

Effects of Postural Management on Hip Migration in Children With Cerebral Palsy: A Systematic Review

Christiaan Gmelig Meyling, PPT, MSc; Marjolijn Ketelaar, PhD; Marie-Anne Kuijper, MD; Jeanine Voorman, MD, PhD; Annemieke I. Buizer, MD, PhD

De Hoogstraat Rehabilitation (Mr Gmelig Meyling and Drs Kuijper and Ketelaar), Utrecht, the Netherlands; Center of Excellence in Rehabilitation Medicine (Drs Ketelaar and Voorman), Brain Center Rudolf Magnus, University Medical Center Utrecht and De Hoogstraat Rehabilitation, Utrecht, the Netherlands; Department of Rehabilitation, Physical Therapy Science and Sports (Dr Voorman), University Medical Center Utrecht, Wilhelmina Children's Hospital, the Netherlands; Department of Rehabilitation Medicine (Dr Buizer), Research Institute MOVE, VU University Medical Center, Amsterdam, the Netherlands

Purpose: To review the existing literature on the effects of postural management on hip migration in children with cerebral palsy.

Methods: A systematic literature search was performed using 5 databases. Quality of articles was assessed and study designs were appraised according to the American Academy of Cerebral Palsy and Developmental Medicine Systematic Review Method.

Results: Eight of 655 identified studies were included, reporting postural management in children with cerebral palsy. Seven of 8 studies reported positive effects on hip migration after postural management interventions. However, level of evidence and quality of the articles were low.

Conclusion: The evidence for postural management to prevent or reduce hip migration in children with cerebral palsy is limited by the lack of high-quality studies. Strong recommendations for clinical practice are not possible. Future high-quality research is crucial to improve our understanding of the effects of postural management to prevent hip migration in children with cerebral palsy. (*Pediatr Phys Ther* 2018;30:82–91)

Key words: cerebral palsy, dislocation, hip migration, postural management, review

INTRODUCTION

Hip migration is a common problem in children with cerebral palsy (CP), which ultimately can lead to hip dislocation.¹ This can have a negative influence on range of motion, motor abilities, and personal care and can be associated with pain.^{2,3}

Children with CP typically are born with normal anatomic hip alignment. During growth, hip development may be affected

due to a combination of variables. Lack of weight bearing in combination with muscle imbalance and spasticity has often been cited as the main contributor to hip migration.^{2,4,5} The age when a child pulls to stand was found to be the most important factor in hip migration.⁵ Children who were able to stand by the age of 3 years showed better hip development than children who achieved this by 7 years and 6 months or who never pulled to stand. Another variable related to hip migration is imbalance in muscle tone, with strong hip flexors and adductors opposing weaker hip extensors and abductors.⁴ This can lead to disruption of the femoral head contact with the acetabulum, causing decreased range of motion, bone deformities such as coxa valga, femoral anteversion, and acetabular dysplasia, and consequent hip migration.

The risk of hip displacement is related to the level of gross motor function.^{1,2,6} The severity of gross motor problems in children with CP can be classified with the Gross Motor Function Classification System (GMFCS).⁷ Children in levels I and II can walk without support, children in level III are expected to learn to walk with a mobility aid, whereas children in levels IV and V cannot walk without support. According to a population-based study, the incidence of hip displacement is 0% for children with GMFCS level I and 45% and 72%, respectively, for those with GMFCS levels IV and V.⁶ The risk of hip displacement is highest at 2 to 3 years of age.⁸ The expected increase in

0898-5669/110/3002-0082

Pediatric Physical Therapy

Copyright © 2018 Academy of Pediatric Physical Therapy of the American Physical Therapy Association

Correspondence: Christiaan Gmelig Meyling, PPT, MSc, De Hoogstraat Rehabilitation, Rembrandtkade 10, 3583TM Utrecht, the Netherlands (c.g.meyling@dehoogstraat.nl).

Grant Support: Christiaan Gmelig Meyling received an educational grant from De Hoogstraat Rehabilitation Scientific Research Fund.

Supplemental digital content is available for this article. Direct URL citation appears in the printed text and is provided in the HTML and PDF versions of this article on the journal's Web site (www.pedpt.com).

The authors declare no conflicts of interest.

DOI: 10.1097/PEP.0000000000000488

the migration percentage (MP) in children in GMFCS level V is 7% to 10% per year.^{6,9}

Hip migration and the risk for developing hip dislocation can be measured by anterior-posterior pelvic radiographs. In these radiographs, the measurement of the MP, as described by Reimers⁹ and Scrutton⁵ is the most accurate and effective index.^{10,11} MP determines by how much the femoral head is displaced laterally and is done by calculating the percentage of the femoral head area that is not covered by the acetabulum, as observed in an anterior-posterior pelvic radiograph ((AC/AB) × 100) (Figure 1). Definitions of hip migration are shown in Table 1.²

In the Swedish follow-up surveillance program for CP, CPUP, Hägglund et al¹⁰ also used levels of MP as threshold for hip screening and intervention. They recommended MP 33% or more as a threshold for reaction or intensified observation. Hips with MP 40% or more have a high risk for further displacement, indicating the need for surgical intervention. In children with MP 33% to 40%, treatment should be based on other clinical signs and the progression of MP over time, which should be evaluated with repeated examinations analyzed by the same examiner.¹⁰

However, the content of the recommendation in case of MP 33% to 40% is not clearly described by Hägglund et al.¹⁰ There are also no clear recommendations for preventive intervention in children with MP 33% or less. In clinical practice, many questions remain about the evidence for interventions in progressive hip migration, especially for those children with MP 40% or less.

Conservative approaches to the management of hip migration have become popular over the last decade, particularly the use of postural management programs.¹¹ We define postural management as all nonsurgical approaches such as postural management equipment (eg, standing devices or lying system), orthoses, or individual physical therapy sessions. Clinicians question whether postural management plays a role in preventing or reducing hip migration. Increased care demands, pain, and discomfort may be associated with postural management, which may have adverse effects on the ability of the family to enhance the activity and participation of the child.¹² Until now it is not clear whether the positive effects justify the efforts.

A MacKeith Multidisciplinary Meeting in 2006 formulated a consensus statement concerning postural management.¹³ Postural management was defined as “a planned approach encompassing all activities and interventions which impact on an

TABLE 1	
Migration Percentage Definitions ^a	
Migration, %	Definition and Progression
0-10	Normal
11-30	Mild subluxation; progression uncertain
31-60	Moderate subluxation; progression probable
61-90	Severe subluxation; progression certain
>90	Dislocated

^aReproduced with permission from Connelly et al.²

individual's posture and function.” Postural management programs aim to increase children's comfort and may reduce deformity. Programs are individualized for each child and may include special seating, night-time support, standing supports, active exercise, orthotics, surgical interventions, and individual therapy sessions.”^{13(p244)} The statement recommends individually-tailored postural management programs based on individual circumstances, guided by the GMFCS level. Children in GMFCS level III require postural management programs that emphasize postural activity from an early age. Intervention to prevent deformity is provided as an integrated approach between postural management equipment, activity, and surgery. Children in GMFCS levels IV and V should start 24-hour postural management programs in lying as soon as appropriate after birth, in sitting from 6 months, and in standing from 12 months.¹³

The recommendations are based on few available studies of low quality. Following the final conclusion of the consensus statement, more evidence for the effectiveness of intervention is necessary to reach a unified approach in managing hip migration in children with CP. Ten years later, several studies have been conducted on the effect of postural management to manage hip migration in children with CP. A recent systematic review evaluated the quality of evidence for methods to prevent hip dislocation in CP.¹⁴ These included interventions such as botulinum neurotoxin A, intrathecal baclofen and obturator nerve block, bracing, complementary and alternative medicine, selective dorsal rhizotomy, and postural management. The authors concluded that the evidence was insufficient to support or refute the use of identified interventions to prevent hip displacement in children with CP. Because of the more general focus of this review, specific details concerning postural management were not reported. Therefore, a more in-depth evaluation of the evidence of postural management in CP is still needed. This systematic review focuses specifically on the evidence of postural management for reduction or prevention of hip migration in children with CP. We connect previous recommendations in the literature and consensus statements with our findings, leading to implications for clinical practice and future research.

METHODS

This systematic review was conducted according the principles of American Academy of Cerebral Palsy and Developmental Medicine (AACPDM) methods for developing systematic reviews of treatment interventions and Preferred Reporting

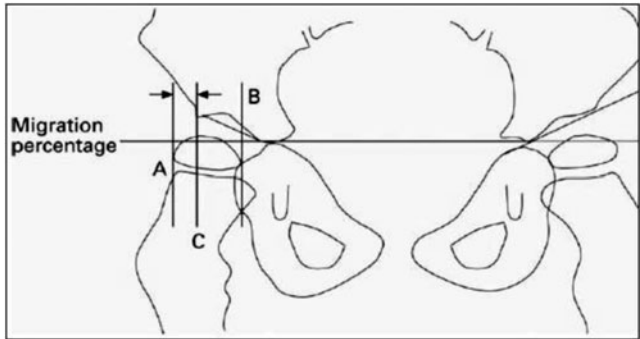


Fig. 1. Measurement of the migration percentage: migration percentage = AC/AB × 100.

Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.^{15,16}

A systematic literature search was performed June 2016 in 5 databases (PubMed, EMBASE, Cochrane, CINAHL, and PEDro). No limits were placed on publication date or article type. Screening of title and abstract of identified articles was done by 1 author (C.G.M.). The reference lists of articles that were not excluded based on title and abstract were screened for potential relevant articles. This has led to a selection of potentially relevant articles based on title and abstract. These articles were screened full-text and selected for inclusion by 3 pairs of reviewers.

Consensus on the final inclusion of the articles was reached after a consensus meeting with all coauthors. Supplemental Digital Content 1 (available at: <http://links.lww.com/PPT/A210>) includes search terms by database.

Inclusion and Exclusion Criteria

Articles were included if (1) study participants were children diagnosed with CP and (2) they were between 0 and 18 years of age and (3) study focused on postural management to reduce or prevent hip migration and (4) study measured MP as an outcome. Articles were excluded if (1) they focused on surgical or pharmacological interventions or (2) the full-text article was not in English. Articles that reported on the effects of a combination of surgical and conservative treatment were excluded if (1) surgical intervention took place within 6 months prior to study entry for postural management or (2) effects of surgical and conservative interventions could not be distinguished in the study results. Because of the focus on postural management in terms of interventions in this review, botulinum neurotoxin A was excluded.

Data Extraction and Quality Rating

Three pairs of reviewers (with 1 reviewer as the constant in all pairs) completed quality rating and data extraction. They independently coded the level of evidence (LoE) and extracted subject and descriptive data according to the criteria from the AACPDM Systematic Review Methodology.¹⁶ Study validity was appraised using 17 questions¹⁷ based on a combination of Sackett et al,¹⁸ PEDro,¹⁹ AACPDM Systematic Review Methodology,¹⁶ and Feters and Tilson²⁰ (Supplemental Digital Content 2, available at <http://links.lww.com/PPT/A211>). We did not use a cutoff point for quality because this assessment only gives an impression of the methodological quality of included articles.

Data extraction was completed by using a standard table with predetermined categories (Table 2). Other outcome measures, in addition to MP, that were related to the aim of the review were arranged according to the International Classification of Function, Disability and Health for Children and Youth (ICF-CY, Table 3).²¹ The results of this review were presented in order of level of evidence.

RESULTS

A total of 655 articles were identified (Figure 2). After removing duplicates, 521 articles were screened by title and

abstract. A total of 495 articles were excluded and the remaining 26 articles were screened by full text. A further 18 articles were excluded according to the inclusion and exclusion criteria. The remaining 8 articles were included and reviewed.

Table 2 includes the characteristics of the 8 included studies. None of the studies was rated as evidence level I or II studies. Of the 8 studies, 3 were level III studies (cohort with concurrent controls), 4 were level IV studies (cohort without concurrent controls), and 1 was a level V study (case report). Table 3 includes an overview of results and outcomes of the included studies.

Level III Studies^{22–24}

Quality of included level III studies varied between 9 and 12 of a total of 17 points (see Supplemental Digital Content 3, available at: <http://links.lww.com/PPT/A212>). Picciolini et al²⁴ reported a significant difference between treatment (*siège moulé* postural program and neurodevelopmental therapy [NDT]) and control groups (NDT) after 2 years of intervention, with stability of MP in the treatment group and marked worsening of MP in controls. In the study of Macias-Merlo et al,²² the MP of the study group (daily standing in abduction) remained stable in comparison to children who did not stand in abduction. The differences between the groups were statistically significant.²² The effect of standing as a preventive intervention and after bilateral adductor-iliopsoas-tenotomy was reported by Martinsson and Himmelmann.²³ In this study we report the preventive groups: standing in abduction (study group 2) versus standing without abduction (control group 2). A significant reduction of MP was found for those who used standing in abduction as prevention for 1 hour a day or more when corrected for GMFCS levels.²³

Level IV Studies^{11,25–27}

Quality of included level IV studies varied between 4 and 8 of the 17 points (see Supplemental Digital Content 3, available at: <http://links.lww.com/PPT/A212>). Pountney et al^{11,27} reported postural management programs in lying, sitting, and standing (Chailey Adjustable Postural Support). The 2009 study reported that children who used a 24-hour postural management approach had significantly less chance of both hips being subluxated than those using equipment at minimal levels. There were no significant differences in MP between the historical controls and the intervention groups at 5 years of age.¹¹ The study of 2002 reported that children using the 24-hour postural management approach maintained significantly more hip integrity than children who used the equipment less intensely.²⁷ The effects of daily static weight bearing in a standing shell on hip dislocation were conveyed by Dalén et al.²⁵ In this study, standing time had a significant and negative association with hip migration in children with spastic CP. Hankinson and Morton²⁶ reported the effect of daily use of a lying hip abduction system on hip migration. They reported a significant improvement of MP in comparison to the baseline period, but only for 1 side.²⁶

Level V Study²⁸

The score for quality of this study was 4 out of the 17 points (see Supplemental Digital Content 3, available at:

TABLE 2
Characteristics of Studies

Study	Level	Design	Appraisal Score	GMFCS	Age at Start Intervention	Inclusion Criteria Related to Intervention ^a	Study Duration	Intervention	n	Dose	Control	n	Dose
Picciolini et al ²⁴	III	Cohort study with concurrent controls	12/17	III-IV-V	3.5 y (SD = 2.5)	Children with bilateral CP without previous surgery or spasticity treatment in previous 6 mo ^b	2 y	Siège moulé and NDT	32	Siège moulé: 5h/d NDT: 45 min 2 times/wk	NDT	22	45 min 2 times/wk
Macias-Merlo et al ²²	III	Cohort study with concurrent control group	9/17	III	12-14 mo	Spastic CP who had not attained independent walking by 12-14 mo of age, who demonstrated decreased weight bearing and who showed muscle imbalance at the hip with tendency toward increased hip adduction	From start intervention at 12-14 mo until 5 y	Stander in 60-65° abduction	13	70-90 min/d until 5-y old Professional: 4-6 wk visits + weekly PT	Standard care	13	Weekly 3 times PT
Martinsson and Himmelmann ²³	III	Cohort study with concurrent controls	9/17	III-IV-V	Mean 3.6 y (range 1.3-6.0 y)	Nonambulatory children with CP (GMFCS III-V) "as they are those with increased risk for hip dislocation"	1 y	SG2: straddled (= standing in upright in maximum-tolerated hip abduction)	11	Subscribed: 1-5 h standing per day in 1-3 daily sessions Real time: 0.5-1.5 h/d	CG2: standing without abduction (no details reported)	63	Not reported
Pountney et al ¹¹	IV	Prospective cohort study with historical controls	8/17	III-IV-IV	≤18 mo	≤18 mo "because, at this stage, differences in hip development become statistically apparent and allowed time for postural management to be effective," and children not walking independently by 5 y of age ^b	From start intervention at 18 mo until 5 y	Postural management in lying, sitting and standing (CAPS)	39	Recommended use: lying at night + seating ≈6 h/d + standing 1 h/d Moderate use: 2 items ≥6 h/d Minimal use: 1 item or ≤6 h/d	Standard care with respect to other interventions (surgery and hip orthoses)	202	Not standardized
Dalén et al ²⁵	IV	Cohort study without concurrent control group	6/17	IV/V	3-18 y	Children with severe CP who had been prescribed and used a standing shell ^b	Unknown	Standing shell	18	Mean 40 min/d (range 4-164 min/d)	—	—	—

(continues)

TABLE 2
Characteristics of Studies (Continued)

Study	Level	Design	Appraisal Score	GMFCS	Age at Start Intervention	Inclusion Criteria Related to Intervention ^a	Study Duration	Intervention	n	Dose	Control	n	Dose
Hankinson and Morton ²⁶	IV	Case series	4/17	Unknown	Mean 9.2 y (4-14 y)	Spastic quadriplegia or diplegia who had been unable to stand with support by age of 3 y; tight hip adductors (<30°), and/or significant hip migration over 20%. In order to use those with more established sleep routines, they chose children older than 4 y ^b	18 mo (of which 12-mo intervention)	Jenx Dreama lying hip abduction system 20° abduction	11	12 months daily use lying system at night (9-9.4 h/night) Professional: 2 visits (range 2-4), 4 phone calls (range 1-17)	-	-	-
Pountney et al ²⁷	IV	Cohort study without concurrent controls	4/17	unknown	5 mo to 9.8 y	Children with bilateral CP who had used postural management equipment for a minimum of 2 y ^b	Mean review period: 7 y (1.9-16.9 y)	Postural management in lying, sitting and standing (CAPS)	59	All CAPS: 24 h lying, sitting, standing 2 CAPS: 2 items No CAPS: CAPS seat only and/or other postural support	-	-	-
Picciolini et al ²⁸	V	Case report	3/17	Unknown	Case 1: 2.5 y Case 2: 7 y	Clinical and radiological evidence of hip subluxation but unresponsive to pharmacological and surgical treatment ^b	Case 1: 2-5 y Case 2: 3 y	Siège moule and gouttière	2	Case 1: 5 h/d Siège moule Case 2: Siège moule and gouttière (dose not described)	-	-	-

Abbreviations: CAPS, Chailey Adjustable Support; CG, control group; CP, cerebral palsy; GMFCS, Gross Motor Function Classification System; NDI, Neurodevelopmental treatment; PT, physical therapy; SD, standard deviation; SG, study group.

^aDescription/citation of authors in the original article.

^bReason why the intervention was prescribed specifically for these children was not reported.

TABLE 3
Results and Outcome

Outcome Measures					Statistics	Results	Adverse Events
Study	Body Structure and Function	Activity/Participation	Contextual	Time Points			
Picciolini et al ²⁴	Migration percentage	–	Length of time of use (questionnaire)	Baseline (T0), after 1 y (T1), after 2 y (T2)	Wilcoxon matched-pairs signed-ranks test and Mann-Whitney 2-sample test for continuous variables over time in treatment groups McNemar χ^2 test and χ^2 test for comparison of categorical variables Multiple GEE models for influence of treatment on MP while taking into account the within-subject correlation including Wald test for interaction terms between time and treatment (and other covariates)	Treatment group—no change in worst hip after 2-y intervention ($P = .24$) Treatment group—no change in the best hip after 2-y intervention ($P = .93$) Control group showed a significant worsening of the worst hip at 1 and 2 y ($P \leq .01$) Control group showed a moderate worsening of the best hip at 1 and 2 y ($P \leq .01$) Differences between treatment and control groups were significant for both hips after 2 y In the control group after 2 y, there were no more normal hips and much higher percentage of subluxated hips (62%) compared with the treatment group (40%) ($P = .03$). GEE worst hip: strong negative statistical interaction between treatment and time (joint Wald test $P \leq .01$) while adjusting for gender, age, and several clinical covariates, confirming MP worsening in the control group and MP stability in the treatment group Other variables did not have a significant adverse effect on MP in both groups	Not reported
Macias-Merlo et al ²²	Migration percentage	–	–	At 5 y of age	Migration percentage: mean (SD), median, 95%CI, max, min, difference Mann-Whitney U test to compare differences on each of the variables between the groups	Migration percentage in all children who stood with abduction remained within stable limits (13%-23%) at 5 y of age, in comparison to children who did not stand in abduction (12%-47%) ($P \leq .01$). Mean MP max (worst hip) in the standing group was significantly lower than in the control group (mean difference 14.92; SD = 7.69; $P \leq .01$) MP > 33% did not occur in the intervention group, but did in 8/13 in the control group	Not reported
Martinsson and Himmelmann ²³	Migration percentage ROM for hip abduction and hip and knee extension (goniometer)	–	Time in stander	Start and end of baseline year and after intervention year	Linear multiple regression analyses to determine correlations between standing time, surgery, and combined procedures Mann-Whitney U test to determine differences between groups	Significant correlation between straddled weight bearing ≥ 1 h per day and change of MP ($P \leq .01$) ($n = 11/86$) SG2: Significant reduction in MP was found for those who used straddled weight bearing as prevention for ≥ 1 h daily when corrected for GMFCS levels ($P = .029$) ($n = 8/63$) ROM: there were no statistical differences for any ROM measure in SG2 and CG2	Six dropouts (of which 2 increased muscle tone and general health problems, 2 preferred body support walker) but not reported as adverse events (continues)

TABLE 3

Results and Outcome (Continued)

Outcome Measures							
Study	Body Structure and Function	Activity/Participation	Contextual	Time Points	Statistics	Results	Adverse Events
Pountney et al ¹¹	Migration percentage Treatment for hip problems (medical records) Chailey Levels of Ability	–	Length of time of use (intervention group)	30 mo and 5 y	<i>Intervention group:</i> Use of equipment vs hip status (cutoff MP 33%): Fisher exact test <i>Intervention vs historical control group:</i> MP: Mean and range (statistics unknown) Hip problems: Frequencies, percentages and χ^2 (statistics unknown) Treatment: Frequencies, percentages and Fisher exact	<i>Intervention group:</i> Children who used equipment at recommended and moderate levels had significantly less chance of both hips being subluxated than those using equipment at minimal levels (χ^2 ; $P = .02$) <i>Intervention vs historical control group:</i> No significant differences among MPs between the historical control and intervention groups at 60 mo The frequency of children with hip problems was significantly less in the intervention group in comparison to the historical control group at 5 y ($\chi^2 = 11.53$; $P \leq .01$) The frequency of children receiving bilateral or unilateral treatments (ie, surgery, use of a hip and spinal orthosis, and/or botulinum toxin injections) in the intervention group was significantly less compared with the historical control group at 5 y ($\chi^2 = 11.53$; $P \leq .01$)	Not reported
Dalén et al ²⁵	BMD Migration percentage	–	–	Cross-sectional within 3 mo of the BMD measurements	Correlations for standing time on BMD and MP Path analyses with standardized regression analyses for effects between variables	BMD: Standing time was not associated with BMD (standard estimate: 0.13; $P = .59$) Hip dislocation: Spasticity was the most important variable (standard estimate 0.48; $P = .05$) and standing time the second most important variable (standard estimate: 0.29; $P = .01$) explaining the variance in, and negative effect on hip dislocation Overall improvement of hip migration percentages on right hip from 7% per annum in baseline period to –4% with the system ($P \leq .05$). On the left, changes were not significant	Three children had experienced 4 fractures The reason for the fracture was known in 1 case—a fall from a bench
Hankinson and Morton ²⁶	Migration percentage	Questionnaire about ease of positioning of hips during sitting, sleeping, and cleaning	–	At beginning and end of baseline period lasting 6 mo, and after 6- and 12-mo intervention period	Individual MP: percentages Change hip migration between baseline and intervention period (statistics unknown) Mann-Whitney U test for outcome questionnaire	Overall improvement of hip migration percentages on right hip from 7% per annum in baseline period to –4% with the system ($P \leq .05$). On the left, changes were not significant	Three participants dropped out due to inability to sleep with the system One participant dropped out due to surgery Not reported as adverse events
Pountney et al ²⁷	Migration percentage Acetabular index (<8 y) Chailey Levels of Ability	–	Type of positioning equipment	Not reported	No report of MP Statistics unknown for correlation between hip migration and postural management	Children using “all CAPS” before hip subluxation maintained significantly more hip integrity than other groups (χ^2 ; $P = .05$)	Not reported
Picciolini et al ²⁸	Migration percentage Cobb angle	–	–	Cross-sectional	Individual outcome (MP % left/right)	Case 1: after 2.5-y postural management, the pelvis is symmetric, MP reduction of 16% (from 36% to 20%), and reduction Cobb angle of 25% Case 2: after 3-y postural management, MP reduction of 39% (from 65% to 16% right) and 5% (from 20% to 15% left)	Not reported

Abbreviations: BMD, bone mineral density; CG, control group; CI, confidence interval; GEE, generalized estimating equation; MP, migration percentage; ROM, range of motion; SD, standard deviation; SG, study group.

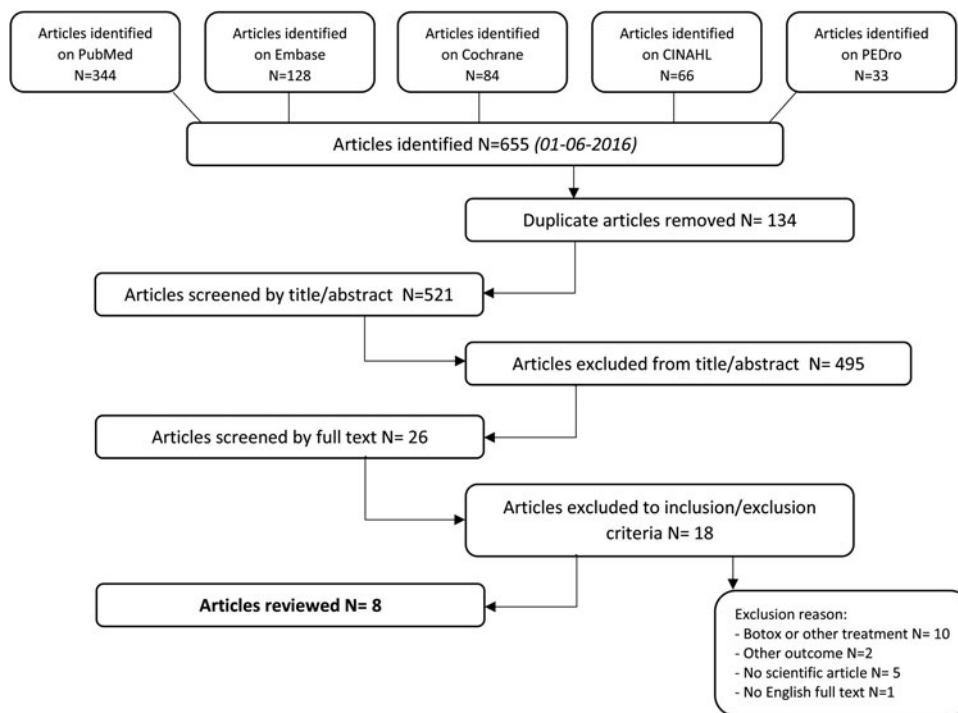


Fig. 2. Flow diagram of search.

<http://links.lww.com/PPT/A212>). Picciolini et al²⁸ described postural management in sitting and standing in 2 cases of CP. The cases, unresponsive to pharmacological and surgical treatment, were treated with postural management. There was a progressive reduction of MP of the treated hip, indicating a benefit of the combined nonsurgical approach.²⁸

DISCUSSION

Based on GRADE, the body of evidence was graded as low quality.²⁹ Therefore, no strong conclusions can be drawn regarding the effects of postural management on hip migration in CP. Seven of the 8 studies reported positive results after postural management interventions. However, because of the low quality of the studies, recommendations for clinical practice are weak. We discuss the results in this light and provide suggestions for future research.

Quality

Inclusion and exclusion criteria for the study population were poorly described.^{22,24-28} Criteria regarding GMFCS levels were not described in 3 studies²⁶⁻²⁸ and criteria regarding age were not described in 5 studies.^{22,24,25,27,28} Previous studies have shown that hip displacement is directly related to the level of the GMFCS and often occurs at 2 to 3 years of age.^{1,2,6,30} It is not surprising that only children with GMFCS levels III to V were included in the studies. Age at the start of intervention varied between 5 months and 18 years in the included articles. Only 2 of the 8 studies included children before 18 months of age.^{11,22} It is not possible to make a strong recommendation for specific age groups.

The reason for inclusion was reported in only 2 studies.^{22,23} Macias-Merlo et al reported that children with GMFCS level III

were included as “they were felt to most likely benefit from a standing program to promote walking, with an increased incidence of hip migration versus children at Level I or II.”²² Martinsson and Himmelmann²³ reported that GMFCS levels III to V were chosen as they are those with increased risk for hip dislocation.²³ Because of the limited and varying descriptions, no conclusions can be made on suitable inclusion and exclusion criteria for postural management.

The intervention and adherence to intervention was poorly described.^{11,23,25,27,28} Most interventions were not described in sufficient detail to ensure accurate replication in future research. The information on positions, degrees of hip abduction, duration, and intensity differed in the studies. Hence, the content of postural management is not clear based on the currently available evidence. The adherence to intervention is an important issue in clinical trials, and no study in this review addressed how adherence was ensured or evaluated.

None of the articles reported adverse events. Given the radical changes in the child postures during the intervention, adverse events such as pain or discomfort might have occurred.

We agree with Gough that “we need to consider the possibility that the increased care demands imposed by a continuous postural management programme on the family of the child with CP may have adverse effects on the ability of the family to enhance the activity and participation of the child.”^{12(p107)}

All discussed aspects of quality make it impossible to generalize the positive conclusions of these studies for use of postural management in children with CP.

Content and Effects of Postural Management

The studies reported postural management interventions in standing,^{22,23,25} sitting,²⁴ lying,²⁶ or combination of

these postures.^{11,27,28} Two of 3 studies with standing programs reported statistically significant positive results on hip migration.^{22,23} In the third study,²⁵ standing time was associated with statistically significant negative results on hip migration in spastic CP. The authors suggested that spastic muscle forces, acting on the femoral head in the acetabular cavity, might be stronger, as the child is strapped and joints are prevented from moving.²⁵ Given these varying results, it is important to take into account the variables that might affect hip migration during standing and examine these variables in future research.

Picciolini et al reported postural management in a sitting position, with positive results on hip migration.²⁴ Although this study reached the highest quality score (12/17 points), we suggest caution because of possible bias in selection procedures, relatively small sample groups, and lack of long-term outcomes.

Hankinson and Morton²⁶ reported postural management during the night in a lying position with significant improvement of MP only on 1 side.²⁶ The quality of the current evidence regarding the effectiveness of sleep positioning systems for children with CP is very low, and more robust research is needed.³¹ It is known that many children with CP have sleep problems.^{32,33} In addition, postural management in the lying position might have a negative effect on sleep routines and comfort of the child.³⁴ Therefore, there are possible objections against sleep positioning systems to reduce or prevent hip migration. The evidence for effects of 24-hour postural management on hip migration^{11,27} remains unclear because of limited methodological quality.

Because of the lack of evidence and the fact that postural management may have a large effect on daily activities of a child, with unclear effects on motor development, behavior, or well-being, further research is recommended.^{11,35} There is limited evidence relating to the effect of a postural management program on the context of the family, which is the child's main environment.¹² The challenge is to investigate these factors in long-term research to define a subgroup of children with CP who may benefit from postural management, taking into account the possible adverse effects on all domains of the ICF-CY.

What We Have Learned After 2006 Consensus Statement

Since the potential role of postural management was noted in the consensus statement in 2006,¹³ several studies have been conducted about the effects of postural management. With the current knowledge, the recommendations of this statement should be reassessed.

In accordance with the statement, we agree, based on the current review, that individualized postural management programs may be helpful for children with CP GMFCS levels III to V. However, the optimal content of postural management remains unclear due to poor quality of currently studies. The recommendations concerning 24-hour postural management and age at start of intervention should be considered with caution.

Paleg et al³⁵ provided recommendations for dosing pediatric-supported standing programs based on a systematic review. The authors recommended supported standing for 5 days a week, 60 minutes/day in 30° to 60° bilateral hip abduction.³⁵ However, the quality of the studies that were the

basis for this recommendation was not thoroughly investigated. These studies were partly included in the current review. Based on the available evidence now, we cannot formulate recommendations as strongly.

Despite the thorough evaluation of postural management and the inclusion of an additional 2 studies, we conclude with Miller et al¹⁴ that the level of evidence was poor and therefore no firm conclusions can be provided.

Recommendations for Clinical Practice

From this review, there are indications that hip abduction in a standing or sitting position may improve hip migration. Supported standing is consistent with the data that lack of weight bearing in combination with spasticity is associated with hip migration. This could be a reason for the absence of hip migration in GMFCS level I.^{1,2,6} Nevertheless, the current available evidence is too limited to formulate strong recommendations for clinical use of standing programs. Therefore, we note that postural management should be an individual approach, according to the clinical and functional status of the child, including personal and environmental factors. Decision-making with parents and considering the environment in using postural management for the child with CP are essential.

Recommendations for Future Research

The lack of sufficient information concerning intervention and baseline characteristics to replicate interventions is a concern for clinical studies.^{36,37} To be able to interpret results, it is essential that baseline child characteristics, type and frequency of intervention, adherence to intervention, standardized outcome of interest (MP), and adverse events are systematically reported. Because of the individualized nature of postural management, randomized controlled studies may not be the most appropriate to evaluate the effects of postural management. Single-subject research designs may be more appropriate, as they offer control through systematic measurement and implementation, often under conditions that reflect the complexity and practicality of everyday practice.³⁸ We recommend the use of CP registers and multicenter collaboration that contributes to the standardized clinical and radiological follow-up of the hips, which has shown to be an effective approach.^{39,40} In addition, CP registries contribute to longitudinal data collection and may overcome sample size barriers. The use of the "Template for Intervention Description and Replication" (TIDieR) is recommended to improve the replicability of interventions. The TIDieR checklist and guide should improve the reporting of interventions and make it easier for authors to structure accounts of their interventions, reviewers and editors to assess the descriptions, and readers to use the information.⁴¹

CONCLUSION

The evidence for postural management to prevent or reduce hip migration in children with CP is limited by the lack of high-quality studies. Considering the results, there is a positive trend in the use of hip abduction in postural management. Strong recommendations for clinical practice are not possible

based on the limited quality of the currently available studies. Future high-quality research is crucial to improve our understanding of the effects of postural management to prevent hip migration in children with CP. We recommend the use of CP registers and multicenter collaboration, which will contribute to standardized follow-up of the hips, longitudinal data collection and systematic report of baseline characteristics, type and frequency of intervention, adherence to intervention, standardized outcome of interest (MP), reporting of adverse events, and child and parental experience.

ACKNOWLEDGMENTS

We thank Dr Paulien H. Wiersma for helping with the construction of the search strategy.

REFERENCES

- Hägglund G, Lauge-Pedersen H, Wagner P. Characteristics of children with hip displacement in cerebral palsy. *BMC Musculoskelet Disord*. 2007;8:101.
- Connelly A, Flett P, Graham HK, Oates J. Hip surveillance in Tasmanian children with cerebral palsy. *J Paediatr Child Health*. 2009;45(7/8):437-443.
- Cornell MS. The hip in cerebral palsy. *Dev Med Child Neurol*. 1995;37(1):3-18.
- Spiegel DA, Flynn JM. Evaluation and treatment of hip dysplasia in cerebral palsy. *Orthop Clin North Am*. 2006;37(2):185-196, vi.
- Scrutton D. The early management of hips in cerebral palsy. *Dev Med Child Neurol*. 1989;31(1):108-116.
- Terjesen T. The natural history of hip development in cerebral palsy. *Dev Med Child Neurol*. 2012;54(10):951-957.
- Palisano R, Rosenbaum P, Walter S, Russell D, Wood E, Galuppi B. Development and reliability of a system to classify gross motor function in children with cerebral palsy. *Dev Med Child Neurol*. 1997;39(4):214-223.
- Larnert P, Risto O, Hägglund G, Wagner P. Hip displacement in relation to age and gross motor function in children with cerebral palsy. *J Child Orthop*. 2014;8(2):129-134.
- Reimers J. The stability of the hip in children. A radiological study of the results of muscle surgery in cerebral palsy. *Acta Orthop Scand Suppl*. 1980;184:1-100.
- Hägglund G, Lauge-Pedersen H, Persson M. Radiographic threshold values for hip screening in cerebral palsy. *J Child Orthop*. 2007;1(1):43-47.
- Pountney TE, Mandy A, Green E, Gard PR. Hip subluxation and dislocation in cerebral palsy—a prospective study on the effectiveness of postural management programmes. *Physiother Res Int*. 2009;14(2):116-127.
- Gough M. Continuous postural management and the prevention of deformity in children with cerebral palsy: an appraisal. *Dev Med Child Neurol*. 2009;51(2):105-110.
- Gericke T. Postural management for children with cerebral palsy: consensus statement. *Dev Med Child Neurol*. 2006;48(4):244.
- Miller SD, Juricic M, Hesketh K, et al. Prevention of hip displacement in children with cerebral palsy: a systematic review. *Dev Med Child Neurol*. 2017;59(11):1130-1138.
- Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *J Clin Epidemiol*. 2009;62(10):1006-1012.
- Darrah J HR, O'Donnell M, Vogtle L, Wiart L. AACPD Methodology to Develop Systematic Reviews of Treatment Interventions (Revision 1.2). www.aacpd.org. Published 2008.
- Morgan C, Darrah J, Gordon AM, et al. Effectiveness of motor interventions in infants with cerebral palsy: a systematic review. *Dev Med Child Neurol*. 2016;58(9):900-909.
- Sackett DL SS, Richardson WS, Rosenberg W, Haynes RB. *Evidence-Based Medicine*. 2nd ed. New York, NY: Churchill Livingstone; 2000.
- de Morton NA. The PEDro scale is a valid measure of the methodological quality of clinical trials: a demographic study. *Aust J Physiother*. 2009;55(2):129-133.
- Fetters L, Tilson J. *Evidence Based Physical Therapy*. Philadelphia, PA: FA Davis; 2012.
- World Health Organization. *International Classification of Functioning, Disability and Health: Children and Youth Version*. Geneva, Switzerland: World Health Organization; 2007:9-51.
- Macias-Merlo L, Bagur-Calafat C, Girabent-Farres M, A Stuberger W. Effects of the standing program with hip abduction on hip acetabular development in children with spastic diplegia cerebral palsy. *Disabil Rehabil*. Jun 2016;38(11):1075-1081.
- Martinsson C, Himmelmann K. Effect of weight-bearing in abduction and extension on hip stability in children with cerebral palsy. *Pediatr Phys Ther*. 2011;23(2):150-157.
- Picciolini O, Le Metayer M, Consonni D, et al. Can we prevent hip dislocation in children with CP? Effects of postural management. *Eur J Phys Rehabil Med*. 2016;52(5):682-690.
- Dalén Y, Säaf M, Ringertz H, Klefbeck B, Mattsson E, Haglund-Kerlind Y. Effects of standing on bone density and hip dislocation in children with severe cerebral palsy. *Adv Physiother*. 2010;12(4):187-193.
- Hankinson J, Morton RE. Use of a lying hip abduction system in children with bilateral cerebral palsy: a pilot study. *Dev Med Child Neurol*. 2002;44(3):177-180.
- Pountney T, Mandy A, Green E, Gard P. Management of hip dislocation with postural management. *Child Care Health Dev*. 2002;28(2):179-185.
- Picciolini O, Albisetti W, Cuzzaglio M, Spreafico F, Mosca F, Gasparroni V. "Postural Management" to prevent hip dislocation in children with cerebral palsy. *Hip Int*. 2009;19(suppl 6):S56-S62.
- Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ*. 2008;336(7650):924-926.
- Soo B, Howard JJ, Boyd RN, et al. Hip displacement in cerebral palsy. *J Bone Joint Surg Am*. 2006;88(1):121-129.
- Blake SF, Logan S, Humphreys G, et al. Sleep positioning systems for children with cerebral palsy. *Cochrane Database Syst Rev*. 2015;11:CD009257.
- Leis AL, Cardoso MV, Hall WA. Sleep disorders in children with cerebral palsy: an integrative review. *Sleep Med Rev*. 2015;30:63-71.
- Dutt R, Roduta-Roberts M, Brown CA. Sleep and children with cerebral palsy: a review of current evidence and environmental non-pharmacological interventions. *Children (Basel)*. 2015;2(1):78-88.
- Goldsmith S. The Mansfield Project: postural care at night within a community setting—a feedback study. *Physiotherapy*. 2000;86:528-534.
- Paleg GS, Smith BA, Glickman LB. Systematic review and evidence-based clinical recommendations for dosing of pediatric supported standing programs. *Pediatr Phys Ther*. 2013;25(3):232-247.
- Kunz R, Autti-Ramo I, Anttila H, Malmivaara A, Makela M. A systematic review finds that methodological quality is better than its reputation but can be improved in physiotherapy trials in childhood cerebral palsy. *J Clin Epidemiol*. 2006;59(12):1239-1248.
- Hoffmann TC, Erueti C, Glasziou PP. Poor description of non-pharmacological interventions: analysis of consecutive sample of randomised trials. *BMJ*. 2013;347:f3755.
- Romeiser-Logan L, Slaughter R, Hickman R. Single-subject research designs in pediatric rehabilitation: a valuable step towards knowledge translation. *Dev Med Child Neurol*. 2017;59(6):574-580.
- Hägglund G, Andersson S, Duppe H, Lauge-Pedersen H, Nordmark E, Westbom L. Prevention of dislocation of the hip in children with cerebral palsy. The first ten years of a population-based prevention programme. *J Bone Joint Surg Br*. 2005;87(1):95-101.
- Wynter M, Gibson N, Willoughby KL, et al. Australian hip surveillance guidelines for children with cerebral palsy: 5-year review. *Dev Med Child Neurol*. 2015;57(9):808-820.
- Hoffmann TC, Glasziou PP, Boutron I, et al. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ*. 2014;348:g1687.