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Neurodevelopmental Treatment (Bobath) for Children With Cerebral Palsy: A Systematic Review

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Abstract

Aim: To assess the effects of neurodevelopmental treatment for children with cerebral palsy. **Methods:** We conducted a systematic review following the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions and reported in accordance to PRISMA Statement. Through a comprehensive literature search we considered all randomized clinical trials that compared neurodevelopmental treatment with conventional physical therapy for children with cerebral palsy. We used the Cochrane Risk of Bias Table to assess the risk of bias of the included randomized clinical trial, and the GRADE approach to evaluate the certainty of the body of the evidence. **Results:** We found 3 randomized clinical trials (2 published and 1 ongoing) comprising 66 children. Published randomized clinical trials presented methodological and reporting limitations and only 1 provided data for outcomes of interest. No difference between neurodevelopmental treatment and conventional physical therapy was found for gross motor function (mean difference 1.40; 95% confidence interval –5.47 to 8.27, low certainty evidence). **Conclusion:** This review found that the effects of neurodevelopmental treatment for children with cerebral palsy are still uncertain. Further studies are required to assess the efficacy and safety of neurodevelopmental treatment for this purpose and until there, current evidence do not support its routinely use in practice. Number of protocol registration in PROSPERO database: CRD42017082817 (available from https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=82817).

Keywords

neurodevelopmental treatment, cerebral palsy, Bobath, review, evidence-based medicine

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Bobath therapy was one of the earliest specific therapies developed for children with cerebral palsy, but the evidence on its effectiveness is limited and has not been reviewed systematically. Cerebral palsy is the most prevalent type of physical disability in children.[1] According to a recent systematic review, the overall prevalence of cerebral palsy is 2.11 per 1000 live births in high-income countries[2] and between 2.0 and 2.8 in low- and middle-income countries.[3] In United Sates, the rate of cerebral palsy increased by approximately 20% between 1960 and 1986,[4] and this increase has been attributed to the survival of low- and very-low-birth-weight babies.[5]

The clinical features of cerebral palsy are highly heterogenous. Common manifestations involve dysfunction in posture, muscle tone and movement.[6] The management of cerebral palsy is complex and requires a multidisciplinary approach. Movement disorders in children with cerebral palsy has been

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treatment with different rehabilitation interventions. The neurodevelopmental treatment (previously known as Bobath concept) is a strategy developed from theoretical assumptions that aim to improve gross motor function and postural control by facilitating muscle activity through key points of control assisted by the therapist.[7] The key elements in neurodevelopmental treatment are facilitation (using sensory inputs to improve motor performance), management of compensatory motor behavior and an overall management strategy (a 24-hour interdisciplinary management approach).[8,9] Since its development, neurodevelopmental treatment has been used by therapists worldwide,[10] and it is currently defined as a consumer-centered, hands-on, "problem solving approach."[11]

Despite being one of the oldest and most frequently used interventions to treat children with cerebral palsy,[12] there is no evidence that neurodevelopmental treatment promotes functional improvement of children with cerebral palsy.[13]

Previous reviews of interventions for children with cerebral palsy have either focused on specific types of motor disorders[14] or present methodologic concerns (inclusion of non randomized studies and lack of critical assessment for primary studies).[15-17] To our knowledge, this systematic review is the first to identify, critically appraise, and synthesize the best, currently available evidence on the effectiveness of neurodevelopmental treatment for treating children with cerebral palsy.

Methods

Study Design

We conducted a systematic review, following the recommendations of the *Cochrane Handbook for Systematic Reviews of Interventions*.[18] The protocol of this systematic review was registered prospectively in the PROSPERO database under the registration CRD42017082817 (available from https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=82817). A version of the protocol was published in the Cochrane Library as well. We also followed strictly all recommendations from PRISMA Statement[19] for preparing this article.

We only considered for inclusion randomized clinical trials with parallel design, focusing on children and adolescents (younger than 18 years) with clinical diagnosis of cerebral palsy, regardless the presence of comorbidities, in which neurodevelopmental treatment was compared to no treatment, inactive treatment (waiting list, placebo/sham), or conventional physical therapy approaches. Studies that applied neurodevelopmental treatment in conjunction with other types of treatments were also considered for inclusion, providing that the participants in the control group received only the other treatment (ie, they do not receive neurodevelopmental treatment).

We considered outcomes clinically relevant for practice, but the report of the outcomes of interest was not used as an inclusion criterion in this systematic review. For studies that fulfilled our inclusion criteria but did not assess the outcomes of interest, we only report the data narratively.

1. Primary Outcomes:
   - Motor function, assessed by
     1. Gross Motor Function Measure (GMFM)–66,[20]
     2. Gross Motor Function Measure (GMFM)–88,[21]
     3. Pediatric Evaluation of Disability Inventory[22] (PEDI), and
     4. Peabody Developmental Motor Scales, Second Edition (PDMS-2)[23] (We recognize that there is limited evidence for the reliability and validity of the PDMS-2 and that the original PDMS is not recommended for use in children with cerebral palsy.)
   - Participation, assessed by validated tools such as the Children's Assessment of Participation and Enjoyment (CAPE) test[24]
   - Any adverse outcome (eg, pain, discomfort and tonus impairment), assessed by the proportion of participants presenting at least 1 adverse event

2. Secondary Outcomes:
   - Changes in level of motor function, assessed by validated tools such as the Gross Motor Function Classification System (GMFCS).[25] (We planned to consider any change resulting in an increase in the score of the GMFCS [eg, a change in GMFCS from level III to level IV after neurodevelopmental treatment], or no change, as "worsening," and any change resulting in a decrease in the score of the GMFCS [eg, a change in GMFCS from level III to level II after neurodevelopmental treatment] as an "improvement." We acknowledge that the GMFCS was developed as a classification system and lacks validation.)
   - Upper limb function, assessed by measures such as the Melbourne Assessment of Unilateral Upper Limb Function[26]
   - Hand motor function, assessed by measures such as the Assisting Hand Assessment[27]
   - Changes in levels of hand function, assessed by measures such as the Manual Ability Classification System.[28] (We planned to consider any change resulting in an increase in the level of hand function [eg, a change in Manual Ability Classification System levels from level III to level IV after neurodevelopmental treatment], or no change, as "worsening." and any change resulting in a decrease in the level of hand function [eg, a change in Manual Ability Classification System levels from level III to level II after neurodevelopmental treatment] as an "improvement." We acknowledge that the Manual Ability Classification System was developed as a classification system and lacks validation.)
   - Quality of life, assessed by measures such as the Cerebral Palsy Quality of Life Questionnaire for Children[29] and the Cerebral Palsy Quality of Life Questionnaire for Adolescents[30]
   - Changes in levels of function in everyday activities, assessed by measures such as the Pediatric Functional Independence Measure[31]

We collected outcomes for the following time points: short term (<1 month postintervention), intermediate term (1 to <6 months postintervention), and long term (≥6 months postintervention). When a study measured an outcome more than once during the same time point, we considered the last measure for analysis, to avoid double-counting of participants.

Search for Studies

We performed a systematic and broad search of the literature to identify any randomized clinical trials that would meet the inclusion criteria. There were no imposed restrictions related to the publication status, language, or date of publication. We performed electronic searches of the literature on February 2018, in the following databases:

Cochrane Central Register of Controlled Trials (CENTRAL; 2018, issue 1), in the Cochrane Library, and which includes the Cochrane Developmental, Psychosocial and Learning Problems Specialized Register

- MEDLINE Ovid (1946 to January week 5, 2018)
- MEDLINE In-Process & Other Non-Indexed Citations Ovid (searched February 8, 2018)
- MEDLINE Epub Ahead of Print Ovid (searched February 8, 2018)
- Embase Ovid (1974 to February 8, 2018)
- CINAHL EBSCOhost (Cumulative Index to Nursing and Allied Health Literature; 1937 to February 9, 2018)
- Science Citation Index Web of Science (SCI; 1970 to February 8, 2018)
- Conference Proceedings Citation Index–Science, Web of Science (CPCI-S; 1990 to February 8, 2018)
- SciSEARCH (1991 to February 21, 2018)
- Cochrane Database of Systematic Reviews (CDSR; 2018, issue 2) part of the Cochrane Library
- Database of Abstracts of Reviews of Effect (DARE; 2015, issue 4, final issue) part of the Cochrane Library
- LILACS (lilacs.bvsalud.org; searched February 9, 2018)
- OpenGrey (opengrey.eu; searched February 21, 2018)
- PEDro (pedro.org.au; searched February 9, 2018)
- ClinicalTrials.gov (clinicaltrials.gov; searched February 9, 2018)
- World Health Organisation International Clinical Trials Registry Platform (WHO ICTRP; who.int/ictrp/en; searched February 9, 2018)

Were used relevant terms and appropriate syntax and indexing terms for each database. The search strategies are fully presented in Supplementary Material 1. We also performed hand-searching of reference lists of the studies retrieved from our electronic search and of the relevant publications on the topic. We also contacted specialists about nonpublished or ongoing randomized clinical trials that could fulfill the inclusion criteria.

Data Collection and Analysis

Two review authors (MAZ or ALCM) independently screened all titles and abstracts retrieved by the search strategy for eligibility. Other 2 review authors (RLP, DVP, or COCL) then retrieved and independently assessed the full-text reports of the papers deemed potentially relevant, or for which more information was needed, and selected the studies that meet the aforementioned inclusion criteria. Reasons for excluding studies at this second stage were recorded. A third author (RR) arbitrated disagreements. The selection process was performed with the Rayyan software[32] and presented in a PRISMA diagram.[19]

Two authors (MAZ and ALCM) independently extracted data from the included studies on participant characteristics (age, gender, and type of cerebral palsy), intervention (type of intervention, frequency of treatment, and duration), methods (study design, randomization, blinding, sample size, and unit of analysis), and outcomes (including motor function, upper limb function, hand function, quality of life, and participation). Disagreements were resolved by a third author (RR). We contacted study authors in case of ambiguous or unclear results.

Assessment of Risk of Bias of Included Studies

The risk of bias from the included studies was assessed by the Risk of Bias table from the Cochrane Collaboration. Judgments were based on the recommendations of the *Handbook for Systematic Reviews of Interventions*.[18] Risk of bias for each randomized clinical trial was assessed in 7 domains: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting, and other potential threats to validity.

Each domain was judged low risk of bias (if the domain was considered adequate), high risk of bias (if the domain was considered inadequate), or unclear risk of bias (when there was no sufficient data for the judgment). As all outcomes were subjective in nature, we did not assess the domains blinding of participants and personnel and blinding of outcome assessors separately for each outcome. All judgments were made by 2 independent review authors (RR and ALCM), and any disagreement was solved by a third author (DVP). We also presented reasons for judgments in this report.

Measures of Treatment Effect, Statistical Analysis, Heterogeneity Assessment, and Publication Bias Investigation

For continuous outcomes, we intended to estimate the treatment effects as mean differences (if the outcome was presented in the same scale) or as standardized mean difference (if the outcome was presented in different scales that used the same rationale). For dichotomous outcomes, we planned to estimate the treatment effects as risk ratios (with 95% confidence interval). We also planned to perform random effects meta-analysis (Der Simonian and Laird method using the Review Manager 5.3 software).[33]

We planned to assess the heterogeneity between studies considering clinical diversity (clinical heterogeneity), methodologic diversity (methodological heterogeneity), and statistical heterogeneity. We intended to calculate the chi-square test to assess heterogeneity and to consider a P value >.1 as indicative of statistical heterogeneity, using the I^2 test for the assessment of inconsistency. We planned to choose a 50% threshold for the I^2 test as indicative of significant statistical heterogeneity and to investigate possible sources of heterogeneity by performing prespecified subgroup analyses.

We also intended to investigate publication bias with funnel plots if 10 or more randomized clinical trials were combined in the same meta-analysis.

Additional Analysis

We intended to perform subgroup analysis considering

1. the type of neuromotor abnormality (spastic, ataxic, and dyskinetic), because the response to treatment could be different across different types of neuromotor abnormality;

2. the topographic distribution (hemiplegia, diplegia, and quadriplegia), because hemiplegia could be associated with a higher treatment effect; and
3. the coexistence of postural deformities (eg, scoliosis and subluxation), because the response to treatment could vary with associated postural deformities.

We also planned to perform sensitivity analysis considering

1. the overall risk of bias (comparing high/unclear risk of bias studies with low risk of bias studies);
2. missing data for primary outcomes (by comparing studies with or without imputed values); and
3. the fixed effect model meta-analysis, considering that if the results from a fixed effect model meta-analysis changed the direction of the effect, we would present both results.

Because of lack of data, we were unable to conduct these additional analyses.

Assessment of the Certainty of the Body of the Evidence and a "Summary of Findings" Table

We used the GRADE approach to assess the overall certainty of evidence.[34] For the main comparison (neurodevelopmental treatment versus conventional physical therapy), 2 authors (RR and ALCM) summarized the evidence in a Summary of Findings table using GRADEpro GDT.[35] We initially considered randomized clinical trials as high-quality evidence and downgraded the certainty (to moderate, low, or very low certainty) according to the following criteria: risk of bias, inconsistency, indirectness, imprecision, and publication bias.[34] We justified all decisions to downgrade the certainty of evidence in the footnotes. In the Summary of Findings table, we reported all available results for the motor function, at intermediate and long-term follow-up. We also include in this table the outcomes of participation and adverse outcomes (primary outcomes), and of upper limb function, hand motor function, and quality of life (secondary outcomes).

Results

Search Results

We identified 5800 records from electronic searches and additional 64 records from other sources. After removing duplicates, we screened the titles and abstracts of 4350 records for relevance. From these, we selected, obtained, and screened 14 full-text records, 3 of which fulfilled our selection criteria (2 published and 1 ongoing studies) and were included in the review[36,37] (see Figure 1 for PRISMA flow diagram). We contacted authors of the 2 included randomized clinical trials that were published for pertinent information. Excluded studies with reasons for exclusion are presented in Supplementary Material 2.

Included Studies

One randomized clinical trial was published as full-text[37] and the second was available only as conference abstract.[36] They were single-center studies, with parallel design and conducted

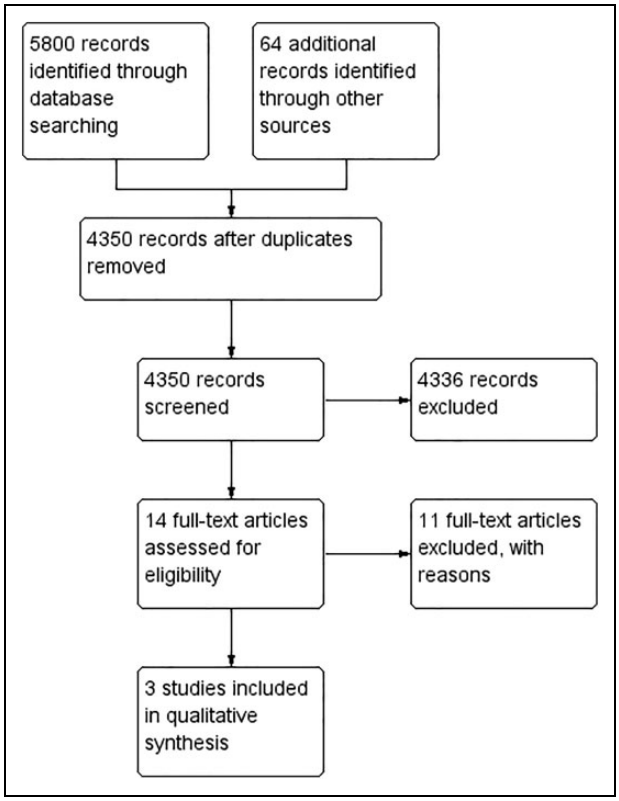

Figure 1. PRISMA flow diagram.

in Turkey[36] and Japan.[37] Combined, these studies involved 66 participants with age ranging from 6 to 15 years. Both included children with spastic motor impairment and compared neurodevelopmental treatment to conventional physical therapy. The characteristics of the included studies are presented in Table 1. We also identified one ongoing trial registered in the Clinical Trials Registry–India (CTRI) under the registration number CTRI010791. In the description of this register, it is specified that neurodevelopmental treatment will be compared to conventional physical therapy for patients with cerebral palsy. When data are available, this trial may fulfill the inclusion criteria of this systematic review and, therefore, should be considered in future updates.

Risk of Bias of Included Studies

Overall, the risk of bias was influenced by the insufficient information for a proper judgment. The summary graph of the risk of bias assessment is depicted in Figure 2. All judgments and justifications are presented in Supplementary Material 3.

Effects of Intervention

Both included studies compared neurodevelopmental treatment with conventional physical therapy. One of them assessed none of the outcomes of interest for this systematic review.[36] The second randomized clinical trial,[37] involving 16 participants, assessed the primary outcome motor function using the scales

Table 1. Characteristics of the Included Studies.

Study (year)	Study design and setting	Participants	Interventions	Outcomes assessed	Intervention period and time points	Funding (as cited in the manuscript)
Ari (2015)[36]	Randomized parallel clinical trial; single-center study conducted in Turkey	– 50 randomized participants with spastic diplegic cerebral palsy – Mean age: 6.5 y (range 3-15)	Group 1 (n = 25): NDT twice a week for 6 wk Group 2 (n = 25): conventional physical therapy twice a week for 6 wk	– Trunk control measurement Scala – Pediatric Berg Balance Test – Timed Up and Go – One-minute walking test – Manual muscle testing None of the outcomes assesses by this study were planned to be assessed in this review	6 wk of treatment; outcomes assessed immediately after intervention end	There was no information regarding funding
Arai (2014)[37]	Randomized parallel clinical trial; single-center study conducted at Japan	– 16 randomized participants with bilateral spastic cerebral palsy caused by periventricular leukomalacia – Mean age: 5.5 y (range: 4-7)	Group 1 (n = 8): NDT Group 2 (n = 20): conventional physical therapy Both groups were treated for 16 wk, 2 h on weekdays and 1 h on holidays	– GMFM-66 – GMFM-88 – PEDI	16 wk of treatment. Outcomes assessed at 0, 8, 16, 24, 32 wk	There was no information regarding funding

Abbreviations: GMFM, Gross Motor Function Measure; NDT, neurodevelopmental treatment; PEDI, Pediatric Evaluation of Disability Inventory.

Figure 2. Risk of bias summary.

GMFM-66, GMFM-88, and PEDI at 24 weeks (intermediate-term) and 32 weeks (long-term) of treatment. Results are presented below and also in Figure 3.

- *GMFM 66 (0 to 66 scale, higher scores mean better motor function):* No important differences between the groups at intermediate term (mean difference 2.40; 95% confidence interval, –5.29 to 10.09) or at long term (mean difference 1.40; 95% confidence interval, –5.47 to 8.27). This represents an absolute difference of 3.6% more (8% less to 15% more) at intermediate term and 2.1% more (8.3% less to 12.3% more) at long term.
- *GMFM 88 (0 to 88 scale, higher scores mean better motor function):* No important differences between the groups at intermediate term (mean difference 13.70, 95% confidence interval, –26.45 to 53.85) or at long term (mean difference 16.40, 95% confidence interval, –21.24 to 54.04). This represents an absolute difference of 15.6% more (30% less to 61.2% more) at intermediate term and 18.6% more (24.1% less to 61.4% more) at long term.
- *PEDI scale:* data for this outcome are not presented, but authors reported no statistically significant difference between groups.

Certainty of the Evidence

The summary of findings table for the comparison neurodevelopmental treatment vs conventional physiotherapy is presented in the Supplementary Material 4. The certainty of evidence was rated as very low because of imprecision (single study, small sample size, wide 95% confidence interval including null) and risk of bias (no blinding and uncertain about allocation concealment).

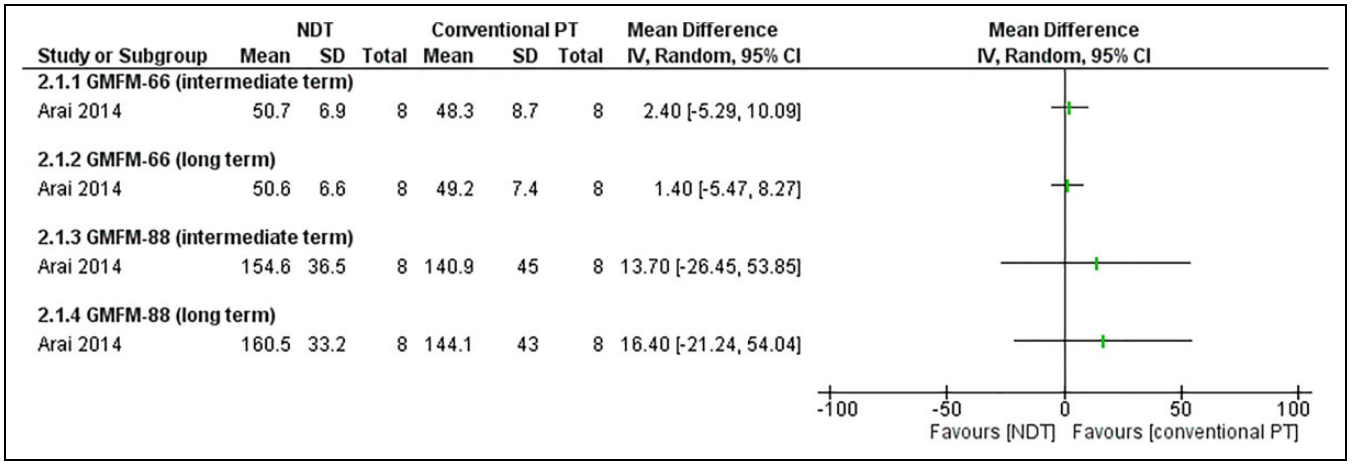

Figure 3. Forest plot.

Discussion

Based on the results of 2 randomized clinical trials, neurodevelopmental treatment for children with cerebral palsy is no different from conventional physical therapy for global motor function at intermediate- or long-term follow-up (very-low-certainty evidence), but the uncertainty of this result is very high.

We included 2 randomized clinical trials that provided data comparing neurodevelopmental treatment with conventional physical therapy for children with cerebral palsy with spastic impairment. However, because of lack of data (1 included randomized clinical trial provided no data on any of the outcomes included in the review), we could not synthesize the data in meta-analyses. The current evidence for global motor function is therefore limited, as it comes from a single study with a small sample size. Furthermore, this study did not measure any of the other primary (participation, adverse events) or secondary outcomes (changes in level of motor function, upper limb function, changes in level of hand function or quality of life).

We did not find studies comparing neurodevelopmental treatment with placebo or no intervention, probably because of ethical issues.

The overall certainty of the evidence was very low (see Summary of Findings table in Supplementary Material 4). We downgraded the certainty of the evidence due to risk of bias and imprecision (single study with a small sample size and wide confidence interval, including null). The overall quality of individual randomized clinical trials was limited because both randomized clinical trials had a high risk for performance bias (lack of blinding of participants). Moreover, neither randomized clinical trials provided information about allocation concealment, and the information available was unclear for selective reporting and other sources of bias.

We followed our published protocol (PROSPERO CRD42017082817) and performed a broad and sensitive search in several electronic databases. We did not perform searches in one of our prespecified databases, SciSearch. However, because most of the citations in this database are also available in Science Citation Index Web of Science, we believe that the potential risk for having missed relevant studies is small. The processes of study selection, data extraction, and quality assessment were performed in duplicate by 2 reviewers, who also checked all data entered into Review Manager software for accuracy. Because of the limited amount of data, we could not perform any subgroup or sensitivity analyses, or assess publication bias.

Limitations of this systematic review include the possibility of having missed relevant studies, although we believe it is unlikely. We did not consider studies where the comparator was nonconventional physical therapy. We believe that until we raise the certainty of the evidence regarding the main comparisons explored in this review, performing head-to-head analysis with interventions with unclear effects can be misleading. Further updates of this systematic review or other reviews may explore these additional comparisons and include other participants, such as adults with cerebral palsy.

We found 3 other systematic reviews on similar topics.[38-40] Their search is outdated, and they did not follow some essential recommended steps such as assessment of the certainty of the evidence. None of these reviews found additional benefits with the use of neurodevelopmental treatment for children with cerebral palsy, which corroborates the findings of our review. An overview of systematic reviews published in 2014[41] found a systematic review[42] that assessed neurodevelopmental treatment for improving limb function for adults after stroke. The authors graded the certainty evidence as low and stated that there is not enough evidence to support any change in current clinical practice.

In addition to its use primarily in cerebral palsy, neurodevelopmental treatment has also been used as an adjuvant rehabilitation technique in other conditions. A review of the literature that assessed neurodevelopmental treatment in stroke rehabilitation also found lack of evidence to support its use routinely.[43] Additionally, a scoping review that focused on neurodevelopmental treatment in a broader scenario of neurologic rehabilitation but in adults included 17 primary

intervention studies and had similar results as ours: some methodological limitations and lack of evidence provided from the included studies prevented solid conclusions for practice.[44]

The findings of this review indicate that the effectiveness of neurodevelopmental treatment for children with cerebral palsy is unclear. Because of the lack of good certainty evidence, neurodevelopmental treatment should be used with caution. The child's response should be observed carefully. Combined treatments of neurodevelopmental treatment with other types of treatments still need further evaluation. Another important point is that decision makers and patients should not confuse absence of evidence with evidence of absence. Our results do not imply that neurodevelopmental treatment have no effect in children with cerebral palsy, but that the effects are unclear and until further research is developed and reported properly, this intervention should be used carefully and individually.

Because of a lack of available data, and the very low certainty of the current evidence, more randomized clinical trials are needed to answer a considerable amount of questions about neurodevelopmental treatment for children with cerebral palsy, including (1) What is the effect of neurodevelopmental treatment for different types of motor impairment (spastic, ataxic, and dyskinetic)? (2) What is the effect of neurodevelopmental treatment for different topographical distributions of the condition (hemiplegia, diplegia, and quadriplegia)? (3) Is neurodevelopmental treatment safe? (4) Does neurodevelopmental treatment improve upper limb function and quality of life? (5) Is neurodevelopmental treatment more effective and safer than nonusual physical therapy approaches?

Conclusions

Two small randomized clinical trials provided insufficient information to draw solid conclusions for practice regarding neurodevelopmental treatment approaches for children with cerebral palsy. Future randomized clinical trials must be carefully planned and conducted to increase the quality of the evidence and reduce the uncertainty.

Author Contributions

MAZ, ALCM, and RR drafted the study protocol and selected which studies to include and extract data from. MAZ, ALCM, RR, and RLP assessed the risk of bias of the included studies. MAZ, ALCM, and RLP performed the statistical analysis. DVP and COCL revised the content. All authors interpreted the analysis, contributed to the draft of the final review, and read and approved the final manuscript.

Declaration of Conflicting Interests

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Supplemental Material

Supplemental material for this article is available online.

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