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Interventions to improve upper limb function for children with bilateral cerebral palsy: a systematic review

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ABBREVIATIONS

AACPDM	American Academy for Cerebral Palsy and Developmental Medicine
HABIT-ILE	Hand–arm bimanual intensive therapy including lower extremities
ICF	International Classification of Functioning, Disability and Health
ITB	Intrathecal baclofen
MACS	Manual Ability Classification System
RCT	Randomized controlled trial
SDR	Selective dorsal rhizotomy

AIM To systematically review the efficacy of interventions on upper limb function in children 0 to 19 years of age with bilateral cerebral palsy on the basis of outcome measures of upper limb function and measures of activities and/or participation according to the International Classification of Functioning, Disability and Health.

METHOD Cochrane, PubMed, Embase, CINAHL, and Web of Science were searched from inception to September 2017. Methodological quality and strength of evidence were analysed by two independent raters using Sackett's level of evidence and the American Academy for Cerebral Palsy and Developmental Medicine (AAPDM) guidelines.

RESULTS Fifteen studies with a large variety of interventions and heterogeneity in outcome measures met the inclusion criteria. Twelve studies provided level IV evidence according to AAPDM guidelines. For three small randomized controlled trials the level of evidence was II. Only one of these trials showed strong methodological quality: a study on hand–arm bimanual intensive therapy including lower extremities.

INTERPRETATION We identified a large variety of interventions, heterogeneity in outcome measures, and generally weak to moderate methodological quality for most studies. We recommend further research specifically aimed at bimanual-intensive, goal-directed, and task-specific training programmes for the upper limb in children with bilateral cerebral palsy, using either high-quality (multicentre) trials or well-designed single-case trials.

Cerebral palsy (CP) is a disorder with an estimated prevalence of 2 in 1000 live births¹ and is divided into three subtypes: spastic, dyskinetic, and ataxic.² The spastic type of CP is further categorized into unilateral or bilateral distribution; the dyskinetic and ataxic types are commonly viewed as distributed bilaterally.^{3,4} In the case of a mixed form of CP, the child is classified according to the dominant clinical feature. In spastic CP, some dystonic features are often present, especially when the upper extremities are involved.⁴ The term bilateral (spastic) CP as recommended by the Surveillance of Cerebral Palsy in Europe² has been widely accepted as an alternative to the frequently used terms diplegia, tetraplegia, or quadriplegia. It is the most common subtype, as it constitutes about 55% of all patients with CP.²

More than 60% of children with bilateral CP have impaired hand function.⁵ Manual ability among these children is typically classified within all levels of the Manual Ability Classification System (MACS),⁶ including the more severe MACS levels IV and V,^{5,7} whereas children with

unilateral CP are usually classified within MACS levels I to III. In children with CP, limited ability to manipulate objects with the hands is reported as one of the strongest predictors of limitations in everyday activities and participation restrictions.⁷ Therefore, improving manual abilities is one of the most important treatment goals.

Treatments targeting upper limb function in children with CP aim to improve functional abilities, promote functional independence, and/or reduce disabling muscle tone. Frequently reported treatments are constraint-induced movement therapy, bimanual training, virtual reality and computer-based training, or combinations of these treatments with intramuscular chemodenervation by botulinum neurotoxin A (BoNT-A).^{8,9} However, current effectiveness studies for upper limb function predominantly focus on children with unilateral spastic CP. For spasticity management in all types including bilateral CP, intramuscular BoNT-A, oral diazepam, or selective dorsal rhizotomy (SDR) have proved to be effective.¹⁰ However, the focus of these interventions is usually on the effects on the lower

limbs rather than the upper limbs. Thus, knowledge about interventions to improve upper limb function in children with bilateral CP is limited.⁷

So far, results on the effectiveness of interventions on upper limb function in children with bilateral CP have not been systematically summarized. One older systematic review¹¹ of all types of intervention for upper limb spasticity focused on children with unilateral as well as bilateral CP. In this review, no evidence for the effectiveness of intrathecal baclofen (ITB) or SDR could be established. There were no signs of improved functional skills of the upper limbs. Several other authors reviewed the efficacy of upper limb treatment for unilateral spastic CP.^{9,12,13} As none of these reviews specifically focused on children with bilateral CP, or they restricted their focus to only one treatment modality, a comprehensive overview of the efficacy of various interventions on upper limb function in these children is not available.

The aim of this systematic review was to provide an overview of interventions on upper limb function in children 0 to 19 years of age with bilateral CP and to synthesize research data on the effectiveness of these interventions. The main clinical question was ‘what is known about the efficacy of interventions on upper limb function in children with bilateral CP?’. To answer this, we reviewed the literature published from inception to September 2017, and systematically evaluated the efficacy of interventions on upper limb function in children with bilateral CP. In addition, we assessed the methodological quality of the studies using the guidelines of the American Academy for Cerebral Palsy and Developmental Medicine (AACPDM).¹⁴ Outcome measures were classified according to the components of the International Classification of Functioning, Disability and Health (ICF).¹⁵

METHOD

Search strategy

Relevant articles were identified by searching the Cochrane Library (1946–2017), CINAHL (1982–2017), Embase (1974–2017), PubMed (1946–2017), and Web of Science (1945–2017). The search of published studies was performed on 27th July 2016 and updated on 15th September 2017. Reference lists of selected articles were also reviewed by two reviewers (JEV and VFPP) for studies not retrieved by the electronic search.

Exploded Medical Subject Heading (MeSH) terms and key words used in PubMed were as follows: (1) cerebral palsy AND (2) quadriplegi*OR diplegi*OR bilatera*AND (upper extremity*OR upper limb*) AND (function*OR perform*) AND Treatment*OR Therap*OR Surger*OR Splint OR Botulinum toxin*.

A language restriction to publications in English, French, and German was included owing to a lack of translation services. MeSH and a thesaurus were used to customize the search terms for each database. The search strategy was adapted by an experienced librarian to make it

What this paper adds

- There is a large variety of interventions on upper limb function in children with bilateral cerebral palsy.
- Heterogeneity of outcome measures and interventions impeded firm conclusions about intervention efficacy.
- Most studies had low-level evidence and weak to moderate methodological quality.
- The strongest evidence from a small randomized controlled trial was for hand–arm bimanual intensive therapy including lower extremities.

applicable to other databases. The full search strategy is given in Appendix S1 (online supporting information).

Selection criteria

Inclusion criteria

To be included, studies had to meet the following four criteria. (1) The study population consisted of at least 10 children or adolescents diagnosed with bilateral CP in the age range 0 to 19 years. Studies of mixed age groups were included if data of participants aged 0 to 19 years were reported separately. (2) The study investigated the effect of a surgical, pharmacological (e.g. BoNT-A), or non-pharmacological treatment, whether used independently or in combination, on upper limb function. (3) Data collection was prospective in nature (e.g. pre/posttest designs, randomized controlled trials [RCTs]). (4) Outcome measures reflected upper limb function as well as activities and/or participation according to the ICF.

Studies were excluded if (1) the data for upper limb function were not separately described in the case of mixed data outcomes for the upper and lower extremities or (2) the article was a review, survey, anecdote, letter, or comment, or was published in a non-peer-reviewed journal (in line with AACPDM policy and procedures).

Procedures for inclusion, quality assessment, and data extraction

Eligibility for inclusion, based on title and abstract, was assessed independently by two reviewers (JEV and VFPP). Abstracts meeting inclusion criteria or requiring more information from the full text to verify inclusion were retained. The full text was read to determine its suitability when in doubt. Articles were included when agreement between reviewers was achieved. The full texts of articles that met the inclusion criteria were retrieved and examined in more detail to: (1) assess methodological quality; and (2) synthesize research data on the effectiveness of the interventions.

Methodological assessment

Level of evidence and methodological quality

First, the level of quantitative evidence of each study was assessed according to Sackett’s methodology.¹⁶ Second, all included studies were scored on their methodological rigour using the criteria of the AACPDM Treatment Outcome Committee.¹⁴ According to the AACPDM guidelines, level IV and V studies would not have to be assessed on their methodological quality. Preliminary

screening showed that most studies had less rigorous research designs. Nevertheless, we decided to include and review all studies as a means of informing future studies. The grading of the studies and scoring on their methodological rigor were conducted independently by two raters (JEV and VFPP). AACPDM methodology levels were operationalized (Table SI, online supporting information) and scored by two reviewers independently (JEV and VFPP). In the case of disagreement or any discrepancies in scores, details were discussed until consensus was reached. One reviewer (VFPP) extracted the data and entered data items into a data extraction summary form. Data were extracted according to the participants, interventions, comparators, outcomes, study design (PICOS) approach, as emphasized in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement¹⁷ for reporting systematic reviews, and comprised the research design (i.e. Sackett's levels of evidence), eligibility criteria, diagnosis including motor type, patient characteristics, number of participants, intervention, and comparison group details.

Data analysis

Studies were categorized by type of intervention and all outcomes were specified on the basis of consensus by two reviewers (PBMA and VFPP) according to the ICF framework.¹⁵ A summarizing table including *p*-values was constructed according to the AACPDM¹⁴ outcomes of interest for two ICF categories: 'body function and structures' and 'activities and participation'. Considering the heterogeneity of outcome measures in the included studies, we decided to categorize the different outcome measures within the ICF domains on the basis of consensus of three authors (CHMVDE, PBMA, and VFPP). From this table, a more concise one with an overview of seven relevant outcome domains was constructed comprising mobility of joint functions, muscle power, muscle tone, movement functions (ICF domain 'body functions and structures') and hand and arm use, fine hand use, and self-care (ICF domain 'activities and participation').

For each outcome domain, the reported effect was scored as positive ('+') or negative ('-') when results were statistically significant; as no effect ('0') when results were not statistically significant; and as not applicable ('NA') if not measured. Both within-group and between-group results with a *p*-value less than 0.05 were considered statistically significant. Standardized mean differences (Cohen's *d*) were calculated using statistical package STATA/IC 13.1 (StataCorp LLC, College Station, TX, USA) for significant between-group differences where possible. Several decision rules were defined to score the effectiveness. First, when multiple outcome measures and/or subscales were used to assess the same outcome domain within a study, then more than 50% of the outcome measures needed to score '+' to report an effect as positive. Second, when total scores were provided, those scores were preferred to the results of subscale scores.

RESULTS

Study selection

The search strategy yielded 493 studies; 63 met the eligibility criteria after the first selection based on title and abstract. A flow chart of the selection process is shown in Figure S1 (online supporting information). The full articles of these 63 studies were reviewed and 46 studies were subsequently excluded for the following reasons: diagnosis,¹⁸⁻²⁵ age,²⁶⁻²⁹ sample size,³⁰⁻⁴⁹ design,⁵⁰⁻⁵³ intervention,⁵⁴⁻⁵⁷ and outcome measure.⁵⁸⁻⁶³ Of the remaining 17 studies, two articles reported data on mixed study samples consisting of participants with quadriplegia, diplegia, traumatic brain injury, and spinal cord injury (among others)⁶⁴ or participants with quadriplegia, diplegia, hemiplegia, and ataxia.⁶⁵ As the results for bilateral CP were not separately reported, the authors were approached and asked whether they could supply more specific data. Because these data could not be retrieved, the two studies^{64,65} were excluded. Therefore, this review included 15 studies⁶⁶⁻⁸⁰ investigating the efficacy of interventions on upper limb function in children with bilateral CP.

Study characteristics

Five of the 15 included studies were cohort studies without a control group, six were case series, one was a case-control study, and three were small RCTs^{66,67,80} (Table SII, online supporting information). Three small RCTs provided level II evidence and 12 studies level IV evidence. Thus, most of the studies provided low-level evidence according to Sackett's criteria. Table I depicts the methodological quality of all included studies. The three RCTs showed strong,⁶⁷ moderate,⁸⁰ and weak⁶⁶ methodological quality whereas one study⁷⁵ with level IV evidence was rated as strong. Of all AACPDM criteria, 'statistical evaluation' and 'assessor blinding' were least met. The quality was weak for nine studies, moderate for four, and strong for two (Table I).

In two RCTs the control group received no intervention; in one study the control group received usual care consisting of physical therapy. The mean age of participants in the included studies ranged from 4 years 6 months to 12 years 6 months and the total number was 288, varying from 10 to 40 per study. The proportion of females ranged from 10% (one out of 10) to 67% (eight out of 12) in 14 studies; one study included only males.⁷⁶

Motor type of CP was described in different ways. Eight studies had homogenous populations and consisted only of children with spastic diplegia; four studies had heterogeneous populations and consisted of a mixed population with both quadriplegia and diplegia. Two studies lacked information about the distribution of children with diplegia and quadriplegia in their study population.^{71,73} One study exclusively presented children with spastic quadriplegia.⁸⁰ Within the studies with mixed populations, the proportion of children with diplegia ranged from 10.5% (two out of 21) to 69% (20 out of 29). As for the manual abilities, MACS⁶ levels were documented in four studies. One

Table I: Conduct of study

Study	Quality ^a	1	2	3	4	5	6	7
BoNT-A only/BoNT-A and OT								
Lee et al. ⁷²	W 3/7	N	Y	Y	N	N	Y	N
Lin et al. ⁷⁴	M 4/7	Y	Y	Y	N	N	Y	N
SDR and OT/PT								
Buckon et al. ⁶⁸	W 2/7	N	N	Y	N	N	N	Y
Buckon et al. ⁶⁹	M 4/7	N	Y	Y	N	N	Y	Y
Dudgeon et al. ⁷¹	W 3/7	N	Y	Y	N	N	Y	N
Lewin et al. ⁷³	W 2/7	N	N	N	N	N	Y	Y
Intrathecal baclofen and PT								
Campbell et al. ⁷⁰	W 3/7	N	Y	Y	N	N	Y	N
HABIT-ILE-training								
Bleyenheuft et al. ⁶⁷	S 6/7	Y	Y	Y	N	Y	Y	Y
Armeo Spring and OT								
Turconi et al. ⁷⁹	M 5/7	Y	Y	Y	N	N	Y	Y
Transcranial magnetic stimulation								
Valle et al. ⁸⁰	M 5/7	Y	Y	Y	Y	N	N	Y
Wii/virtual reality training								
Alsaif and Alsenany ⁶⁶	W 2/7	N	N	Y	N	N	N	Y
Shin et al. ⁷⁷	W 0/7	N	N	N	N	N	N	N
Positioning								
Noronha et al. ⁷⁶	W 2/7	N	Y	Y	N	N	N	N
Hippotherapy								
Shurtleff et al. ⁷⁸	W 3/7	Y	N	N	N	N	Y	Y
Hyperbaric oxygen therapy								
Montgomery et al. ⁷⁵	S 6/7	Y	Y	Y	Y	N	Y	Y

Methodology assessment according to the American Academy for Cerebral Palsy and Developmental Medicine. ^aQuality of the conduct of the study. BoNT-A, botulinum neurotoxin A; HABIT-ILE, hand–arm bimanual intensive therapy including lower extremities; M, moderate; N, no; OT, occupational therapy; PT, physical therapy; S, strong; SDR, selective dorsal rhizotomy; W, weak; Y, yes.

study⁷³ reported that the distinction between children with diplegia and quadriplegia was made on the basis of observable functional deficits of the upper extremities. Gross motor function was classified by the Gross Motor Function Classification Scale (GMFCS)⁸¹ in eight studies; in three studies, there was no further classification of motor level; four studies described merely the level of ambulation.

Study samples were recruited from a large variety of settings ranging from a children's hospital and a regional medical centre to rehabilitation institutes. In three studies the setting was not documented. In 10 studies exclusion criteria were reported,^{66,67,72,74–80} including different types of comorbidity: severe hearing loss, visual impairment, epilepsy, autism, history of BoNT-A or phenol injections, neurosurgery, or ophthalmic surgery.

Ten different interventions were identified: (1) BoNT-A injections with or without occupational therapy; (2) SDR and occupational therapy/physical therapy; (3) ITB and physical therapy; (4) hand–arm bimanual intensive therapy including lower extremities (HABIT-ILE) training; (5) Armeo Spring device training combined with occupational therapy; (6) transcranial magnetic stimulation; (7) hyperbaric oxygen therapy; (8) Wii/virtual reality training; (9) sitting/standing positioning; and (10) hippotherapy. In seven studies participants received a single treatment modality; in the other eight studies treatment was combined with occupational therapy or physical therapy (Table SII).

Efficacy of interventions across outcome domains of the ICF

The effectiveness of 15 studies was assessed and summarized across the relevant ICF domains according to the AACPD guidelines (Table SIII, online supporting information). An overview of the efficacy of the interventions sorted by seven relevant outcome domains is shown in Table II. Outcome measures that reflected the ICF domain 'body functions and structures' included range of movement, muscle strength, muscle tone, and coordination. The ICF domain of 'activity and participation' was reflected in fine hand use, arm and hand use, and self-care. Contextual factors were reported by three studies, including subjective parent reported symptoms,⁸⁰ a caregivers report on achieved goals,⁷⁰ and caregiver's health-related quality of life.⁷⁴ However, measures of these studies were minimally related to upper limb function and therefore are not presented.

The effectiveness of three interventions (BoNT-A with or without occupational therapy, SDR and occupational therapy/physical therapy, and Wii virtual reality training) was described by more than one study. Six studies on the effectiveness of BoNT-A with or without occupational therapy^{72,74} and SDR and occupational therapy/physical therapy^{68,69,71,73} showed level IV evidence, and two studies on Wii virtual reality training^{66,77} provided level II and IV evidence respectively. Significant beneficial effects on different outcome measures in six out of seven domains were reported by two studies on the effectiveness of BoNT-A with or without occupational therapy.^{72,74} In three out of four studies that examined the effectiveness of SDR and occupational therapy/physical therapy,^{68,69,71,73} a significant improvement on the domain of self-care was reported; however, in the remaining domains, outcome domain findings were non-significant or inconsistent. In addition, one study on SDR and occupational therapy/physical therapy⁶⁸ reported a significant effect on grasp strength and fine motor coordination, represented in two domains. Two studies, a case–control study⁷⁷ and one small RCT,⁶⁶ examined the effectiveness of Wii virtual reality training. The small RCT (level II evidence) reported significant improvements in three domains: movement functions (i.e. upper limb coordination), hand and arm use, and fine hand use.

The effectiveness of seven other interventions was described by a single study. Five of these studies (two cohort studies and three case series) showed level IV evidence, and assessed the effectiveness of the following interventions: ITB and physical therapy,⁷⁰ Armeo Spring device training combined with occupational therapy,⁷⁹ hyperbaric oxygen,⁷⁵ positioning,⁷⁶ and hippotherapy.⁷⁸ Lewin et al.⁷³ documented the effect of ITB and physical therapy in a mixed population of patients with spastic diplegia and quadriplegia. Because data of upper limb mobility patterns and muscle tone were not presented for the whole group but only for the group of patients who made gains, it was

Table II: Reported effects per treatment on different domains of the International Classification of Functioning, Disability and Health (ICF)

Intervention and study	Body functions and structures				Activity and participation			
	Joint mobility ICF ^a : B710	Muscle power ICF: B730	Muscle tone ICF: B735	Movement functions ICF: B760	Hand and arm use ICF: D445	Fine hand use ICF: D440	Self-care ICF: D5	
Botulinum neurotoxin A Lee et al. ⁷² ; Lin et al. ⁷⁴	NA; +		+; +	+; NA	+; NA	+; +	NA; +	
SDR and OT/PT Buckon et al. ⁶⁸ ; Buckon et al. ⁶⁹ ; Dudgeon et al. ⁷¹ ; Lewin et al. ⁷³	0; NA; NA; ?	±; 0; NA; NA	0; NA; NA; ?	+; NA; 0; NA	NA; NA; 0; ?	0; NA NA; ?	+; NA; + Diplegia 0 Quadriplegia; +	
ITB and PT Campbell et al. ⁷⁰		+		0	0		0	
HABIT-ILE training Bleyenheuft et al. ^{67b}				+ less AH 0 more AH		+ less AH 0 more AH	+	
Armeo Spring and OT Turconi et al. ⁷⁹	0	0	0	0	+	±	±	
TMS Valle et al. ^{80b}	+		0					
HBO ₂ therapy Montgomery et al. ⁷⁵				+	+	+	0	
Wii/virtual reality training Alsaif and Alsenany ^{66b} ; Shin et al. ⁷⁷				+; +	+; NA	+; NA		
Positioning Noronha et al. ⁷⁶				0	0	±		
Hippotherapy Shurtleff et al. ⁷⁸				+	+			

^aCodes of the ICF correspond with the domains within the ICF. ^bRCTs: hand–arm bimanual intensive therapy including lower extremities training (HABIT-ILE)⁶⁷; significant effect size (Cohen's *d*) ranged from 0.24 to 0.66; transcranial magnetic stimulation (TMS)⁶⁰ significant effect size ranged from 1.55 to 3.75; Wii⁶⁶ significant effect size ranged from 0.89 to 3.12. Symbols: ?, unclear data presentation, data were not presented for the whole group, unable to separate data for diplegia/quadriplegia; +, statistically significant effect; 0, no statistically significant effect; ±, inconsistent results within the same ICF domain. AH, affected hand; HBO₂, hyperbaric oxygen; NA, not applicable; OT, occupational therapy; PT, physical therapy; SDR, selective dorsal rhizotomy; TMS, transcranial magnetic stimulation.

impossible to draw conclusions from these data. Self-care data, however, were separately presented and demonstrated significant gains in the areas of feeding and dressing. Two studies with level II evidence were small RCTs on repetitive transcranial magnetic stimulation⁸⁰ and HABIT-ILE⁶⁷ and met the AACPDm criteria for moderate and strong methodological quality respectively. The effect of HABIT-ILE training was significant (small to moderate effect sizes) for manual ability, fine motor control, and self-care. Repetitive transcranial magnetic stimulation showed large effect sizes (with wide confidence intervals) on passive range of motion for the group with 5Hz stimulation immediately after 5 days of treatment. Although there was a trend towards improvement in muscle tone (Ashworth scores) in the 5Hz treatment group, the results did not reach statistical significance.

DISCUSSION

To our knowledge, this review is the first to summarize the evidence from both observational and controlled studies on the efficacy of interventions on upper limb function in bilateral CP across all domains of the ICF. Fifteen studies were identified, but the large variety in the content of interventions and the heterogeneity of outcome measures prevented a meaningful synthesis of results across studies. Most of the studies in this review showed level IV evidence. Three small RCTs showed level II evidence. These RCTs reported that HABIT-ILE is effective for improving manual ability, fine motor control, and self-care; that repetitive transcranial magnetic stimulation is modestly effective for improving passive ROM; and that ITB and physical therapy is effective for improving upper limb coordination and arm and fine hand use. However, only one of these three RCTs met the AACPDm criteria for strong methodological quality¹⁴: a study about HABIT-ILE.

HABIT-ILE is given in a day camp setting providing 6.5 hours per day intensive, task-specific training. For unilateral spastic CP, there is modest evidence that intensive activity-based, goal-directed interventions are more effective than standard care to improve upper limb function, in addition to strong evidence for goal-directed occupational therapy home programmes.⁹ The results of this review suggest that intensive activity-based training programmes such as HABIT-ILE could also be beneficial for children with bilateral CP. This conclusion should, however, be interpreted with caution, given that only one small RCT has been conducted in which the training included both the upper and lower limbs.

Methodological considerations, and strengths and limitations of this review

First, the low level of evidence and weak to moderate methodological quality of the included studies is a serious concern. Apart from the heterogeneity in outcome measures and poor definition of the patient population, the small sample sizes and weak to moderate methodological

quality impeded synthesis of the results. Hence, larger (multicentre) trials are needed that use high-quality methods and well-defined outcome measures and patient populations.

Second, most interventions comprised more than one component (with or without occupational therapy and/or physical therapy); therefore the efficacy of an individual component could not be established.

Third, identification of studies and comparison of results was hampered by the use of different classification systems. The classification as proposed by the Surveillance of Cerebral Palsy in Europe² is now frequently used and has become the criterion standard for uniform classification of CP.

The studies reported in this review included heterogeneous patient groups with bilateral CP: children with diplegia, quadriplegia, and mixed populations. In addition, in most studies, important information about comorbidities and the motor type of CP (GMFCS and/or MACS level) was insufficiently described or even lacking. In four studies^{67,72,74,79} the MACS levels were described, but the included patients presented with a large variety in MACS levels (levels II–V). Hence, findings were reported in relation to neither comorbidities nor MACS levels, making inferences impossible. Studies presented a large variety of classifications of the motor type of CP and upper and lower extremity function. This information is needed to compare effects across studies and to generalize findings. Hence, for future research, we recommend the use of uniform classifications both for diagnosis and for gross and fine motor functions. The MACS and the revised edition of the Bimanual Fine Motor Function,⁸² as a classification of fine motor capacity in children with CP, are both useful for this purpose.

Outcome measures

This systematic review shows that a variety of outcomes were assessed, such as joint mobility, movement functions, and self-care. However, clinically important outcomes such as palm hygiene and pain were not assessed. In children with severe motor types of CP (e.g. MACS levels IV and V) these outcomes may be particularly important. Furthermore, upper limb function was evaluated by a variety of measures that could not be categorized as upper limb assessments nor considered to be validated for CP. For unilateral spastic CP, several systematic reviews have summarized outcome measures to evaluate upper limb function.^{83,84} For bilateral spastic CP, Elvrum et al.⁸⁵ identified five hand function measures and found the strongest evidence of validity and reliability for the ABILHAND-Kids and Melbourne-2. However, evidence for their responsiveness is still lacking. The Both Hands Assessment,⁸⁶ measuring the effectiveness of bimanual performance and the extent of asymmetric hand use in children in MACS levels I to III, has recently been developed and shown good evidence of internal scale validity and item and person reliability. Further high-quality studies on these and other

measures may help to identify measurement instruments covering all domains of the ICF, specifically for children with bilateral CP, and facilitate the evaluation of the efficacy of interventions.

Research implications

Implementing evidence from systematic reviews may be challenging in heterogeneous populations of children with complex disorders such as CP. Systematic reviews tend to favour studies where randomization is easier to achieve and which include more homogeneous populations, not always reflecting the population seen in clinical practice. Smaller studies using single-case designs may constitute a bridge between research and clinical practice by taking into account the individual variability of responses to an intervention.⁸⁷

CONCLUSIONS

Effective use of the upper limb in children with bilateral CP is essential for their independence in daily life activities.¹¹ Many treatment options are available, but these have predominantly been investigated in children with unilateral spastic CP. Only a limited number of studies investigated the efficacy of a variety of interventions on upper limb function in children with bilateral CP. From the studies reported in this review, it is difficult to draw firm conclusions about the effectiveness of these interventions. Therefore, there is scarce evidence available to be used in clinical practice.

Nevertheless, this review is an important starting point to understand the state of the evidence and to identify future directions for upper limb interventions in children with bilateral CP where possible. The study by Bleyenheuft et al.⁶⁷ on the effects of HABIT-ILE provides level

II evidence, strong methodological quality, and shows promising results, even though their intervention was not entirely focused on upper limb function but integrated with a lower limb intervention. In addition, the intervention was not tailored to children with more severe motor types of CP (MACS levels IV and V). Whether children with these complex types can participate in a bimanual intensive training programme, such as the HABIT-ILE training, could be further explored using a single-case design.

In conclusion, we recommend further research specifically aimed at bimanual intensive, goal-directed, and task-specific training programmes for the upper limb in children with bilateral CP using either high-quality (multicentre) RCTs or well-designed single-case trials.

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SUPPORTING INFORMATION

The following additional material may be found online:

Appendix S1: Search strategy.

Table S1: Conduct questions with item criteria for quality assessment

Table SII: Summary of studies: interventions and participants

Table SIII: Summary of studies: outcomes, measures, and results

Figure S1: Processes performed to identify studies for inclusion.

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RESUMEN**INTERVENCIONES PARA MEJORAR LA FUNCIÓN DE LAS EXTREMIDADES SUPERIORES EN NIÑOS CON PARÁLISIS CEREBRAL BILATERAL: UNA REVISIÓN SISTEMÁTICA**

OBJETIVO Revisar sistemáticamente la eficacia de la función de la extremidad superior con las intervenciones realizadas en niños de 0 a 19 años de edad con parálisis cerebral bilateral basada en medidas de la función de la extremidad superior, de actividades y / o participación, según la Clasificación Internacional del Funcionamiento, de la Discapacidad y de la Salud.

MÉTODO Se investigaron desde su inicio hasta septiembre del 2017 las siguientes bases de datos: Cochrane, PubMed, Embase, CINAHL y Web of Science. Tres evaluadores independientes analizaron la calidad metodológica y la calidad de la evidencia utilizando el nivel de evidencia de Sackett y las guías de la Academia Americana para la Parálisis Cerebral y Medicina del Desarrollo (AAPDM).

RESULTADOS Quince estudios con una gran variedad de intervenciones y heterogeneidad en las escalas de resultado cumplieron con los criterios de inclusión. Doce estudios proporcionaron evidencia nivel IV de acuerdo con las guías de la AAPDM. Otros tres ensayos pequeños controlados y aleatorios se clasificaron como nivel II de evidencia. Solo uno de estos ensayos mostró una calidad metodológica sólida que consista en un estudio sobre terapia bimanual intensiva mano-brazo que incluía extremidades inferiores.

INTERPRETACIÓN Se identificaron una gran variedad de intervenciones, heterogeneidad en las escalas de medición de los resultados, y en general una calidad metodológica de débil a moderada para la mayoría de los estudios. Recomendamos investigaciones adicionales dirigidas específicamente a programas de entrenamiento bimanual, orientado a objetivos específicos para la tarea del miembro superior en niños con parálisis cerebral bilateral, utilizando ensayos de alta calidad (multicéntricos) o ensayos dirigidos a estudiar solo un concepto bien diseñados.

RESUMO**INTERVENÇÕES PARA MELHORAR A FUNÇÃO DO MEMBRO SUPERIOR EM CRIANÇAS COM PARALISIA CEREBRAL BILATERAL: UMA REVISÃO SISTEMÁTICA**

OBJETIVO Revisar sistematicamente a eficácia de intervenções para a função do membro superior em crianças de 0 a 19 anos de idade com paralisia cerebral bilateral com base em medidas de resultado da função do membro superior e medidas de atividades e/ou participação de acordo com a Classificação Internacional de Funcionalidade, Incapacidade e Saúde.

MÉTODO Cochrane, PubMed, Embase, CINAHL, e Web of Science foram pesquisadas do início até setembro de 2017. A qualidade metodológica e força da evidência foram analisados por três avaliadores independentes usando o nível Sackett's e evidência e as diretrizes da Academia Americana de Paralisia Cerebral e Medicina do Desenvolvimento (AAPDM).

RESULTADOS Quinze estudos com uma grande variedade de intervenções e heterogeneidade de medidas de resultado atenderam aos critérios de inclusão. Doze estudos forneceram evidência nível IV de acordo com as diretrizes da AAPDM. Para três pequenos estudos randomizados controlados o nível de evidência foi II. Apenas um destes estudos mostrou forte qualidade metodológica: um estudo sobre terapia intensiva bimanual mão-braço incluindo as extremidades inferiores.

INTERPRETAÇÃO Identificamos uma grande variedade de intervenções, heterogeneidade em medidas de resultado, e em geral qualidade metodológica de fraca a moderada para a maioria dos estudos. Recomendamos mais pesquisas especificamente voltadas para programas de treinamento intensivos bimanuais, direcionados a objetivos e específicos para tarefas para o membro superior de crianças com paralisia cerebral usando ou estudos de alta qualidade (multicêntricos) ou estudos de sujeito único bem desenhados.