Efficacy of early interventions with active parent implementation in low-and-middle income countries for young children with cerebral palsy to improve child development and parent mental health outcomes: a systematic review

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ABSTRACT

Purpose: To determine the efficacy of interventions with active parent implementation for young children with cerebral palsy (CP) to improve child and parent outcomes in low-middle income countries (LMICs).

Methods: Five databases were systematically searched. Randomised or comparison studies evaluating interventions with the training of the parent and/or home practice components to implement with their child with CP (< 60 months of age) were included. The modified Downs and Black scale assessed methodological quality. Data were pooled to calculate mean differences and 95% confidence intervals (95% CI).

Results: Searches yielded 189 unique articles. 11 studies from ten papers of moderate to high quality were included. Parent-implemented general developmental interventions had a small negative effect on gross motor function compared to interventionist-implemented therapy. Parent-implemented upper limb training compared to interventionist-implemented neurodevelopmental therapy had a small positive effect on bimanual hand function. Parent-implemented functional feeding training had a large significant effect on chewing function compared to parent-implemented oral motor exercises. Parent-implemented interventions targeting general child development and feeding had mixed effects on parent stress outcomes.

Conclusions: Parent-implemented interventions in LMICs are promising to improve child bimanual hand and chewing function. Further research evaluating the efficacy of parent-implemented interventions to improve parent mental health is needed.

IMPLICATIONS FOR REHABILITATION:

- Intensive motor training-based interventions with active parent implementation were effective to improve child gross motor, bimanual hand, and chewing function in young children with CP compared to passive, generic interventionist-implemented or health education interventions.
- Interventions with active parent implementation had mixed results to improve parent mental health, however, this was frequently not assessed. A consistent level of support and training provided to parents may be required to have a positive effect on parent stress.
- To further understand the feasibility of early interventions with active parent implementation in LMICs, data on adherence to home practice dose and session attendance and a qualitative understanding of contextual and child factors influencing parent implementation is needed.

Introduction

The leading cause of motor disability in children worldwide is cerebral palsy (CP) [1]. The condition is defined as a group of disorders related to movement and posture that cause activity limitations and motor impairment [2]. The prevalence of CP is disproportionately higher in low-and-middle-income countries (LMICs), with an estimate of 1 per 345 live births compared to 1 in 700 in high-income countries (HICs) [3,4]. The severity of motor impairment and frequency of comorbidities are greater in LMICs compared to HICs, with between 55 to 61% of children being marginal ambulators or non-ambulant, compared to 37% in HICs [5,6].

Caregivers of children with CP in LMICs experience higher rates of stress, and depression than caregivers of children without a disability [7]. Increased burden of care and responsibilities to manage their child’s healthcare as well as limited knowledge about disability and poverty may contribute to parent mental health challenges [8]. This can lead to difficulties with the parent-child relationship [9] and further impact child developmental outcomes [10]. The use of parents to implement early intervention can prioritise the parent-child relationship and provide mutually enjoyable parent-infant interactions and improve parental mental health [11]. Currently, clinical practice guidelines for early
intervention strongly recommend task-specific motor training, daily practice, and parent coaching to structure practice beyond scheduled therapy sessions and teach parents to build relational connections with their infant [11]. Coaching of families can work to build parents’ capacity to provide targeted practice of specific exercises and activities to optimise repetition, the intensity of practice, and consequently developmental outcomes [11]. Qualitative studies have, however, suggested that implementing intervention at home can be challenging for parents when there is not enough time and when still coping with grief about their child’s disability [12,13].

The international clinical practice guidelines for early intervention in CP are underpinned by a range of systematic reviews and clinical trials undertaken in HICs, which may not be generalisable or feasible in LMICs [11]. Additional contextual barriers in LMICs may impact both the implementation and effectiveness of early interventions for children with CP. Families in LMICs face additional barriers to accessing task-specific motor training with daily practice and positive parent-child interaction. These barriers include financial constraints and increased travel distances compounded by societal stigma regarding disability [14,15]. Scarce human resources for paediatric care in LMICs can also limit the capacity of health care professionals to provide early intervention to children, education, and support to parents [16]. Supporting early interventions with active parent implementation in LMICs may address these barriers and pose as a sustainable model of providing care to the large number of children with CP in LMICs.

To date, there have been no systematic reviews of the efficacy of early interventions with active parent implementation in LMICs to improve child development and/or parent mental health. This study aimed to systematically review the efficacy of early interventions with active parent implementation in children with CP, conducted in LMICs, to improve either child developmental or parent mental health outcomes.

Methods

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [17]. The objectives and methods of this review were registered in the International Prospective Register of Systematic Reviews (PROSPERO) (CRD42020180115).

Search strategy

The following databases were comprehensively searched by the first author: PubMed, Web of Science, PsycINFO, Cochrane, and Embase from January 1950 to December 2020. Abstracts from conferences and dissertations were excluded. Reference lists of included articles were hand-searched to identify any further articles meeting inclusion criteria. See Appendix S1 (online supporting information) for search terms by the database.

Selection criteria

The initial search and removal of duplicates were performed by the first author. Two authors independently screened abstracts. Inclusion criteria were as follows:

1. study was a randomised controlled trial (RCT, including wait-list design), controlled-cohort study, controlled crossover trial with a sample of $n \geq 5$, interrupted time series, or $n \geq 10$ case series with a comparison group and/or period;

2. population comprised children diagnosed with, or at high risk of CP with a mean age less than 60 months at study entry and their parent/s;

3. intervention included active parent implementation including a parent-implemented home program or the interventionist training/coaching the parent with their child;

4. studies were in part conducted in the home or community context;

5. studies were conducted in an LMIC as defined by the World Bank classifications based on gross national income [18];

6. study outcomes included parent psychosocial measures such as depression and stress, or caregiver-child relationship outcomes; and/or child developmental measures such as motor, cognitive, communication, adaptive, and behavioural skills.

Studies were excluded if they were:

1. not peer-reviewed full-text publications and published in English due to limited availability of translation services;

2. conducted with low-income groups within a HIC;

3. implemented by a therapist directly to a child without parent involvement;

Abstracts meeting inclusion criteria or those requiring the full text to clarify inclusion were retained and reviewed independently by two authors. The consensus was reached through discussion. Articles were reviewed by a third author where any disagreements about eligibility arose.

Data extraction

Data were extracted independently by two authors, including population characteristics, intervention content and methods, the theoretical structure, content, and dosage of the intervention programs, and outcomes relating to child developmental, parental mental health, or parent-child interaction measures. The outcome data from immediately following completion of the intervention or comparison arm time points were extracted.

Data synthesis

Methodological quality and risk of bias

The methodological quality of each included study was assessed against the modified Downs and Black scale [19] by two independent reviewers with disagreements resolved through consultation with another author. The Downs and Black scale assesses the quality of experimental and observational studies and is organised into 4 broad categories: reporting, external validity, internal validity (bias and confounding), and power [20]. A quality score (maximum of 28) was allocated to each study, with scores $\geq 21$ considered high quality, 14–20 moderate quality, and $<14$ low quality [20].

Effect size calculation

For studies reporting continuous outcomes, the effect sizes (Cohen’s $d$) and 95% confidence intervals (CIs) for each child and parent outcome at the post-intervention time point were calculated [21]. The effect size expresses the magnitude of the effect of the intervention regardless of statistical significance. Cohen suggests $d=0.2$ is a small effect, 0.5 is a medium effect and 0.8 is a large effect size [21]. For studies with dichotomous outcomes, odds ratios (ORs) and 95% CIs were calculated. An OR greater than one indicated that children or parents in the intervention group were more likely than children or parents in the control
group to achieve a specific outcome. Where meta-analysis was possible, data were pooled. Either mean differences (MD) were calculated when homogeneity of outcome measures was present, otherwise standardised mean differences (SMD) were calculated using a random-effects model due to heterogeneity of interventions anticipated before executing the systematic searches of the database. All analyses were completed using STATA 16 and RevMan 5.4.

Results

Description of studies

A total of 189 unique articles were identified for potential inclusion. After the independent screening of title and abstract by two authors, full texts of 36 articles were reviewed, with 10 papers consisting of 11 studies meeting the full inclusion criteria [22–31]. One paper comprised two experimental studies with unique participants, one conducted in an urban setting and one in a rural setting [22]. Nine papers consisting of 10 studies were RCTs [22,32–39] and one study was a controlled clinical trial [40]. The flow of studies through the search process is summarised in the PRISMA flow chart (Figure 1).

Participant and study characteristics

In total, the 11 studies included 612 children with a confirmed diagnosis of CP. Four studies were undertaken in Africa (Zimbabwe, South Africa, Zambia, and Tanzania) [34,36,37,40], five in Asia (Bangladesh, India, Pakistan, and Turkey) [22,33,34,39], two in the Middle East (Iran, Jordan) [32,35], and one in South America (Brazil) [38]. The primary aim of these studies was to improve child development (7 studies; n = 376 children) [22,34–36,38,40], feeding and weight gain (3 studies; n = 222 children) [33,37,39] or upper limb outcomes (1 study; n = 14 children) [32]. In four studies, secondary aims were to improve parent mental health outcomes (n = 214 children) [22,37,40]. The participant and study characteristics are reported in Table 1.

The content and structure of parent-implemented early interventions and control/comparison conditions are detailed in Table 2. Early interventions focused on general development, upper limb, and functional feeding content areas. Parent-implemented components of interventions and control arms included parent-implemented home program and/or interventionist training of the parent with the child. Interventions and control arms also included interventionist-implemented therapy and health advice components.

Seven studies targeted general child development [22,34–36,38,40]. Interventions consisted of parent-implemented home practice programs or interventionist training the parent [22,34–36,38,40] and four studies included interventionist-implemented therapy and/or health advice components as well [35,36,38,40]. In three studies, the interventionist trained the parent with their child in motor, speech, language, and cognitive activities [22,34]. One study also included health advice on nutrition and hygiene, and a daily parent-implemented home program [34]. Three studies included therapist training of the parent in positioning and functional activities, interventionist-implemented individual therapy, and a daily home program [35,36,38]. In another study, a parent group on home exercise programs and health advice was

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**Figure 1.** PRISMA flow diagram demonstrating the flow of studies through the review.
Table 1. Population characteristics and methods of included studies.

| Author, year       | Country                          | Design      | Mean age (mths, SD) | Gender n | Treatment                                                                 | n     | Control                                      | n     | Dropout (%) |
|--------------------|----------------------------------|-------------|---------------------|----------|---------------------------------------------------------------------------|-------|----------------------------------------------|-------|--------------|
| Al-Oraibi et al. 2011 | Jordan                           | RCT         | 57 (24)             |          | UL training (CIMT)                                                        | 7     | General developmental intervention (NDT)    | 7     | 35           |
| Arslan et al. 2017 | Turkey                           | RCT         | 42 (24)             |          | Functional feeding intervention (Functional Chewing Training)             | 50    | Passive feeding intervention (Traditional oral motor exercises)            | 30    | 0            |
| Carlo et al. 2013 * | India, Pakistan, Zambia          | RCT         | <1 (range 28–42 weeks g.a.) | 97 (59) | General developmental intervention (Early intervention and health care counselling) | 59    | Health education and care (Health care counselling)                        | 64    | 6            |
| Dambi et al. 2014  | Zimbabwe                         | CCT         | 26 (36)             |          | General developmental intervention (Community-based rehabilitation)       | 20    | General developmental intervention (Institutional rehabilitation)          | 26    | 25           |
| Ghorbanpour et al. 2019 | Iran                            | RCT         | 44 (17)             |          | General developmental intervention (Mothering handling training)          | 19    | General developmental intervention (Occupational therapy)                  | 20    | 3            |
| Hughes et al. 2017 | South Africa                     | RCT         | NR (range 18–68 mths) |          | General developmental intervention (Individual therapy with thumb splint home program) | 9     | General developmental intervention (Individual therapy and home program)   | 10    | 32           |
| Inal et al. 2017   | Turkey                           | RCT         | 58 (9.6)            |          | Functional feeding intervention (Functional Chewing Training)             | 16    | Passive feeding intervention (Traditional oral motor exercises)            | 16    | 20           |
| McConachie et al. 2000A | Bangladesh                     | RCT         | 35 (11)             |          | General developmental intervention (Urban distance parent training)       | 16    | General developmental intervention (Urban mother-child group)              | 11    | 40           |
| McConachie et al. 2000 B | Bangladesh                    | RCT         | 43 (14)             |          | General developmental intervention (Rural distance parent training)        | 19    | Health education and care (Rural health Advice)                             | 12    | 23           |
| Miinda et al. 2018 | Tanzania                         | RCT         | 28 (12.3)           |          | Functional feeding intervention (Clinic-based nutrition education, occupational therapy) | 63    | Health education and care (Routine health care)                            | 47    | 7            |
| Saquetto et al. 2018 | Brazil                          | RCT         | 55 (32)             |          | General developmental intervention (Conventional rehabilitation and parent education program) | 29    | General developmental intervention (Conventional rehabilitation program)     | 31    | 0            |

CCT: Clinical controlled trial; g.a.: gestational age; UL: upper limb; CIMT: constraint induced movement therapy; NDT: neurodevelopmental therapy; RCT: Randomised controlled trial; CP: Cerebral palsy; mths: months; NR: not reported.

*Data from only the randomised controlled trial implemented in infants with birth asphyxia unresponsive to stimulation and the initial step of resuscitation who received bag and mask ventilation were included in this review. This population met the inclusion criteria for being at high risk of CP [31].

Reasons for withdrawal or lack of assessment included technical problems [32], difficulties arranging transport to the sessions [32], child death [22,34], loss to follow up [33,34,37,39], change in location [40], caregiver illness [40], child ill health [39] or parent refusal of assessment [22].
### Table 2. Planned structure and content of intervention programs.

| Author, year | Content of intervention program | Duration (mths) | Frequency of sessions/mth | Intensity (hrs/session) | Total dose (hrs total) | Content of control program | Duration (mths) | Frequency of sessions/mth | Intensity (hrs/session) | Total dose (hrs total) |
|--------------|---------------------------------|-----------------|---------------------------|------------------------|-----------------------|---------------------------|-----------------|---------------------------|------------------------|-----------------------|
| Al-Oraibi et al. 2011* | Title: CIMT. Context: Community-based rehabilitation facility. Content: Individual adapted CIMT using a glove on the dominant hand to perform fine motor activities; parental education and discussion; home program and diary to record practice. Interventionist PT | 2 | IP: 4; PH: 48 (6 days/wk) | IP: 1–2; PH: 2 | IP: NR; PH: 96 | Title: NDT. Context: Community-based rehabilitation facility. Home. Content: Individual face-to-face NDT including weight-bearing and facilitation of arm movement. Interventionist: PT | 2 | IT: 4; PH: NR | IT: 1–2; PH: NR | IT: 8–16; PH: NR |
| Arslan et al. 2017* | Title: Functional chewing training. Context: Community-based rehabilitation facility. Content: Individual parent training program on positioning the child and food, sensory stimulation, chewing exercises and food consistency; a weekly follow-up phone call with parent; Interventionist: PT | 3 | IP: 3; PH: 75 (5 times/day, 5 days/wk) | IP: NR; PH: 0.3 | IP: NR; PH: 100 | Title: Traditional oral motor exercises. Context: Community-based rehabilitation facility. Content: Individual face-to-face parent training on traditional oral motor exercises including passive and active exercises of lips and tongue; weekly follow-up phone call with parent. Interventionist: PT | 3 | IP: 3; PH: 75 (5 times/day, 5 days/wk) | IP: NR; PH: 0.3 | IP: NR; PH: 100 |
| Carlo et al. 2013* | Title: Early intervention and health care counselling. Context: Home. Content: Individual parent training program of cognitive, fine motor, gross motor, social, self-care and language learning activities; pictorial cards of activities; parent home practice; health education including breastfeeding, nutrition, hygiene, safety in the home and community, awareness of danger signs, diarrhoea management, health check-ups and vaccinations. Interventionist: Parent trainer | 36 | HA: 2–4; PH: NR | HA: NR; PH: NR | HA: NR; PH: NR | Title: Health care counselling. Content: Home. Content: Health education including breastfeeding, nutrition, hygiene, safety in the home and community, awareness of danger signs, diarrhoea management, health check-ups and vaccinations. Interventionist: Parent trainer | 36 | HA: 2–4; PH: NR | HA: NR; PH: NR | HA: NR; PH: NR |
| Dambi et al. 2014* | Title: Community-based rehabilitation. Context: Community-based rehabilitation facility. Content: Individual therapy; Group parent training group activities for a home exercise program and group discussion; Group health promotional talks on CP, burden of care; provision of light refreshments. Interventionist: Parent trainer | 3 | IT/IP: 2; PH: NR | IT/IP: Range 0.2–0.4; PH: NR | IT/IP: Range 1.2–2.4; PH: NR | Title: Institutional rehabilitation. Context: Hospital out-patient rehabilitation. Content Individual face-to-face therapy. Interventionist: PT | 3 | IT: Range 1–9; PH: NR | IT: Range 0.27–0.54; PH: NR | IT: Range 1.6–3.2; PH: NR |
| Ghorbanpour et al. 2019* | Title: Mothering handling training. Context: Home. Content: Individual parent training on handling including principles of movement development, best positions and movements during bathing, sleeping, eating, playing, dressing, lifting and carrying the child in- and outdoors; parent education on daily living activities and home adaptation using manual; routine OT; weekly follow-up phone calls. Interventionist: OT | 3 | IP: Initial training: Once off; Follow-up contact: 4; IT: 8; PH: NR | IP: Initial training: 4; Follow-up NR: IT: 0.75; PH: NR | IP: Initial training: 4; total: NR. | Title: Routine OT. Context: Community-based rehabilitation facility. Content: Routine OT including stretching, positioning, strengthening. Interventionist: OT | 3 | IT: 12; PH: NR | IT: 0.75; PH: NR | IT: 27; PH: NR |
| Hughes et al. 2017* | Title: Individual therapy with thumb splint home program. Context: Hospital out-patient clinic, home. Content: Individual therapy with child; home program with standard neoprene thumb abduction splint including neurodevelopmental theory preparation techniques, active graded exercise, and functional task practice. Interventionist OT | 3 | IT: 1; PH: 3/day | IT: NR; PH: NR | IT: NR; PH: NR | Title: Individual therapy and home program. Context: Hospital out-patient clinic, home. Content: Individual therapy with child; home program including neurodevelopmental theory preparation techniques, active graded exercise, and functional task practice. Interventionist: OT | 3 | IT: 1; PH: 3/day | IT: NR; PH: NR | IT: NR; PH: NR |

(continued)
| Author, year | Content of intervention program | Duration (mths) | Frequency of sessions/mth | Intensity (hrs/session) | Total dose (hrs total) | Content of control program | Duration (mths) | Frequency of sessions/mth | Intensity (hrs/session) | Total dose (hrs total) |
|--------------|---------------------------------|----------------|--------------------------|------------------------|----------------------|---------------------------|----------------|--------------------------|------------------------|----------------------|
| Inal et al. 2017* | Title: Functional chewing training. Context: Community-based rehabilitation facility. Content: Individual parent training program on positioning the child and food, sensory stimulation, chewing exercises and food consistency; weekly follow-up phone call with parent; Interventionist: PT | 3 | IP: 3. PH: 75 (5 times/day, 5 days/week) | IP: NR. PH: 0.3 | IP: NR. PH: 100 | Title: Traditional oral motor exercises. Context: Community-based rehabilitation facility. Content: Individual face-to-face parent training on traditional oral motor exercises including passive and active exercises of lips and tongue; weekly follow-up phone call with a parent. Interventionist PT | 3 | IP: 3. PH: 75 (5 times/day, 5 days/week) | IP: NR. PH: 0.3 | IP: NR. PH: 100 |
| McConachie et al. 2000 A* | Title: Urban distance parent training. Context: Urban community-based special school, home. Content: Individual parent training to demonstrate the practice of activities for motor, speech, language and cognitive skills; Take-home pictorial manuals including positioning, activities, homemade aids; Interventionist: Special education teachers | 9–12 | IP: 1. PH: NR | IP: 1–2. PH: NR | IP: 3–6. PH: NR | Title: Urban mother-child group. Context: Urban community-based special school. Content: Group practice in daily living skills and developmental activities. Interventionist: Special education teachers. | 9–12 | IP: Daily. PH: NR. | IP: NR. PH: NR | IP: NR. PH: NR |
| McConachie et al. 2000 B* | Title: Rural distance parent training. Context: Rural community-based special school, home. Content: Individual parent training to demonstrate practice of activities for motor, speech, language and cognitive skills; Take-home pictorial manuals including positioning, activities, homemade aids; Interventionist: Special education teachers | 9–12 | IP: 1. PH: NR | IP: 1–2. PH: NR | IP: 3–6. PH: NR | Title: Rural health advice. Context: Rural community-based special school. Content: Individual advice on health and nutrition, provision of vitamin supplements, given a box of toys and books to take home. Interventionist: Paediatrician. | 9–12 | HA: Once-off. PH: NR. | HA: NR. PH: NR | HA: NR. PH: NR |
| Mlinda et al. 2018* | Title: Nutrition education and OT. Context: Hospital out-patient clinic, home. Content: Group/individual nutrition education, training of parents on positioning during feeding, feeding techniques and appropriate utensils, and occupational therapy for oral motors and functional skills; free plastic feeding equipment; one home visit. Interventionist OT | 6 | IP: range 6–8 total. HV: 1 total PH: NR | IP: Education sessions: NR. PH: 0.5. HV:NR. PH: NR | IP: Education sessions: NR. PH: 3–4. | Title: Routine care. Context: Hospital out-patient clinic. Content: Individual routine care: general health education, nutritional assessment, PT bi-monthly if spasticity. Interventionist: Paediatrician. PH: 0.5 | 12 | IT/HA: Every 2 months. PH: NR. | IT/HA: NR. PH: NR. IT/HA: NR. PH: NR | IT/HA: NR. PH: NR. IT/HA: NR. PH: NR |
| Saquetto et al. 2018* | Title: Conventional rehabilitation and parent education program. Context: Community-based rehabilitation centre. Content: Individual therapy using neurodevelopmental approaches; activities included the acquisition of functional skills, transfer of postures, maintenance of positions; parent education on daily motor activities, goal-setting, self-directed learning strategies; home program to practice participation in self-care activities; parent to complete activity log. Interventionist: PT. | 3 | IT/IP: 4. PH: Daily IT/IP: 0.75. PH: 0.5 | IT/IP: 9. PH: 14 | Title: Conventional rehabilitation program. Context: Community-based rehabilitation centre. Content: Individual therapy using neurodevelopmental approaches; activities included the acquisition of functional skills, transfer of postures, maintenance of positions. Interventionist: PT | 3 | IT: 4. PH: NR | IT: 0.5. PH: NR | IT: 6. PH: NR |

CP: cerebral palsy; OT: occupational therapy; PT: physiotherapy; NR: not reported; mths: month; hrs: hours; IT: Interventionist-implemented therapy; HA: health advice; IP: interventionist training of the parent; PH: parent-implemented home practice; HV: home visit; *intervention is primarily implemented by parents; *intervention is equally implemented by parent and therapist/interventionist.
conducted alongside interventionist-implemented individual therapy [40]. Parent practice and adaptation of activities for the home were supported through parent-completed logs of home practice [38], weekly follow-up phone calls [35], the provision of manuals [22,35], and pictorial cards of developmental activities [34]. In six studies, the primary dose of intervention was implemented by the parent during daily home practice programs and therapist training of the parent with the child [22,34–36,38]. In one study, the primary dose of intervention was implemented equally by the therapist and the parent [40].

The comparison arm of two general child development studies included the therapist training the parent with their child [22,36] and a parent-implemented home program [36]. One study compared the therapist training the parent, to a daily urban mother-child group where special education teachers trained parents in daily living skills (i.e., drinking from a cup) and developmental activities practice (i.e., colour matching) [22]. One study compared a neoprene splinting approach plus an interventionist-implemented therapy and a parent-implemented home program, to the same intervention without the splinting approach [36]. The comparison arms of the remaining studies consisted of passive or usual care interventionist-implemented therapy [35,38,40], or health advice [22,34].

Functional feeding interventions involved the intervention training of parents plus a parent-implemented home program; compared to care as usual or health advice. In all three studies the primary dose of intervention was implemented by the parent [33,37,39]. The intervention of two studies involved the interventionist training the parent on food positioning, food consistency, sensory stimulation, and active motor chewing exercises (4 times/month), alongside a parent-implemented home program (6 days/week) and weekly follow-up calls [33,39]. This intervention was compared to dose-matched parent-implemented oral motor exercises involving a passive and active range of motion exercises of lips and tongue [33,39]. In another study, group parent education on the principles of child positioning, food consistency, feeding techniques, and utensil used in conjunction with the therapist training the parents on positioning and feeding techniques (1 time/month); was compared to health education (1 time/2 month) [37].

The intensive upper limb training intervention encompassed modified constraint-induced movement therapy (mCIMT) which involved weekly parent-implemented training and a daily parent home practice program [32]. The interventionist trained parents to engage their child in fine motor activities while a custom glove was placed on the child’s dominant hand [32]. The primary dose of intervention was implemented by the parent and the comparison arm was an interventionist-implemented passive motor training approach.

Intervention duration varied from two [32] to 36 months [34]. The frequency of intervention sessions ranged from one to four sessions per month with session length ranging from 0.2 [31] to four hours [35]. The total dose of parent-implemented training ranged between four [35] to six hours [22]. The total dose of parent-implemented training combined with interventionist-implemented therapy varied from 1.2 [40] to nine hours [38]. The total dose of parent-implemented training and/or interventionist-implemented therapy was not reported in four studies [32–34,39]. The total dose of home practice programs varied from 14 [29] to 100 h [33,39]. There were seven that did not define the dose or frequency of the home practice program implemented by the parent [22,34–37,40]. Reporting of fidelity measurements including adherence to intervention sessions (attendance to interventionist-implemented or interventionist training of parent sessions) and total dose of parent-implemented home practice varied between studies. Two studies reported that 69% of urban parents and 63% of rural parents attended four of nine (44%) parent training sessions [22]. In three studies, adherence to intervention sessions was over 90% [32,34,40]. Adherence was not reported in six studies [33,35–39]. Two studies monitored the parent-implemented home practice dosage [32,34]. One study reported that parents practiced for a mean of 4.3/7 days per week (62.1% of expected dose) over the 36 month study duration [34]. Another study reported that children wore the modified constraint glove for a mean of 92.2/96 (SD = 29.2) hours and completed 56.6/96 (SD = 25.7) hours of fine motor activities over two months [32]. There was no reporting on adverse events in any study [22,32–37,39,40].

Methodological quality
Methodological quality was high in three studies (i.e., >20–28 [34,35,39], and moderate in eight studies (score range 14–20, Table 3) [22,32,33,35–37,40]. Five studies had adequate power to detect statistically significant differences in the primary outcomes [22,34,39,40]. The raters of seven studies were masked to group allocation [22,32–35,39] and four studies used concealed random allocation [33,34,36,38].

Child outcomes
Child outcomes from ten studies are reported in Table 4. Data from three interventions targeting general development comprising of the interventionist training the parent, interventionist-implemented therapy, and parent-implemented home practice elements (n = 68) compared to interventionist-implemented care as usual (n = 77) yielded a mean difference (MD) of −0.41 logits (95% CI −5.31, 4.49; p = 0.87) for gross motor function on the Gross Motor Function Measure-66 (GMFM-66) at the postintervention timepoint (see Figure 2) [35,38,40]. Three studies reported upper limb outcomes [35,38,40]. Intensive upper limb training using modified constraint-induced movement therapy (mCIMT) and a parent-implemented home program, compared to interventionist-implemented care as usual (neurodevelopmental therapy) had a small positive effect to improve bimanual hand function measured on the Assisting Hand Assessment (ES 0.37, 95% CI −0.72, 1.40; p = 0.51) [32]. A general developmental intervention where the interventionist trained the parent in positioning and movement activities and a parent-implemented home program conferred no additional benefit over interventionist-implemented care as usual to improve the acquisition of fine motor skills measured on the Peabody Fine Motor Scales (ES −0.18, 95% CI −0.80, 0.46; p = 0.59) [35]. One study comparing a parent-implemented intervention of a neoprene splinting approach, interventionist-implemented therapy, and a parent-implemented home program, to the same intervention without the splinting approach led to small positive benefits to improve quality of upper limb movement on the Quality of Upper Extremities Skills Test measure (ES 0.29, 95% CI −0.63, 1.18; p = 0.53) [36].

One study including the interventionist training of the parent, a home program and health advice, compared to health advice alone had a small positive effect on psychomotor (ES 0.36, 95% CI 0.01, 0.72; p = 0.05) and cognitive (ES 0.37, 95% CI 0.01, 0.72; p = 0.04) development measured on Bayley Scales of Infant Development-II [34]. The interventionist training the parent on
Table 3. Summary of methodological quality of studies on the Modified Downs and Black Scale.

| Item description                                                                 | Al-Oraibi et al. 2011 | Arslan et al. 2017 | Carlo et al. 2013 | Dambi et al. 2014 | Ghorbanpour et al. 2019 | Hughes et al. 2017 | Inal et al. 2017 | McConachie et al. 2000 | Mlinda et al. 2018 | Saquetto et al. 2018 |
|-----------------------------------------------------------------------------------|------------------------|--------------------|-------------------|-------------------|------------------------|-------------------|-------------------|------------------------|----------------------|------------------------|
| 1. Is hypothesis/aim/objective of the study clearly described?                    | 1                      | 1                  | 1                 | 1                 | 1                      | 1                 | 1                 | 1                      | 1                    | 1                      |
| 2. Are main outcomes described in the introduction or Methods section?           | 1                      | 1                  | 1                 | 1                 | 1                      | 1                 | 1                 | 1                      | 1                    | 1                      |
| 3. Are characteristics of the patients clearly described?                        | 1                      | 1                  | 1                 | 1                 | 1                      | 1                 | 1                 | 1                      | 1                    | 1                      |
| 4. Are the interventions of interest clearly described?                          | 2                      | 2                  | 2                 | 2                 | 0                      | 2                 | 2                 | 2                      | 2                    | 1                      |
| 5. Are the distributions of principal confounders in each group of subjects to be compared clearly described? | 1                      | 1                  | 1                 | 1                 | 1                      | 1                 | 1                 | 1                      | 1                    | 1                      |
| 6. Are the main findings of the study clearly described?                         | 1                      | 1                  | 1                 | 1                 | 1                      | 1                 | 1                 | 1                      | 1                    | 1                      |
| 7. Estimates of the random variability for the main outcomes?                    | 2                      | 2                  | 2                 | 2                 | 2                      | 2                 | 2                 | 2                      | 2                    | 2                      |
| 8. Have all adverse events been reported?                                         | 0                      | 0                  | 0                 | 0                 | 0                      | 0                 | 0                 | 0                      | 0                    | 0                      |
| 9. Have characteristics of patients lost to f/u been described?                  | 1                      | 1                  | 1                 | 1                 | 1                      | 1                 | 1                 | 1                      | 1                    | 1                      |
| 10. Have actual probability values been reported for the main outcomes except where the probability value is < 0.001? | 0                      | 0                  | 0                 | 0                 | 0                      | 0                 | 0                 | 0                      | 0                    | 0                      |
| 11. Were subjects representative of the entire population from which they were recruited? | 0                      | 0                  | 0                 | 0                 | 0                      | 0                 | 0                 | 0                      | 0                    | 0                      |
| 12. Were subjects prepared to participate representative of the entire population from which they were recruited? | 0                      | 0                  | 0                 | 0                 | 0                      | 0                 | 0                 | 0                      | 0                    | 0                      |
| 13. Were staff, places, and facilities where the patients were treated, representative of the majority of patients receive? | 1                      | 0                  | 1                 | 0                 | 1                      | 1                 | 1                 | 0                      | 0                    | 0                      |
| 14. Was an attempt made to blind study subjects to the intervention they have received? | 0                      | 0                  | 0                 | 0                 | 0                      | 0                 | 0                 | 0                      | 0                    | 0                      |
| 15. Was an attempt made to blind those measuring the main outcomes of the intervention? | 1                      | 1                  | 1                 | 0                 | 1                      | 1                 | 1                 | 0                      | 1                    | 0                      |
| 16. If any of the results of the study were based on “data dredging” (unplanned analyses), was this made clear? | 1                      | 1                  | 1                 | 1                 | 1                      | 1                 | 1                 | 1                      | 1                    | 1                      |
| 17. In trials and cohort studies, do the analyses adjust for different lengths of f/u of patients, or case-control studies is the time period between intervention and outcome the same? | 1                      | 1                  | 1                 | 1                 | 1                      | 1                 | 1                 | 1                      | 1                    | 1                      |
| 18. Were statistical tests to assess main outcomes appropriate?                  | 1                      | 1                  | 1                 | 1                 | 1                      | 0                 | 1                 | 1                      | 1                    | 1                      |
| 19. Was compliance with the intervention’s reliable?                              | 1                      | 1                  | 1                 | 1                 | 1                      | 0                 | 1                 | 1                      | 1                    | 1                      |
| 20. Were outcome measures used accurate (valid/relaible)?                        | 1                      | 1                  | 1                 | 1                 | 1                      | 1                 | 1                 | 1                      | 1                    | 1                      |
| 21. Were patients in different intervention groups (trials and cohort studies) or case-controls recruited from same population? | 1                      | 1                  | 1                 | 0                 | 1                      | 1                 | 1                 | 1                      | 1                    | 1                      |
| 22. Were the study subjects in different intervention groups (trials and cohort studies) or case-controls recruited over same period of time? | 0                      | 0                  | 1                 | 1                 | 1                      | 1                 | 1                 | 1                      | 1                    | 1                      |
| 23. Were study subjects randomised to intervention groups?                       | 1                      | 1                  | 1                 | 0                 | 1                      | 1                 | 1                 | 1                      | 1                    | 1                      |
| 24. Was the randomised intervention assignment concealed from patients and staff until recruitment was complete? | 0                      | 1                  | 1                 | 0                 | 1                      | 0                 | 0                 | 0                      | 1                    | 0                      |
| 25. Was adequate adjustment for confounding in the analyses from which the main findings were drawn? | 1                      | 1                  | 1                 | 1                 | 1                      | 0                 | 1                 | 1                      | 1                    | 1                      |
| 26. Were losses of patients to follow-up taken into account?                      | 0                      | 1                  | 0                 | 0                 | 0                      | 0                 | 0                 | 0                      | 0                    | 0                      |
| 27. Did study have sufficient power to detect a clinically important effect where the probability value for a difference being due to chance is less than 5%? | 0                      | 0                  | 1                 | 0                 | 1                      | 0                 | 0                 | 1                      | 0                    | 1                      |

TOTAL SCORE (Maximum of 28) 18 20 25 16 22 15 21 19 17 20

Scores ≥21 considered high quality; 14–20 moderate quality; <14 low quality [20].

The modified Downs and Black scale utilises a 1 = yes, 0 = no/unable to determine a scoring system for 26 items. Item 5 uses a three-point scoring system where 2 = yes, 1 = partially and 0 = no [20].
| Author, year | Outcome | Outcome measure | Time Point (mths) | N | Intervention Mean (SD) | N | Control Mean (SD) | Effect size (Cohen's d) (95% CI) | P values |
|-------------|---------|----------------|------------------|---|----------------------|---|------------------|---------------------------------|---------|
| Al-Oraibi et al. 2011 | Bimanual hand function | Assisting hand assessment* (higher scores are better) | 2 | 7 | 6.43 (12.60)* | 7 | 0.57 (18.80)* | 0.37 (~0.72, 1.40) | 0.51 |
| Arslan et al. 2017 | Frequency of problematic child feeding behaviours and parent nutrition-related behaviours | Behavioral pediatrics feeding assessment scaleb (lower scores are better) | 3 | 50 | 69.14 (15.63) | 30 | 92.5 (19.49) | -1.36 (~0.25, 1.35) | <0.01 |
| Arslan et al. 2017 | Number of problematic child feeding behaviours and parent nutrition-related behaviours | Behavioral pediatrics feeding assessment scaleb (higher scores are better) | 3 | 50 | 4.48 (3.59) | 30 | 2.50 (0.94) | 1.78 (~2.31, 1.25) | <0.01 |
| Carlo et al. 2013 | Cognition | Bayley scales of infant development, 2nd edition, mental development indexc (higher scores are better) | 36 | 59 | 102.6 (9.8) | 64 | 98.0 (14.6) | 0.37 (~0.01, 0.72) | 0.04 |
| Carlo et al. 2013 | Motor function | Bayley scales of infant development, 2nd edition, psychomotor development indexc (higher scores are better) | 36 | 59 | 108.7 (12.0) | 64 | 103.3 (17.0) | 0.36 (~0.01, 0.72) | 0.05 |
| Carlo et al. 2013 | Social-emotional function | Ages and stages questionnaire f (higher scores are better) | 36 | 74 | 30.8 (21.1) | 80 | 35.1 (32.3) | -0.16 (~0.47, 0.16) | 0.33 |
| Dambi et al. 2014 | Gross motor function | Gross Motor Function Measure- 66e (higher scores are better) | 3 | 20 | 44.90 (19.80) | 26 | 43.50 (9.00) | 0.12 (~0.49, 0.68) | 0.75 |
| Ghorbanpour et al. 2019 | Gross motor function | Gross motor function measure- 66e (higher scores are better) | 3 | 19 | 40.18 (11.88) | 20 | 41.41 (12.01) | -0.10 (~0.72, 0.52) | 0.75 |
| Ghorbanpour et al. 2019 | Fine motor function | Peabody fine motor developmental scale-revision g (higher scores are better) | 3 | 19 | 101.20 (58.72) | 20 | 111.78 (61.36) | -0.18 (~0.80, 0.46) | 0.59 |
| Hughes et al. 2017 | Hand function | The quality of upper extremity skills testf (higher scores are better) | 3 | 9 | 45.16 (13.57)** | 10 | 39.95 (20.92) | 0.29 (~0.63, 1.18) | 0.53 |
| Inal et al. 2017 | Chewing function (normal chewing function) | Karaduman chewing performance scalej (lower scores are better) | 3 | 16 | 2.69 (0.95) | 16 | 3.25 (0.68) | -0.68 (~1.38, 0.05) | 0.06 |
| McConachie et al. 2000A | Child adaptive skills | Independent behaviour assessment scalek (higher z-scores are better) | 9–12 | 16 | -3.11 (1.10) | 11 | -2.75 (1.62) | -0.27 (~1.03, 0.51) | 0.50 |
| McConachie et al. 2000B | Child adaptive skills | Independent behaviour assessment scalek (higher z-scores are better) | 9–12 | 19 | -2.61 (2.40) | 12 | -2.50 (2.25) | -0.05 (~0.79, 0.70) | 0.90 |
| Saquetto et al. 2018 | Gross Motor Function | Gross motor function measure- 66e (higher scores are better) | 3 | 29 | 34.31 (16.10) | 31 | 35.00 (18.92) | 0.13 (~0.38, 0.64) | 0.61 |
| Saquetto et al. 2018 | Self-care | Paediatric evaluation of disability inventory functional skill scale (higher scores are better) | 3 | 29 | 43.32 (15.15) | 31 | 37.16 (18.08) | 0.37 (~0.14, 0.87) | 0.16 |
| Saquetto et al. 2018 | Mobility | Paediatric evaluation of disability inventory functional skill scale (higher scores are better) | 3 | 29 | 26.75 (8.86) | 31 | 25.25 (15.61) | 0.12 (~0.39, 0.62) | 0.65 |
| Saquetto et al. 2018 | Social functionality | Paediatric evaluation of disability inventory functional skill scale (higher scores are better) | 3 | 29 | 47.86 (14.13) | 31 | 42.32 (17.87) | 0.35 (~0.17, 0.85) | 0.19 |
| Saquetto et al. 2018 | Self-care | Paediatric evaluation of disability inventory caregiver assistance scale (higher scores are better) | 3 | 29 | 33.54 (27.38) | 31 | 22.77 (30.93) | 0.37 (~0.15, 0.87) | 0.16 |
Table 4. Continued.

| Author, year          | Outcome                      | Outcome measure                                                                 |
|-----------------------|-------------------------------|---------------------------------------------------------------------------------|
| N. BRANJERDPORN ET AL. | Saquetto et al. 2018         | Paediatric evaluation of disability inventory caregiver assistance scale\(^{a}\) (higher scores are better) |
|                       |                               | **Time Point (mths)** | **N** | **Mean (SD)** | **N** | **Mean (SD)** | **(95% CI)** | **P values** |
|                       |                               | 3                    | 29    | 26.86 (24.70) | 31    | 15.61 (28.69) | 0.42 (0.10, 0.93) | 0.11         |
|                       |                               | 3                    | 29    | 44.25 (27.56) | 31    | 31.71 (31.13) | 0.43 (0.09, 0.98) | 0.10         |
| Carlo et al. 2013     | Communication (≤38.7 normal)  | Ages and stages questionnaire\(^{b}\)                                        |
|                       |                               | 36                   | 71    | 2 (2.8)       | 78    | 8 (10.3)      | 0.26 (0.03, 1.34) | 0.10         |
| Carlo et al. 2013     | Gross motor (≤35.7 normal)    | Ages and stages questionnaire\(^{b}\)                                        |
|                       |                               | 36                   | 71    | 8 (11.3)      | 78    | 12 (15.4)     | 0.53 (0.18, 1.51) | 0.20         |
| Carlo et al. 2013     | Fine motor (≤30.7 normal)     | Ages and stages questionnaire\(^{b}\)                                        |
|                       |                               | 36                   | 71    | 9 (12.7)      | 78    | 18 (23.1)     | 0.49 (0.18, 1.25) | 0.14         |
| Carlo et al. 2013     | Problem solving (≤38.6 normal)| Ages and stages questionnaire\(^{b}\)                                        |
|                       |                               | 36                   | 71    | 18 (25.4)     | 78    | 19 (24.4)     | 1.05 (0.47, 2.37) | 1            |
| Carlo et al. 2013     | Personal social (≤38.7 normal)| Ages and stages questionnaire\(^{b}\)                                        |
|                       |                               | 36                   | 71    | 8 (11.3)      | 78    | 18 (23.1)     | 0.43 (0.15, 1.12) | 0.08         |
| Inal et al. 2017      | Tongue thrust severity (no tongue thrust) | Tongue thrust severity scale\(^{a}\)                                      |
|                       |                               | 3                    | 16    | 3 (18.8)      | 16    | 0 (0)         | NA           | NA           |
| Miinda et al. 2018    | Child oral motor feeding skills (Improved) | Informal observational measure\(^{a}\)                                   |
|                       |                               | 6                    | 63    | 37 (58.7)     | 47    | 21 (44.9)     | 1.76 (0.82, 3.78) | 0.15         |
| Miinda et al. 2018    | Child functional feeding skills (Improved) | Informal observational measure\(^{a}\)                                   |
|                       |                               | 6                    | 63    | 53 (84.1)     | 47    | 33 (70.2)     | 2.25 (0.90, 5.65) | 0.09         |

**CI:** confidence interval; **SD:** standard deviation.

\(^{a}\)The Assisting hand assessment (AHA) is a standardised criterion-referenced test which is scored on 22 items on a four-point rating scale (1, no use; 4, efficient use of the affected hand). The raw score sums are converted to logits based on the Rasch analysis, and then to a relative scale of 0–100 AHA units. A video-recorded play session is used to assess the spontaneous use of the hemiplegic hand in bimanual activities. A clinically meaningful difference in the assessment has been shown to be 3.89 [41].

\(^{b}\)The Behavioral Pediatrics Feeding Assessment Scale (BFAS) is a 35-item standardised, reliable and valid parent-reported questionnaire. Each item is rated on a five-point Likert scale based on the frequency with which a behaviour occurs and also the number of problematic feeding behaviours. Higher scores for frequency and problems are an indication of poorer mealtime functioning [42].

\(^{c}\)The Bayley Scales of Infant Development, 2nd edition is an overall development assessment tool and has been used extensively in a number of LMICs. The Bayley mental development and psychomotor scales have been standardised with a mean of 100 and a standard deviation of 15. Scores 85 and below have been classified as delayed [43].

\(^{d}\)Ages and Stages Questionnaire is a parent-reported screening tool measuring developmental milestones in five domains (communication, fine motor, gross motor, problem-solving ability and personal-social functioning). Each domain consists of six questions and parents indicate whether the milestone of the child is mastered (10 points), partly/inconsistently (5 points), or not yet (0 points). The separate scores from each of the domains are scored separately. The measure has been used across low-middle income contexts [44].

\(^{e}\)The Gross Motor Function measure-66 is a measurement of gross motor function including lying and rolling, sitting, crawling and kneeling, standing, walking, running and jumping in children with cerebral palsy aged 5 months to 16 years old. The measure has high levels of validity and reliability (intraclass correlation coefficient >0.98) [45].

\(^{f}\)The Peabody Fine Motor Developmental Scale-Revision is a sub-section of a comprehensive tool that assesses the grasp, use of hand, eye-hand coordination and hand dexterity. The assessment has high validity and reliability and has been previously used with children in Iran [46].

\(^{g}\)The observational informal measure of child oral motor and functional feeding skills is a checklist developed for use in a previous feeding intervention study in an LMIC [46]. In this trial, the checklist had between good and excellent inter-rater reliability on Cohen's Kappa.

\(^{h}\)Indicates that change scores (pre-post) were used to calculate an effect size.

\(^{i}\)Indicates that score with splint was used in this calculation.
posture, positioning and functional activities with a parent-implemented home practice program, compared to interventionist-implemented therapy had a small positive effect to improve self-care (ES 0.37, 95% CI −0.14, 0.87; p = 0.16) and social (ES 0.35, 95% CI −0.17, 0.85; p = 0.19) outcomes, and small to moderate effects to reduce caregiver assistance for self-care (ES 0.37, 95% CI −0.15, 0.87; p = 0.16), mobility (ES 0.42, 95% CI −0.10, 0.93; p = 0.11) and social function (ES 0.43, 95% CI −0.09, 0.93; p = 0.10) measured on the Pediatric Evaluation of Disability Inventory [38].

Data pooled from two studies comparing two parent-implemented approaches indicated that functional feeding training implemented by parents (n = 66) compared to oral motor exercises implemented by parents (n = 46), had a positive effect on chewing function (MD 1.21; 95% CI 0.03, 2.44; p = 0.05) on the Karaduman Chewing Performance Scale (see Figure 3) [33,39]. Functional feeding compared to oral motor exercises also led to a large significant reduction in the number (ES 1.78, 95% CI 1.25, 2.31; p ≤ 0.01) and frequency (ES 1.36, 95% CI 0.25, 1.35; p ≤ 0.01) of problematic child feeding and parent-nutrition behaviours [33].

Interventionists training parents on individual nutrition and feeding positioning and resulted in a higher likelihood of improved oral motor feeding skills (odds ratio OR 1.76, 95% CI 0.82, 3.78; p = 0.15) and functional feeding skills (OR 2.25, 95% CI 0.90, 5.65; p = 0.09) compared to care as usual comprised of health and nutrition advice [37].

**Parent outcomes**

Studies reporting parent outcomes are summarised in Table 5. Parent-implemented interventions targeting general child development and feeding resulted in mixed parent stress outcomes. Data from two studies of interventionists training parents targeting general child development (n = 35) compared to health advice or a parent play group (n = 23) yielded an SMD of 1.4 (95% CI −0.98, 3.78; p = 0.25) to increase parent stress on the Self-Report Questionnaire [22] (see Figure 4). Whereas, interventionist-implemented therapy and interventionist training of parents in a home exercise program had a reduced likelihood of parent clinical distress on the Caregiver Strain Index (OR 1.67, 95% CI 0.51, 5.40; p = 0.39) compared to those receiving interventionist-implemented care as usual [40]. Interventionist training of parents combined with health advice also decreased the likelihood of parent stress during child feeding (OR 2.20, 95% CI 1.00, 4.86; p = 0.05) compared to care as usual [37]. Caregivers implementing the feeding intervention were more likely to appropriately position their child for feeding (OR 3.84, 95% CI 1.66, 8.87; p = 0.002), feed their child at a slower pace (OR 3.95, 95% CI 1.74, 9.08; p = 0.001) and provide greater support with higher child engagement in feeding (OR 2.7, 95% CI 1.24, 5.89; p = 0.01) [37]. Seven studies did not report on parent outcomes [32–36,38,39].

**Discussion**

The primary aim of this systematic review was to determine the efficacy of parent-implemented early interventions for young children with CP conducted in LMICs to improve child developmental outcomes and/or promote parent outcomes. The ten papers comprising 11 studies included in this review, involved parent-implemented interventions targeting general development, functional feeding, and upper limb training. Parent-implemented interventions were compared to heterogeneous control groups with interventionist-implemented and/or parent-implemented components, delivered at varying intensity. When considering child developmental outcomes, parent-implemented interventions compared to health education, interventionist-implemented therapy alone and another parent-implemented intervention found mixed results. A meta-analysis of three studies of interventionist training of parents, interventionist-implemented therapy and parent-implemented home practice elements compared to interventionist-implemented therapy alone yielded a small negative effect on gross motor function [35,38,40]. Functional and intensive feeding interventions and upper limb training with parent-implemented elements improved child chewing and hand function compared to passive or exercised-based interventions implemented by parents or interventionists [32,33,39]. When considering parent outcomes, parent-implemented interventions had mixed effects on parent stress. The likelihood of parent stress decreased following a functional feeding and general child developmental intervention with interventionist training of parents, compared to interventionist-implemented therapy [37,40]. Parents had higher stress following two general developmental intervention training of parent interventions compared to health advice or a parent play group [22]. These findings need to be considered alongside the age of the child participants, the intensity and content of the intervention, the level of support parents received, and the contextual and child factors that may influence families in LMICs.
| Time point (months) | Treatment | Control | N (%) | N | P-value | OR (95% CI) |
|--------------------|-----------|---------|-------|---|----------|-------------|
| N. BRANJERDPORN ET AL. | Informal measure | | 6 | 63 | 45 (71.4) | 47 | 25 (53.2) | 0.05 | 2.20 (1.00, 4.86) |
| Informal measure | | 6 | 34 (54.0) | 11 (23.4) | 0.002 | 3.84 (1.66, 8.87) |
| Informal measure | | 6 | 49 (77.8) | 22 (46.8) | 0.001 | 1.67 (1.74, 9.08) |
| Informal measure | | 6 | 42 (66.7) | 20 (42.6) | 0.01 | 2.7 (1.24, 5.89) |
| Informal measure | | 3 | 20 | 11 (55.0) | 26 | 11 (42.3) | 0.39 | 1.67 (0.51, 5.40) |
| Self-report Q-20*** | | 9–12 | 6 | 6.75 (4.69) | 6 | 4.71 | 0.69 | 0.16 (0.61, 0.92) |
| Self-report Q-20*** | | 9–12 | 5.74 (4.47) | 3.83 (3.37) | 0.25 | 1.04 (0.65, 1.64) |

**Table 5. Summary of results of studies reporting on parent outcomes.**

| Author, Year | Outcome measure* | N | Control | N | P-value | OR (95% CI) |
|--------------|------------------|---|---------|---|----------|-------------|
| Mindu et al. 2018 | Parent stress during feeding (Good) | 6 | 49 (77.8) | 22 (46.8) | 0.001 | 1.67 (1.74, 9.08) |
| Dambi et al. 2014 | Parent stress (Normal) | 3 | 20 | 11 (55.0) | 26 | 11 (42.3) | 0.39 | 1.67 (0.51, 5.40) |
| McConachie et al. 2000 A | Parent stress Self-report Q-20 | 9–12 | 6 | 6.75 (4.69) | 6 | 4.71 | 0.69 | 0.16 (0.61, 0.92) |
| McConachie et al. 2000 B | Parent stress Self-report Q-20 | 9–12 | 5.74 (4.47) | 3.83 (3.37) | 0.25 | 1.04 (0.65, 1.64) |

SMD: standard mean difference; CI: confidence interval; SD: standard deviation.

- The Caregiver Strain Index is a 13 item questionnaire of common stressors, a higher score indicates increase caregiver strain. The Caregiver Strain Index has been found to have good internal consistency (Cronbach's alpha 0.86) and good face and content validity within cross-cultural LMIC settings such as Malaysia [53].
- The Self-Report Questionnaire-20 is a 20-item self-report screening tool developed by the World Health Organisation specifically for primary health settings in low-middle-income countries. A yes/no response format is utilised to detect non-specific psychological distress. A higher score indicates greater psychological distress [54].

Apart from one study which recruited infants from birth [34], the average age of children at study entry was greater than 24 months, reflecting the historical delay in CP diagnosis, especially in LMICs [55]. The average age of diagnosis of CP is between 2 years 6 months and 4 years 6 months in LMICs [55]. The implementation of early screening in LMICs is increasing due to the availability of standardised tools. Tools such as the General Movements and Hammersmith Infant Neurological Examination for LMICs have been used in research studies in South Africa, Brazil, India, Iran, Bulgaria, Ghana, Brazil, Peru, Thailand and China and validation of these clinical tools for early detection of high risk of CP in LMICs is ongoing [23,24]. To optimise potential early motor and cognitive gains for infants at high risk, methods to increase the implementation of international guidelines for the early detection and diagnosis of CP in LMICs are needed. For infants in LMICs, these advances have the potential to decrease the of CP diagnoses and enable earlier intervention.

Current evidence for active motor learning [25] and optimising neuroplasticity [26], suggests that improvements in motor behaviour are dependent on the high-intensity goal-directed practice of child-initiated movement [27,28]. Parent implementation of early intervention can support families to ensure an adequate dose of task-specific practice and embed practice into daily routines [11]. Interventions with parent-implemented home programs with an expectation of daily practice (greater than six times per week; 14–100 h total) had positive effects across child’s hand function [32,34,36], gross motor [34,38], and oral motor [33,39] outcomes. In comparison, interventions with home programs where the frequency of practice was undefined [40], or where parent-implemented training occurred monthly [22], reported no effect on child adaptive skills [22], fine motor skills [35], and mixed effects on gross motor function [35,40]. The mechanism of experience-dependent plasticity may also explain how a comparison arm consisting of daily parent play group improved child adaptive skills (i.e., a negative effect for the intervention arm of the study), compared to the monthly parent training intervention [22]. The results of this review indicate that daily parent-implemented home programs may reflect the positive effects on some child developmental outcomes. The feasibility of parent implementation to increase repetition and intensity of practice in LMICs need to be considered alongside the lack of fidelity data across the studies.

The acceptability and feasibility of the interventions remain undetermined due to the lack of data on adherence to the total dose and session attendance across six studies (6/11; 55%).

Aspects of the intervention that were or were not acceptable for families or difficulties experienced in adhering to aspects of the intervention may not have been captured due to lack of fidelity monitoring. The dose of parent-implemented home practice was not reported in seven studies [22,34–37,40]. The poor rate of retention of families from six studies (60–80% retention rate) [22,32,36,39,40] suggests that contextual factors may have been barriers to parent implementation in LMICs. Financial constraints such as travel costs and lack of financial support, cultural reasons such as religious rituals, household responsibilities, and personal safety during travel have been previously cited as barriers to attendance at early intervention services for families of children with CP in LMICs which may limit the ability of the parent to be trained by the therapist [14,29]. Contextual and child factors were not reported within the studies included in this review, and therefore specific factors affecting patterns of fidelity and adherence are unable to be explored. To further investigate whether parent-implemented interventions are feasible and acceptable in LMICs, futures studies could consider collecting fidelity data on the dose.
of home practice; qualitative data on barriers and facilitators affecting intervention delivery.

The content of the intervention and comparison arms rather than the parent-implemented model of delivery may have contributed to the improved child outcomes in this systematic review. There is evidence that motor training-based approaches with functional task practice and active movement such as mCIMT, functional chewing training, and goal-directed training delivered using a variety of treatment models, are effective in improving motor outcomes in children with CP [25]. While this data arises from studies in HICs, there is currently no data comparing models of service delivery specific to LMICs. These active approaches were utilised in eight studies [32–34,36–39] including the comparison arm of one study [22]. The treatment content rather than service delivery may be the main reason why these studies had positive effects on motor outcomes such as hand function [36], fine motor function [34], psychomotor development [34], bimanual performance [32], adaptive skills [22] and oral motor function [33,37,39], as well as participation outcomes such as self-care [38] and social function [38]. The results showed that these active treatment types can be effectively delivered by parents. The variation in service delivery across intervention and control arms is a limitation to understanding the efficacy of parent-implemented approaches. The contribution of service delivery (parent-implementation) to the efficacy of the intervention cannot be determined as motor training-based interventions were not compared to the same intervention type implemented with different service delivery (i.e., by interventionists). Rather, in 10 studies interventions were compared to passive, generic interventionist-implemented therapy to the child; or health education-based interventions [22,32–40]. Passive or generic interventions have been not recommended for improving function and movement whether implemented by a parent or interventionist [11]. Further research that directly compares a motor training-based intervention implemented by parents to the same intervention implemented by interventionists would help determine whether parent-implementation results in greater skill development.

A limited number of interventions evaluated parent outcomes and these studies yielded mixed results. In all four studies, parent wellbeing and mental health were secondary aims. The inconsistent evaluation of parent outcomes is reflected in the international clinical practice guidelines on early intervention. Inferences about how parent-implemented interventions impact parent outcomes are difficult to make due to the limited data particularly specific to LMICs. The level of support and training provided to parents may contribute to parent outcomes. Previous literature has identified that parents are best able to implement therapy activities at home when coaching, feedback, and follow-up are provided by the interventionist at regular intervals [30]. This literature is based on data from HICs, due to a lack of data on the most appropriate supports for parent-implemented interventions in LMICs. In two studies where parent stress decreased, parent support and training occurred twice per month [40] and 6–8 times across the 6 months duration of intervention, with an additional home visit [35]. In both studies, parent support and training were provided by allied health professionals including a physiotherapist and occupational therapist [35,40]. In two studies where parent stress increased, support and training to the parent were provided at monthly intervals at the clinic by special education teachers [22]. The limited support and guidance provided by interventionists which is tailored to the home context of the parent may have led parents to lack a sense of confidence and capability in implementing the program activities within the home environment. Additionally, the level of training and experience specific to disability of the special education teachers may be less than the level of training and experience of healthcare professionals. This may have decreased the level of tailored support provided by the interventionist, which may have increased parent stress. Future interventions evaluating parent outcomes are required to further understand the interaction between the level of interventionist support, interventionist training, and improvements in parent outcomes.

This review was subject to several limitations. The inconsistent use of upper limb and developmental outcome measurement tools limited the pooling of studies in a meta-analysis and the confidence of the reported results. The lack of consistent and standardised outcome measures limits the interpretation of the efficacy of parent-implemented interventions. This may reflect a need for measures that are valid, accessible and if necessary, culturally adapted for LMICs. The inconsistent reporting of endpoint data immediately after the intervention, including change from baseline and difference between groups, was another limitation of this review. Attempts were made to contact study authors to obtain any missing change from baseline data. Not all study authors provided the requested information, and this may have impacted the magnitude of mean difference within the meta-analyses of this review. The lack of long-term follow-up limits understanding of the retention of treatment effects. The inclusion of only articles in English limited the breadth of articles searched as English is not the primary language across many LMICs and articles published in non-English journals may not have been captured. The inclusion criteria of studies with children diagnosed with, or at high risk of CP may have limited the breadth of articles included. There may be other examples of parent-implemented interventions trialled in other child neurodevelopmental disability populations that may be appropriate for children with CP. In addition, studies targeting young children at risk of neurodevelopmental delay were full-text reviewed however there were several studies that did not specify the diagnostic profiles of the children. These studies were excluded but they may have included children with CP.

**Conclusion**

Early interventions with therapist training of the parent with the child and/or home practice program components in LMICs for children with CP had positive effects on child bimanual hand and chewing function. Parent-implemented intervention approaches comprised general developmental (functional activity practice and positioning activities), functional feeding (chewing and feeding
training), and upper limb training (mCIMT). Parent-implemented therapy approaches had mixed results to improve parent mental health, however, this was frequently not assessed. Future research can aim to consistently incorporate parent outcomes including mental health, report on the fidelity of intervention delivery and barriers to adherence; and compare motor training-based intervention implemented by parents, to the same intervention implemented by interventionists.

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