023**

| No. | Search terms | Total citations | Title and abstract screened | Full text article reviewed | Duplicates removed manually | Full text articles retrieved |
|---|---|---|---|---|---|---|
| 1 | (TITLE-ABS-KEY ("cerebral palsy" OR cp OR "spastic quadriplegi*" ) AND PUBYEAR > 2006 AND PUBYEAR > 2006) AND (TITLE-ABS-KEY (child* OR adolescen* OR youth OR teen* OR "young adult*" OR school*) AND PUBYEAR > 2006 AND PUBYEAR > 2006 ) AND (TITLE-ABS-KEY ("non ambula*" OR wheelchair* OR "GMFCS IV" OR "GMFCS V") AND PUBYEAR > 2006 AND PUBYEAR > 2006) AND ( TITLE-ABS-KEY (care* OR manage* OR interven* OR treat* OR aid* OR equipment* OR stand* OR frame* OR walker* OR "gait trainer*" OR seat* OR strength* OR skill* OR activit* OR prevent* OR contracture* OR "muscle length*" OR routine* OR physiotherap* OR rehab* OR *therap* OR " hippothera*" OR " hydrotherap*" OR "balanc*" OR "move*" OR "electrical stim" OR "motor function*" OR "neurodevelopmental therap" OR "neuro-developmental therap") AND PUBYEAR > 2006 AND PUBYEAR > 2006) | 593 | 593 | 87 | 5 | 3 |

*Note.* GMFCS = Gross Motor Function Classification System.

**Part 3. Ovid Medline, 27 March 2023**

| No. | Search terms | Total citations | Title and abstract screened | Full text article reviewed | Duplicates removed manually | Full text articles retrieved |
|---|---|---|---|---|---|---|
| 1 | (child* or adolescen* or youth or teen* or "young adult*" or school*).mp. | 4557848 | | | | |
| 2 | limit 1 to yr="2007-Current" | 2451543 | | | | |
| 3 | ("cerebral palsy" or cp or "spastic quadriplegi*").mp. | 93767 | | | | |
| 4 | limit 3 to yr="2007-Current" | 61559 | | | | |
| 5 | ("non ambula*" or wheelchair* or "GMFCS IV" or "GMFCS V").mp. | 11219 | | | | |
| 6 | limit 5 to yr="2007-Current" | 7197 | | | | |
| 7 | (care* or manage* or interven* or treat* or aid* or equipment* or stand* or frame* or walker* or "gait trainer*" or seat* or strength* or skill* or activit* or prevent* or contracture* or "muscle length*" or routine* or physiotherap* or rehab*).mp. or *therap*/ or "hippothera*".mp. or" hydrotherap*".mp. or "balanc*".mp. or "move*".mp. or "electrical stim".mp. or "motor function".mp. or "neurodevelopmental therap".mp. or "neuro-developmental therap".mp. | 16982857 | | | | |
| 8 | limit 7 to yr="2007 -Current" | 10266977 | | | | |
| 9 | 1 and 2 and 3 and 4 and 5 and 6 and 7 and 8 | 425 | 425 | 66 | 15 | 3 |

*Note*. GMFCS = Gross Motor Function Classification System.

**Part 4. PEDRO, 10 April 2023**

| No. | Search terms | Total citations | Title and abstract screened | Full text article reviewed | Duplicates removed manually | Full text articles retrieved |
|---|---|---|---|---|---|---|
| 1 | cerebral palsy and published since 2007 | 810 | 810 | 339 | 5 | 3 |

**Part 5. Google Scholar, 29 April 2023**

| No. | Search terms – 5 pages of results screened for each search | Total citations | Title and abstract screened | Full text article reviewed | Duplicates removed manually | Full text articles retrieved |
|---|---|---|---|---|---|---|
| 1 | non ambulatory cerebral palsy children since 2007 | 50 | 26 | 3 | 24 | 0 |
| 2 | "GMFCS IV & V" physiotherapy since 2007 | 13 | 10 | 2 | 3 | 0 |
| 3 | non ambulant cerebral palsy physiotherapy since 2007 | 50 | 24 | 4 | 26 | 0 |

**Part 6. Google Search, 29 April 2023**

| No. | Search terms – 5 pages of results screened for each search | Total citations | Title and abstract screened | Full text article reviewed | Duplicates removed manually | Full text articles retrieved |
|---|---|---|---|---|---|---|
| 1 | non-ambulant cerebral palsy children physiotherapy | 49 | 37 | 4 | 12 | 1 |

**Part 7. Tu Whera, 30 April 2023**

| No. | Search terms | Total citations | Title and abstract screened | Full text article reviewed | Duplicates removed manually | Full text articles retrieved |
|---|---|---|---|---|---|---|
| 1 | Browsing by subject "Cerebral palsy" | 3 | 3 | 0 | 0 | 0 |
| 2 | All of DSpace "Cerebral palsy" | 76 | 76 | 0 | 0 | 0 |

**Part 8. Manual searches of references from identified relevant reviews, online guidelines etc**

| No. | Article | Total citations | Title and abstract screened | Full text article reviewed | Duplicates removed manually | Full text articles retrieved |
|---|---|---|---|---|---|---|
| 1 | Blake et al. (2015) | 2 | 0 | 0 | 2 | 0 |
| 2 | Whittaker and Tomlinson (2015) | 15 | 15 | 7 | 1 | 0 |
| 3 | McLean et al. (2022) | 120 | 37 | 8 | 2 | 6 |
| 4 | Sunny Hill Health Centre for Children (2014) | 7 | 4 | 1 | 3 | 0 |
| 5 | Paleg et al. (2013) | 52 | 46 | 3 | 6 | 0 |
| 6 | Paleg et al. (2022) | 59 | 37 | 20 | 22 | 0 |