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Original Article

Evidence-based Clinical Guidelines for Optimizing the Use of Standing Frame: A Systematic Review of Dosing Recommendations Among Cerebral Palsy

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Background: Standing frames are a common intervention for children with cerebral palsy (CP), yet there is a lack of standardized dosing recommendations, impeding the enhancement of treatment outcomes in this population.

Objects: This paper aims to optimize dosing strategies for standing frame programs in children with CP. It evaluates effective durations and frequencies for using standing frames to improve gait, hip joint integrity, functional activities, joint range of motion, and muscle tone. The goal is to provide evidence-based clinical recommendations to guide practitioners in treating pediatric CP patients.

Methods: A comprehensive research was conducted across seven databases, yielding 23 studies meeting inclusion criteria. Strength of evidence was assessed using established tools. Clinical recommendations were formulated based on the amalgamation of existing evidence.

Results: The paucity of evidence-based dosing recommendations for children with CP supported standing device is highlighted in this review. Key findings suggest that standing frames implemented 5 days per week demonstrate positive effects on gait (45 minutes/day, 3 times/week), hip joint integrity (60 minutes/day), functional activities (60 minutes/day in 30° to 60° of bilateral hip abduction), joint range of motion (60 minutes/day), and muscle tone (30 minutes/day).

Conclusion: This systematic review of the treatment regimens for children with CP is providing useful insights to the dosing strategies of standing frames. The evidence supports a 30–60 minutes per day and 3–5 days a week intervention with specified durations for optimal outcomes. In enhancing the effectiveness of standing frames, as well as promoting evidence-based practices in the management of children with CP, these clinical recommendations offer guidance for practitioners.

INTRODUCTION

Cerebral palsy (CP) is a neurodevelopmental disorder characterized by motor and postural impairments, which can often lead to musculoskeletal complications such as reduced bone mineral density (BMD), contractures, hip displacement, and difficulty standing or walking [1]. Standing is thought to have benefits in addressing motor and sensory impairments after brain damage [2]. In order to enhance standing ability, diverse treatments have been utilized such as exercise therapy, drug therapy, and electric stimulation therapy [3]. Among these, standing frame therapy is a prominent exercise therapy method aimed at improving standing ability. Previous research has shown the efficacy of standing frame training in enhancing the standing ability of stroke patients [4].

In the case of children with CP exhibiting poor function, standing throughout the day is markedly constrained. Hence, the use of standing frames is often incorporated into a comprehensive care plan for children with CP. With the aim of addressing complications related to mobility and posture, as well as improving functional outcomes, standing frames are commonly used as an intervention strategy for children with CP. A previous survey on the utilization of standing frames in children with CP conducted in the UK indicated that health professionals, educational staff, and parents were committed to the use of standing frames, reporting various clinical indications and perceived benefits [5].

Over the past few decades, several studies have investigated the impact of assisted standing device on diverse aspects of health and functioning in children with disability [6]. Positive results related to BMD, hip stability, muscle strength, and gross motor function have been reported in a systematic review study conducted in children and adults. Conversely, other studies within the same review have focused on psychological aspects such as behavior and test [7].

Evidence-based clinical practice guidelines are developed by systematically reviewing the most reliable evidence and engaging an expert panel, which includes clinicians, to interpret and lead the guideline development process. These guidelines are ideally formulated in situations where there is a lack of clinical consensus and significant diversity in practice patterns [8]. Despite the growing body of literature on assisted standing devices, there remains a need for a comprehensive synthesis of existing evidence to effectively guide clinical practice regarding the optimal dosage of standing devices for children with CP. The purpose of this systematic review is to bridge this gap by providing a nuanced understanding of the diverse interventions, dosages, and outcomes reported in the existing literature. This review aims to establish evidence-based clinical recommendations for optimizing the implementation of standing frames in children with CP by systematically analyzing results from 20 selected studies, encompassing a range of interventions and methodologies.

The review will explore the potential benefits of standing frames on body structure and function, activity, and participation in children with CP. Moreover, it will address the variability in study methodologies, dosage parameters, and participant characteristics, which offer insights into the optimal dosing strategies that may yield the most favorable outcomes.

This systematic review aims to provide a comprehensive and evidence-based guide on the implementation of standing frames, fostering a more complex understanding of their effects and informing future research directions in this important area of CP rehabilitation as clinicians are still seeking effective interventions for children with CP.

MATERIALS AND METHODS

1. Study Design

In an effort to comprehensively examine the current state of research evidence on standing frames therapy for CP, a systematic review of the highest level of research evidence was conducted. Owing to their capacity to synthesize extensive amounts of evidence, systematic reviews were given priority. Reviews play a crucial role in elucidating distinctions among various studies, limiting bias, and furnishing decision support to clinicians, managers, and policy-makers based on the most robust evidence available. Nevertheless, in order to improve understanding on the existing state of the evidence, lower-level evidence was also considered.

2. Search Strategy

We conducted our review in accordance with a protocol aligned with the guidelines provided by the Cochrane Collaboration and PRISMA statements [9,10]. The literature published up to January 2023 was collected by two researchers using PubMed, MEDLINE, CINAHL, Google Scholar, Physiotherapy Evidence Database (PEDro), and Cochrane Library databases. As a search term, 'standing,' 'stander,' 'standing frames,' 'standing shell,' 'prone stander,' 'tilting table,' etc., were combined in various ways according to the characteristics of the search engine using 'AND' and 'OR,' focusing on the MeSH language called 'Cerebral palsy.' The search was confined to articles written in English. In addition, the reference lists of identified articles were reviewed, and the related articles link on PubMed was employed to identify pertinent articles. Manual searches were also carried out. The exploration of published studies took place in July and August 2023, with subsequent updates in December 2023.

3. Inclusion Criteria

The inclusion criteria consisted of articles published in peer-reviewed journals or official conference proceedings, depending on the utilized database. Language was limited to English, and the study followed the PICO strategy:

- Population: Children or adolescents diagnosed with CP aged 3 months to 19 years.
- Interventions: All forms of standing frame device utilization.
- Comparisons: Comparisons of identical groups not using a standing frame device or receiving conventional physical therapy, as well as comparisons of changes or improvements within the cohort within the groups.
- Outcomes: Measurement of body structures, body functions, activities, participation and quality of life as the main

variables.

The exclusion criteria were: (1) Research is ongoing or there are only abstracts; (2) Other types of publication, such as survey format research or editorials or letters to editors; (3) More than 10% of the study population consisted of other conditions; (4) Other types of measurement; (5) Full text is not available; (6) There are no descriptions of the standing frame device method in the text.

1) Types of studies

First, we prioritized systematic reviews. When there were numerous systematic reviews and more recent evidence superseded the findings of earlier evidence, GRADEs were assigned on the basis of the most recent high-quality evidence. We also looked for randomized controlled trials published since the last systematic review and considered new trials that could increase confidence in estimates of treatment effects. For interventions for which there were no systematic reviews, randomized controlled trials were preferentially sought, and low-quality evidence was included and assessed if no randomized controlled trials were available.

2) Types of intervention

In addition to the assessment of measurable outcomes, stud-

Table 1. Summary of findings (included studies, best available evidence levels)

Author	OCEBM Levels of Evidence	Dosage used	Participant
Gibson et al. [13]	2	1 hour/day, 5 days/week, 6 weeks	5 nonambulatory children with CP
Martinsson and Himmelmann [14]	2	30–90 minutes (60 minutes worked best), 5 times/week for 1 year	97 children with CP, 2–6 years old, GMFCS levels 3-5
Salem et al. [15]	2	45 minutes/day, 3 times/week in prone stander, 9 sessions	6 children with CP, GMFCS levels 2 and 3
Tremblay et al. [16]	2	One session, 30 minutes, tilt table with ankle dorsiflexioned	22 children with CP
Rapson et al. [17]	2	60 minutes, 5 times a week	25 children with CP, 1–12 years old, GMFCS levels 3–5
Lauruschkus et al. [18]	2	30–90 minutes, daily	20 children with CP, 5–17 years old, GMFCS levels 4 or 5
Hägglund et al. [19]	3	No dosing information provided in this study	212 children followed until 9–16 years of age
Noronha et al. [20]	3	One session	10 children with spastic diplegic CP
Rauf et al. [21]	3	24 hours positioning in specific seats, night positioning and standing frames for 6 months	74 children with quadriplegic CP aged 3 to 8 years
Martinsson and Himmelmann [22]	3	10 hours/week, every week, for 8 months to 7 years	269 children with CP were studied for more than 7 years in 2 case-control groups, GMFCS levels 4 or 5
Gudjonsdottir and Stemmons Mercer [23]	4	30 minutes a day, 5 days a week for 8 weeks	4 children of preschool age with severe CP
Stark et al. [24]	4	Total program included 6 months	78 children with bilateral CP
Pountney et al. [25]	4	30 minutes/day, Prone standers used daily for an average	59 children with bilateral CP
Pountney et al. [26]	4	3 years of daily use of prone stander	39 children with bilateral CP
Dalén et al. [27]	4	40 minutes/day (range 4–164 minutes/day)	11 boys and 7 girls, median age 10.5 years, with severe CP
Wilmshurst et al. [28]	4	Regularly weight bearing in a frame	9 girls and 18 boys with CP aged 5 to 14 years
Miedaner and Finuf [29]	4	1 session	12children, 17 to 58 months of age, with a diagnosis of spastic quadriplegia or diplegia
Rivi E et al. [30]	4	30–60 minutes of verticalization per day for 5 days a week	1 child with quadriplegia, GMFCS level 5
Goodwin et al. [31]	4	30–60 minutes, 3 times a week on average	12 young people with CP
Barbier et al. [32]	4	Standing frame for an average of 30 minutes/day	24 children with severe CP, GMFCS levels 4 and 5
Macias [33]	5	55°–70° of abduction, 45 minutes a day at home until the age of 5	14 children with diagnosis of CP, spastic diplegia
Rauch [34]	5	Standing frame with whole-body vibration, twice per week over a 6-month period	4 children with CP
Ruys [35]	5	Long leg abduction brace when standing on a prone board, 20 minutes/day	1 boy 12 years of age with hypotonic athetosis and severe acetabular dysplasia

OCEBM, Oxford Centre for Evidence-Based Medicine; CP, cerebral palsy; GMFCS, gross motor function classification system.

ies included research where a clinically warranted all form of standing frame device such as standing frame, prone stander, or tilting table intervention was employed.

3) Types of participants

Participants had to be children or adolescents diagnosed with CP and aged 3 months to 19 years at the start of the program. The study was excluded if more than 10% of the study population consisted of other conditions or exceeded the age limits, and the data could not be separated.

4. Screening, Selection, and Data Extraction

Papers found in all databases were reviewed and independently reviewed by two reviewers. Duplicate papers from the first screening were removed. The two reviewers then screened the titles and abstracts to select eligible papers. The paper was then read in full.

Data from papers read in full were extracted by two reviewers. The following were reviewed in the abstract: population, age, assisted standing device type (intervention), outcome measures, and follow-up. The data extracted from each study were summarized in the results section. Each study was also assigned a level of evidence using the Oxford Centre for Evidence-Based Medicine (OCEBM) levels of evidence in a tabular form (Table 1). This rating system provides a standardized approach to assessing the strength of evidence by categorizing it according to the type of study design and the level of rigor of the study methodology. The following is the hierarchy for assessing treatment benefits, from higher to lower levels of evidence: level 1, a systematic review of randomized trials or n-of-1 trials; level 2, a randomized trial or observational study with dramatic effect; level 3, a non-randomized controlled cohort/ follow-up study; level 4, a case series, case–control study, or a historically controlled study; and level 5, mechanism-based reasoning [11].

5. Assessment of Methodological Quality and Risk of Bias

Level 2 studies were also included in our analysis. To assess the methodological quality and risk of bias in the selected randomized clinical trials, we utilized the PEDro scale. This scale evaluates aspects such as sample selection, randomization procedures, blinding of participants and therapists, initial group homogeneity, and statistical analysis methods including intention-to-treat analysis and comparisons. A maximum score of 10 points is possible on the PEDro scale, with trials scoring above 6 points considered to be of high methodological quality [12].

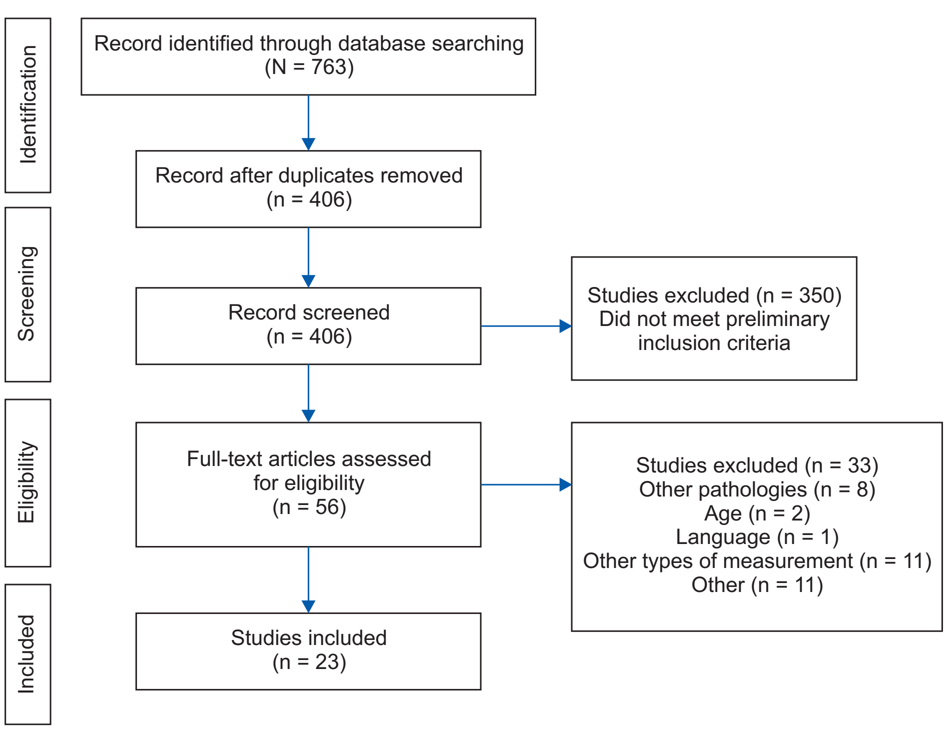

Figure 1. Flow chart of study selection.

6. Ethics and Registration

This systematic review was not formally registered. Since there was no direct interaction with individuals, ethical approval was not required, and the study proceeded without such requirements.

RESULTS

A total of 763 potentially relevant studies were found during the database screening. After removing duplicates, 406 studies qualified for analysis. After reviewing the abstracts, 350 were excluded based on the following preliminary inclusion criteria: (1) written in English, (2) published in a peer-reviewed journal, and (3) included participants ranging from three months through 19 years with CP. In addition, 56 accepted for full-text analysis. Finally, the total sample that was selected following the inclusion and exclusion criteria included 23 (Figure 1).

By using the OCEBM Levels of Evidence, systematic review results (evidence) and clinical dosing recommendations were organized and reported. The quality of the studies (level 2) was assessed using the PEDro scale [12]. In our review, four articles in the sample showed high quality with 6–8 points. However, the other two articles demonstrated a low methodological quality with scores of 5 points. In Table 2, the PEDro Scale assessment of the six selected articles is presented.

1. Level 1 Studies

There were no reportable level 1 studies.

2. Level 2 Studies

1) The study, conducted by Gibson et al. [13], employed a one-group quasi-experimental design with five non-ambulant children (aged 6–9 years) with CP, which aimed to evaluate the effects of a 6-week standing frame program on hamstring length and activities of daily living (ADLs) ease. As revealed in the results, there was a significant increase in hamstring length during standing phases, and a trend of hamstring shortening during non-standing phases was observed. Achieving high compliance (85% of intended sessions), the study indicated caregiver feedback suggesting slight improvements in the ease of performing ADLs after the use of standing frame. This provides preliminary evidence that the 6-week standing frame intervention investigated by Gibson et al. [13] had a favorable effect on hamstring length and potentially improved the ease of performing ADLs in non-ambulant children with CP.

2) Martinsson and Himmelmann [14]'s study sought to determine how daily, straddled weight-bearing over one year affected hip migration percentage (MP) and muscle length in non-ambulatory children with CP. Participants engaged in upright standing with maximum tolerated hip abduction and hip and knee extension for 1/2 to 1.5 hours daily for a year. Controls, matched for age, motor ability, and surgery, were selected from a national CP follow-up program. It has been shown in the results that participants using straddled weight-bearing following surgery experienced the most significant decrease in MP, while those using it for at least 1 hour daily for prevention also showed improvement. In particular, hip and knee contractures were only observed in the control group. Based on the research conducted by Martinsson and Himmelmann [14], one hour of

Table 2. Assessment of methodological quality using the PEDro scale

	Tremblay et al. [16]	Gibson et al. [13]	Salem et al. [15]	Martinsson and Himmelmann [14]	Rapson et al. [17]	Lauruschkus et al. [18]
Randomization of participants	Y	N	N	N	Y	Y
Concealed allocation	Y	N	Y	N	Y	Y
Groups similar at baseline	Y	Y	Y	Y	Y	Y
Blinding of participants	N	N	N	N	N	N
Blinding of therapists	N	N	N	N	N	N
Blinding of assessors	N	N	N	N	Y	NA
More than 85% follow-up of participants in at least one of key outcomes	Y	Y	Y	Y	Y	Y
Intention to treat analysis	N	Y	Y	Y	Y	N
Statistical comparisons between group	Y	Y	Y	Y	Y	Y
Point estimate of at least one of the key outcomes	Y	Y	Y	Y	Y	Y
Total score	6/10	5/10	6/10	5/10	8/10	6/10

PEDro, Physiotherapy Evidence Database; Y, yes; N, no; NA, not applicable.

straddled weight-bearing may reduce MP after certain surgeries or prevent its increase, which can preserve muscle length in children with CP not requiring surgery.

3) Examining the study conducted by Salem et al. [15], the objective of this study was to assess the impact of prolonged standing on gait characteristics in children with CP. Included in the study were six children, with an average age of 6.5 years and diagnosed with spastic CP. A repeated baseline design (A-B-A) was implemented over a 9-week duration. The findings indicate that the gait patterns of children with CP, specifically those classified as level 2 or 3 on the gross motor function classification system (GMFCS), showed improvement with the implementation of a prolonged standing program. However, these enhancements were not sustained beyond the 3-week mark. An increase in the peak dorsiflexion angle during midstance when standing was the main finding of the study.

4) The study on the short-term effects of a single session of prolonged muscle stretch (PMS) on reflex and voluntary muscle activations in 22 children with spastic CP was conducted by conducted by Tremblay et al. [16]. The participants were divided into an experimental group, which underwent PMS of the triceps surae, and a control group. The PMS procedure involved standing with dorsiflexed feet on a tilt table for 30 minutes. A reduction in spasticity in ankle muscles was indicated in the result, as evidenced by significant decreases in neuromuscular responses to passive movement persisting for up to 35 minutes after the PMS session. Moreover, there was a notable increase in the voluntary activation of plantar flexors post-PMS, which suggests potential benefits for managing spasticity in children with CP through repeated PMS sessions.

5) As suggested in the study by Rapson et al. [17], conducting an RCT (randomized controlled trials) to evaluate the impact of standing duration on hip migration in children with CP is feasible with modifications to the protocol. The recommended dose for the intervention group is 60 minutes, 5 times a week, versus 30 minutes, 3 times a week for the control group over 12 months. The study found mean daily standing times of 49 minutes (Monday to Sunday) and 58.1 minutes (weekdays) in the intervention group. Secondary clinical outcomes were available for 90% of the children who completed the trial, although recruitment and retention problems persisted. Interestingly, there were three adverse events unrelated to standing.

6) Dynamic and static standing in non-ambulant children with CP were compared in the study by Lauruschkus et al. [18]. Twenty participants underwent four months of each intervention in a randomized controlled study with a cross-over design. Using the caregiver priorities and child health index of life with disabilities, quality of life was assessed, and through questionnaires, additional information on quality of life and cost-effectiveness were gathered. Dynamic standing was preferred by families, being both cost-effective (€64 savings, $p < 0.01$) and more beneficial. However, from the perspectives of the society and healthcare provider, while dynamic standing had benefits, it incurred higher costs than static standing (€290 and €354 respectively, $p < 0.01$). These results suggest the potential for individualized standing recommendations based on preferences and cost considerations.

3. Level 3 Studies

1) Hägglund et al. [19] conducted a study that aimed to analyze characteristics of hip displacement in children with CP to optimize a hip surveillance program. Among 212 children followed until 9–16 years of age, 18% of them developed displacement with MP > 40%, and 9% had MP between 33 and 39%. Hip displacement often occurred at 2–3 years, with some cases showing MP > 40% by age 2. At initial registration, passive hip motion did not significantly differ from hips without displacement. Risk varied by CP subtype, from 0% in pure ataxia to 79% in spastic tetraplegia. Risk (MP > 40%) correlated with gross motor function (GMFCS) from 0% in GMFCS level 1 to 64% in GMFCS level 5. For children with CP, early identification and radiographic examination are crucial, and a hip surveillance program based on age and GMFCS level is recommended. The primary discovery of the study is that no child at GMFCS level 1 developed a hip MP exceeding 40%, whereas 18 out of the 28 children at GMFCS level 5 did.

2) The impact of positioning (sitting and prone standing) on the hand function of 10 boys with spastic diplegic CP was examined by Noronha et al. [20]. Using the Jebsen-Taylor Hand Function Test, there were no significant differences found in the total scores between sitting and prone standing or between two test sessions. However, when the results from the two tests were combined, subjects performed significantly faster in a prone standing position during the simulated feeding subtest, while they performed faster in a sitting position during the picking up of small objects subtest. Overall, except for the simulated feeding subtest, the subjects exhibited mature and tailored grasp quality during upper extremity tasks. Consider-

ations for analyzing positioning in relation to upper extremity tasks are presented in this paper.

3) Rauf et al. [21] investigated the impact of sitting and prone standing positions on the hand function of 10 boys with spastic diplegic CP (mean age = 12.5 years). Using the Jebsen-Taylor Hand Function Test and a modified scale from Hohlstein, there were no significant differences were in total scores between the two groups or between Tests 1 and 2, as well as between sitting and prone standing. When the results from the two tests were combined, notable differences were found: subjects performed faster in a prone standing position during the simulated feeding subtest and faster in a sitting position during the picking up of small objects subtest. The subjects exhibited mature and tailored grasp quality, except for the simulated feeding subtest. This paper provides considerations for analyzing positioning concerning upper extremity tasks.

4) The study conducted by Martinsson and Himmelmann [22] aimed to assess the long-term effects of abducted standing on hip MP and hip/knee motion range in children with CP over 7 years. The study compared two case–control groups, one with adductor-psoas tenotomy and one without. Participants performing 15° to 30° of abducted standing exhibited decreased MP. Standing abduction at 15° to 30° for 10 hour/week reduces MP and preserves range of motion for up to 7 years. These findings provide a novel contribution to CP research.

4. Level 4 Studies

1) Alertness in four children with CP was measured using a traditional stander and an experimental rocking stander in the study by Gudjonsdottir and Stemmons Mercer [23]. There was a slight trend toward increased alertness when using the stander with side-to-side rocking motion, while there was no significant change noted between the two conditions.

2) The impact of a novel physiotherapy concept on bone density, muscle force, and motor function in children with bilateral spastic CP was assessed by Stark et al. [24]. The retrospective analysis included 78 participants undergoing tilt table with whole-body vibration, physiotherapy, resistance training, and treadmill training in structured in-patient and home-based sessions. Significant improvements were observed after 6 months in BMD, muscle mass, upright positioning angle, muscle force, and modified gross motor function measure. These positive results suggest potential for improved functioning across various domains, encouraging the need to conduct further evidence-based research in pediatric physiotherapy considering developmental implications.

3) A retrospective study was conducted by Pountney et al. [25] investigating the relationship between postural management and hip subluxation/dislocation in children with bilateral CP. The study revealed that children who used Chailey adjustable postural support systems in lying, sitting, and standing for postural support exhibited significantly better maintenance of hip integrity than the other groups. These results emphasize the crucial role of postural management interventions in preventing hip dysplasia.

4) Another prospective cohort study, conducted by Pountney et al. [26], explored the impact of early postural management programs on hip subluxation and dislocation in children with bilateral CP. The study demonstrated that children who used recommended levels of postural equipment had significantly lower rates of hip subluxation than those who used minimal levels. Moreover, when compared to the historical control group, the intervention group exhibited a reduced frequency of hip problems and the need for treatments, including surgery or orthotic interventions. These findings highlight the importance of early provision of postural management equipment in mitigating hip issues in children with CP.

5) The relationship between standing time and bone density/hip dislocation in children with severe CP was explored in the study by Dalén et al. [27]. This study included 18 children with varying levels of spasticity. While standing time did not affect bone density overall, it was negatively associated with hip dislocation in children with higher spasticity levels. This implies that standing interventions may have an impact on hip health in children with CP, particularly those with increased spasticity.

6) In a study conducted by Wilmshurst et al. [28], 27 children with CP underwent measurements of spinal BMD and calcaneal broadband ultrasound attenuation (BUA). Based on their level of mobility, these children were categorized into four mobility groups: mobile with an abnormal gait, mobile with assistance, non-mobile but weight-bearing, and non-mobile or weight-bearing. Analysis showed significant differences in mean ± standard deviation scores for BUA among the mobility groups ($p < 0.001$), while the differences in mean spinal BMD scores were not statistically significant ($p = 0.078$).

7) The effects of therapist-recommended adaptive positioning equipment on the psychological test performance of

children with CP were investigated by Miedaner and Finuf [29]. Included in this study were 12 children, aged 17 to 58 months. Significant improvements in test scores during trials with positioning were observed in this study, suggesting a positive impact on performance. In addition, fine motor task completion improved in 67% of testing situations with positioning. These findings highlight the beneficial effects of adaptive positioning equipment in improving test performance among children with CP.

8) The effects of the use of a standing frame on spontaneous evacuation in children with CP, particularly those with quadriplegia or severe diplegia who often suffer from constipation due to reduced mobility, were investigated by Rivi et al. [30]. There is limited evidence supporting this practice, despite clinicians commonly recommending standing frames to facilitate intestinal transit in this population. The study utilized a single-subject research design involving a child with CP and quadriplegia classified as GMFCS level 5. By using daily diaries and the Bristol Stool Scale, the effects of the standing frame were monitored. It is indicated the results that while the standing frame did not significantly affect the frequency or characteristics of evacuations, it reduced the need for evacuation induction and related pain in the child. However, generalization of the findings is not possible due to the limitations of the study, including the small sample size and short duration. Further research is recommended, which includes larger sample sizes and investigation into the standing frame's impact on respiratory functions. Despite limitations, the study suggests that standing frames may positively influence the management of constipation in children with severe CP, potentially improving their quality of life.

9) Young people's experiences and attitudes toward standing frame use in the management of CP were assessed in the study conducted by Goodwin et al. [31]. There has been limited focus on the perspectives of the users themselves, despite a consensus supporting the utilization of standing frames for non-ambulant individuals with CP. Through semistructured interviews involving 12 participants, the research uncovers a range of viewpoints on standing frames. While some participants endure discomfort in exchange for perceived benefits, others express feelings of social exclusion. Issues with manual handling and aesthetics were the challenges identified. Although benefits have been reported, such as pain relief and increased participation, the use of standing frames may also result in discomfort and decreased independence. The study highlights the importance of healthcare professionals engaging in open discussions with regard to the potential benefits and challenges of standing frame use, considering all aspects of young people's lives.

10) The bone health of children with severe CP who used a static standing frame was compared to those who do not use, in the study conducted by Barbier et al. [32]. The findings indicated that children who used the standing frame had higher bone mineral content, particularly in the lumbar spine, and lower levels of bone resorption factors compared to those who did not use the frame. These results suggest that standing practice could potentially improve bone mineralization and decrease bone resorption in non-ambulant children with CP. However, more study is required to examine the long-term effects of standing practice on bone health and explore additional bone remodeling factors.

5. Level 5 Studies

1) Macias [33] conducted a study on children with spastic diplegia to assess the long-term benefits of using a standing device in abduction. Preserved hip adductor muscle range of motion, widened base of support, and maintained normal hip development indicators at age 5 were observed in this study. Overall, weight-bearing with abduction had positive effects on hip development and muscle alignment for functional gait.

2) There is a growing trend in using whole-body vibration training for muscle strengthening in clinical settings, according to the study by Rauch [34]. This method entails static or dynamic standing on a vibration device, which is thought to stimulate muscle contractions. Longer-term studies target improving muscle strength, balance, and bone mass. Improvements in standing function, BMD, bone mass, and calf muscle size following vibration treatment were observed in a small pilot trial involving children.

3) The application of a trochanteric girdle in managing a case of acetabular dysplasia to prevent hip displacement during weight-bearing activities was discussed the article by Ruys [35]. The patient in question was a 12-year-old boy diagnosed with hypotonic athetosis and severe acetabular dysplasia, which resulted in lateral hip dislocation upon slight adduction beyond neutral position. In addition, the patient's hips had proximal subluxation with only 20° of abduction during weight-bearing or joint compression. The patient had been

previously using a long leg abduction brace while standing on a prone board for several years. This standing program was implemented to provide an alternative upright position to wheelchair sitting as well as to stretch hip flexor and hamstring muscles, strengthen back and neck extensor muscles, and facilitate head control and hand function, and improved digestion and elimination.

DISCUSSION

Different levels of evidence-based research have supported the integration of standing devices in the comprehensive management of children with CP, as they significantly influence BMD, range of motion in the lower extremities, hip mechanics, and spasticity. In the study by Gibson et al. [13], positive benefits of 60 minutes of standing frame program per day on hamstring length and ease of performing ADLs were seen in non-ambulant children with CP. Martinsson and Himmelmann [14] demonstrated that straddled weight-bearing following surgery resulted in the most substantial decrease in hip MP. Children who engaged in straddled weight-bearing for at least one hour per day as a preventive measure also exhibited significant improvement. In the study by Salem et al. [15], positive results were observed on peak dorsiflexion angle during midstance with 45 minutes of supported standing device per day, 3 times a week, 9 sessions.

This systematic review emphasizes the medical effectiveness of standing devices in managing children with CP. However, further research and discussion are required. Some authors suggest that hip and knee joint range of motion may contribute walking ability in children with CP, while improving joint range of motion has not shown to ameliorate activity or participation [36]. In such cases, particularly for children with CP who have experienced a previous pathologic gait pattern, the use of a standing frames device may be recommended due to the high risk of musculoskeletal problems [37].

Even in light of the lingering questions from this systematic review, we strongly recommend the use of standing frames as an essential component of a comprehensive postural care program for children with CP who struggle challenges in maintaining a standing and have restricted or no walking ability. Physical therapists advocating for a postural management plan should incorporate both stander position and active elements. The stander position element involves the use of standers in prone, supine, and standing positions, while the active element involves encouraging the child to engage in standing employing his own physical ability or merging apparatus that facilitate motion and weight-shifting exercises.

According to recent research, physically inactive children with CP may benefit from supported standing sessions five days a week under specific conditions, including durations of 45 minutes per day, 3 times a week for improving gait, 60 minutes with hips abducted 30°–60° for improving functional activities, 60 minutes per day, 5 times a week for increasing joint range of motion, and 30 minutes for minimizing muscle stiffness. Further research is needed in order to define the minimum and optimal doses for desired outcomes in specific CP populations.

Limitations of this current review include several factors:

- Lack of dosing literature for children with CP: Our review found a lack of literature specifically addressing dosing recommendations for the population of children with CP, limiting the depth of analysis in this area.
- Insufficient higher-level evidence: Robust higher-level evidence is lacking to derive potential dosing recommendations applicable to all CP populations, which indicates a need for more comprehensive research in this area.
- Author subjectivity: The review acknowledged the potential influence of authors' subjective judgment in selecting search and classification parameters, interpreting the literature, and making specific clinical recommendations and comments, which could introduce bias into the review process.

These limitations highlight the importance of conducting further research to fill the gaps in the literature and enhance the reliability and applicability of recommended dosing for using supported standing devices in children with CP. From this review of studies, it is evident that the dosage of supported standing device use in children with CP remains unclear. In order to gain a clearer understanding of the potential benefits of assisted standing device and to identify specific groups of children with CP who may benefit the most from it, it is necessary to conduct larger-scale research. This research should include randomization, tighter controls on the duration and angle of standing, and restrictions on simultaneous interventions.

CONCLUSIONS

This systematic review of treatment regimens for children with CP offers valuable insights into dosing strategies for standing frames. The evidence supports interventions of 30–60 minutes per day, 3–5 days a week, with specified durations for optimal outcomes. By enhancing the effectiveness of standing frames and promoting evidence-based practices in managing children with CP, these clinical recommendations provide guidance for practitioners.

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CONFLICTS OF INTEREST

No potential conflicts of interest relevant to this article are reported.

AUTHOR CONTRIBUTION

Conceptualization: CK, HP. Data curation: CK, HP. Formal analysis: CK, HP. Investigation: CK, HP. Methodology: CK, HP. Project administration: CK, HP. Resources: CK, HP. Software: CK, HP. Supervision: CK, HP. Validation: CK, HP. Visualization: CK, HP. Writing – original draft: CK, HP. Writing – review & editing: CK, HP.

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